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EDITORIAL

With this issue of 2006, we bring 57 proceedings of the 81, which started life as presentations at the 12 International Scientific Conference "Research for Rural Development 2006" held at the Latvia University of Agriculture, in Jelgava, on 17th to 20th May 2006.

In the retrospect of 4 months later, we can count the Conference as a great success. The theme – Research for Rural Development - attracted participation of 460 researchers with very different backgrounds. There were 1 presentation from India, 1 from Turkey, 1 from Sweden, 1 from Finland, 1 from Estonia, 5 from Romania, 15 from Lithuania and 56 from Latvia.

Four independent reviewers estimated each report.

The proceedings of the 12 International Scientific Conference "Research for Rural Development 2006" is intended for academics, students and professionals researching in the area of crop production, animal breeding, agricultural engineering, agrarian and regional economics, food sciences, veterinary medicine, forestry, wood processing and water management.

The proceedings will also be useful for researchers in educational sciences.

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AGRICULTURAL SCIENCES (CROP SCIENCES, ANIMAL SCIENCES)

VARIATION IN ENDOSPERM β-GLUCAN CONTENT OF DIFFERENT SPRING BARLEY GENOTYPES

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Abstract
Grain samples of 51 spring barley (*Hordeum vulgare* L.) genotypes, including two-row, six-row, covered and hulless were used for investigation of endosperm β-glucan content. A significant difference (p-value <0.0001) between genotypes in β-glucan content was observed. On average, the six-row barleys had a slightly higher β -glucan content. For six-row genotypes it ranged from 35.9 to 47.1 mg kg^{-1} with the mean value of 41.4 mg kg^{-1}, but for two-row barleys – 38.0 mg kg^{-1} within the range of 33.2 - 44.9 g kg^{-1}. Six-row genotypes had a higher coefficient of variation in comparison with two-row genotypes. Hulless genotypes had a significantly higher β-glucan content than the covered ones (49.3 mg kg^{-1} and 38.9 mg kg^{-1} respectively). The standard deviation of the mean values of β-glucan content for covered genotypes was lower than for the hulless ones. The mean values in 2005 were well plotted against data from the previous season for genotypes included in the two years trial. There were two distinct clusters of covered and hulless genotypes. β - glucan content for varieties bred in Latvia ranged from 33.2 mg kg^{-1} for two-row variety 'Malva' to 46.0 mg kg^{-1} for six-row variety 'Druvis'.
Key words: spring barley, β-glucan, genotypes, variation.

Introduction

A characteristic polysaccharide component of cell walls of cereal endosperm is (1→3), (1→4) β-D-glucan (hereafter: β-glucan) (Evers et al., 1999). Compared to other cereals, barley and oat endosperms have relatively high β-glucan contents. The β-glucan content of barley grain varies usually between 2 and 7 % (Grausgruber et al., 2004).

The β-glucan content of barleys affects performance in various food and feed systems. The double role of β-glucan as a barrier for enzyme diffusion and as the main factor contributing to wort viscosity gives β-glucan a key importance in malting (Munk, 1981). Therefore the breeding of barley varieties with low β-glucan content is desirable.

Other food industries, especially those producing high fiber products which claim nutritional benefits due to β-glucan, might be interested in barley varieties with a high β-glucan content too. The positive roles of the β-glucan in human nutrition and health, such as lowering blood cholesterol levels, increasing mineral and vitamin bioavailability and controlling colon cancer, have been noted (Klopfenstein, 1988)

Barley β-glucan has also been implicated in problems encountered in animal feeding, particularly in chicken and poultry diets, where they may give rise to sticky droppings and affect food intake, growth and feed conversion efficiency (Svihus, 2002). Ideally medium to low β-glucan content would be most suitable for pigs and poultry (Newman and Newman, 1992; Miller et al., 1994).

There have been several studies on the dependence of β-glucan content on barley grain on genetic and environmental factors. Lextonen (1987) reported that two-row barley genotypes had higher β-glucan than six-row barleys, and showed clear differences between barleys grown in different locations in Finland. Comparative composition of covered and hulless barley showed that hulless barley generally contained more protein, starch, and β-glucan. This was due to removal of fibrous hull which has a dilution effect on these components (Bhatty, 1999). Varieties with waxy endosperm (contain starch with 97-100 % of amilopectin) had a higher β-glucan content than varieties with normal starch (Washington et al., 2000; Oscarsson et al., 1997). Narasimhalu et al. (1995) found significantly higher β-glucan contents in barleys from eastern Canada compared to western, and significant differences among 75 barley genotypes studied and reported that Canadian two-row varieties on average contained less β-glucan than Canadian six-row varieties. Another study showed that two-row lines contained higher β-glucan than the six-row ones (Fregeau-Reid et al., 2001). Perez-Vedrell et al. (1996) found that β-glucan content of 10 two-row and six-row barley varieties planted in several Spanish ecological areas in three years varied between 1.9 % to 5.5 %, with an average of 3.5 %, and that significant difference existed between the genotypes, locations, and year.

The aim of the study was to estimate the β-glucan content for spring barley genotypes, representing a wide range of genetic diversity and origin. The main tasks were to determine the variation in β-glucan content between different types of barley and to characterize the β-glucan content for barley varieties bred in Latvia.

Table 1

Spring barley genotypes used in the study

Barley type	n	Genotype, origin country
Two-row, covered	27	Ansis, Abava, Sencis, Kristaps, Rasa, Linga, Idumeja, Balga, Ruja, Gate, Malva, Klinta (Latvia); Hanka, Annabell, Danuta, Justina, Polygena (Germany); Austrian early, Landsorte Aus Tirol (Austria); Primus II, Pongo (Sweden); Hatvani 45/25 (Hungary); Cork, Century (Great Britain); Lechtaler (Portugal); Grimmet (Australia); 379 (Chile)
Six-row, covered	10	Druvis (Latvia); Colsess IV, July (Denmark); B90A, RNB-367 (Nepal); Zoapila, Puebla (Mexico); IV/192 (Macedonia); Valluno (Bolivia); Chosen (North Korea)
Two-row, hulless	14	L 302 (Latvia); KM 2084 (the Czech Republic); SW 1291 (Sweden); Gwire, Gainer Merlin (Canada); X-4 (Lithuania); Orzo Nudo di Altamura (Italy); 2474, Clho 7799 (Guatemala); C.P.I. 22817 (Russia); Sumire Mochi, Wanubet (Japan)

Materials and Methods

The 51 genotype represented a broad range of germplasm (two-row, six-row, covered, hulless) of different origin (Table 1). Thirty-seven covered spring barley genotypes from which 27 with two-row and 10 with six-row ear types, and 14 hulless genotypes were used in the study. Only two-row hulless genotypes were included in this investigation. Hulless barley genotypes 'Merlin', Sumire Moshi', and 'Wanubet' have waxy endosperm.

The genotypes were grown at the State Stende Plant Breeding station in the years 2004 and 2005. The soil at the site was sod-podzolic sandy loam, humus content – 12–15 mg kg^{-1}, soil pH – 6.0–6.7, precrop – potatoes, available for plants P – 88-94 mg kg^{-1} and K – 103–122 mg kg^{-1}, used fertilizer N60 P15 K40 kg ha^{-1}. Plot size was 2 m^2, seed rate - 400 seeds per m^2.

The meteorological conditions for first parts of growing season of 2004 and 2005 were comparatively similar – rich with moist and moderate air temperature. Also June for both years was characterized by mean air temperature above the long-term data. The highest amount of precipitation was observed in June of 2004 (199 % of the long term-average) and in May of 2005 (179 % of the long term-average). July 2004 was characterized by cool and moist conditions, but August was hot and dry. July 2005 was comparatively warm and dry (1.6 °C above long-term data, precipitation was 75 % of the long-term data), August was warm and wet precipitation exceeded by 27 % of the long-term data.

(1→3), (1→4) β-D-glucan content was determined enzymatically following the barley grains procedures of the commercial kits from *Megazyme* (Megazyme International Ireland Ltd.) according to the method developed by McCleary and Glennie-Holmes (1985) and performed by the author at the Scientific Laboratory of Agronomic Analysis (Latvia University of Agriculture). In the procedure, highly purified enzymes were employed. A sample (0.5 g) of flour was weighted and β-D-glucan was depolimerized with lichenase to oligosacharides and then hydrolyzed to glucose with a specific purified β-glucosidase. The β-glucan content (mg kg^{-1}) was calculated using the glucose quantity found in formula (1):

$$\beta - glucan = \Delta E \times \frac{F}{mg} \times 270, \qquad (1)$$

where

ΔE – the absorbance difference at 510 nm in a UV-spectrophotometer after β-glucosidase treatment – blank absorbance;

mg – weight of sample;

F – a factor for conversion of absorbance value to μg glucose.

ANOVA procedures were used for data analysis.

Results and Discussion

The variation in β-glucan content of two-row, six-row, covered and hulless barley genotypes is presented in Table 2. Only small differences were found between the two-row and six-row barleys. The results of t-test proved that differences between the mean β-glucan content of two-row and six-row barley were not significant (p-value=0.14). On average, however, the six-row barleys had a slightly higher β-glucan content. For six-row genotypes it ranged from 35.9 to 47.1 mg kg^{-1} with the mean value of 41.4 mg kg^{-1}, but for the two-row genotypes – 38.0 mg kg^{-1} within the range of 33.2 – 44.9 mg kg^{-1}. Six-row genotypes were characterized by a higher coefficient of variation in comparison with the two-row ones (accordingly 10.8 and 8.4 %). Hulless genotypes had a significantly higher β-glucan content than the covered ones – 49.3 mg kg^{-1} and 38.9 mg kg^{-1} respectively (p-value=0.005). This agrees also

Table 2

Comparison of grain β-glucan content (mg kg^{-1}) for two-rowed *vs* six-rowed, and covered *vs* hulless genotypes (mean of 2004-2005)

Genotype	Mean value	Standard deviation	Minimum value	Maximum value	Coefficient of variation, %
Two-row	38.0	3.2	33.2	44.9	8.4
Six-row	41.4	4.2	35.9	47.1	10.8
Covered	38.9	3.7	33.2	47.1	9.7
Hulless	49.3*	6.4	38.7	62.0	13.5

**p-value<0.05*

with earlier results (Bhatty, 1999). The standard deviation of the mean values and the coefficient of variation of β-glucan content was lower for covered genotypes than foe the hulless ones (Table 2).

According to analysis of variance for two-year data, a significant difference (p-value<0.0001) between genotypes in β-glucan content was observed. β-glucan content increases gradually during grain development; these increases vary depending on variety and growing season (Aman et al., 1989). No statistically significant difference was obtained for the β-glucan content variation between the years 2004 and 2005 (p-value=0.286). It could be because the mean air temperatures during grain filling periods in the growing seasons of 2004 and 2005 were comparatively similar (16.3 and 17.5 °C). The mean values in 2005 were well plotted against the data from the previous season for genotypes included in the two-year trial ($r=0.692>r_{0.05}=0.273$; n=51) (Figure 1). For β-glucan content, both covered and hulles genotypes showed some variation between seasons in the degree of scatter. There were two distinct clusters of covered and hulless genotypes regarding the β-glucan content.

Table 3 represents data of β-glucan content for 13 varieties bred in Latvia and currently included in the State Catalogue of Plant Varieties. Overall, Latvian varieties characterized by the lower β-glucan content in comparison with the genotypes from other origin countries included in this study. β-glucan content for those varieties ranged from 33.2 mg kg^{-1} for two-row variety 'Malva' to 46.0 mg kg^{-1} for only six-row variety 'Druvis'. For barleys for brewing, a low and stable β-glucan content (<40 mg kg^{-1}) is recommended (Fox et al., 2003). The β-glucan content for varieties 'Rasa', 'Idumeja', 'Balga', 'Gate' and 'Klinta' exceeded this level in one or two years of the investigation. Varieties 'Ansis', 'Sencis', 'Kristaps', 'Ruja', 'Linga' and 'Malva' are characterized both by a lower mean value mean value and the range of β-glucan content between the two years. Barley varieties 'Abava', 'Rasa' and 'Gate' have the highest variation of β-glucan between the two years with ranging from 4.9 to 9.2 mg kg^{-1}.

Also for animal feed, especially for pigs and poultry, lower β-glucan content is desirable. It has been suggested that β-glucan might impair the digestion and utilisation of barley-based diet for poultry (Annison, 1991) and mentioned

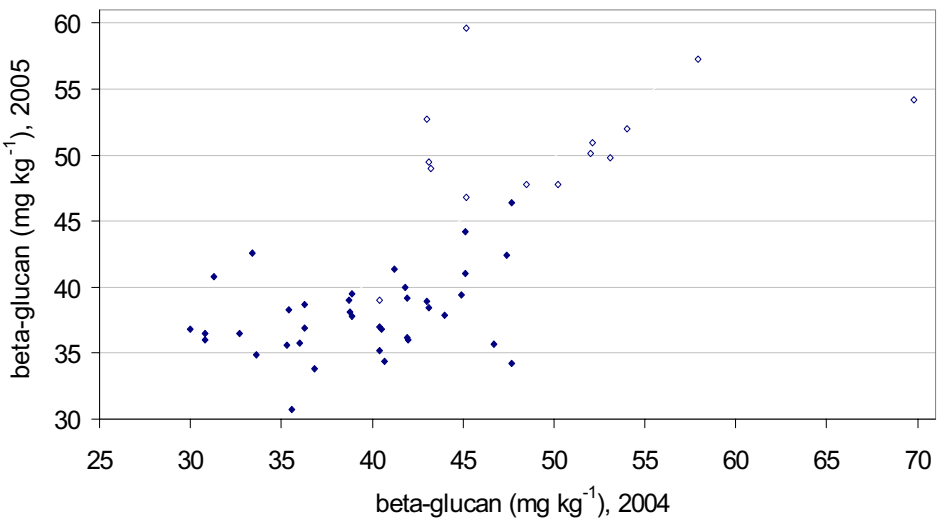

Figure 1. Mean β-glucan from the 2004 trial data plotted against the 2005 results for barley genotypes (■– covered; □– hulless).

Table 3

Characterisation of β-glucan content for varieties bred in Latvia and the range of β-glucan content between two years (2004 and 2005)

Variety	2004	2005	Mean	Range
Ansis	36.8	33.8	35.3	3.0
Sencis	32.7	36.5	34.6	3.8
Abava	33.4	42.6	38.0	9.2
Rasa	42.0	36.0	39.0	6.0
Kristaps	36.3	38.7	37.5	2.4
Druvis	45.2	46.8	46.0	1.6
Idumeja	41.9	39.2	40.6	2.7
Balga	43.0	38.9	41.0	4.1
Ruja	38.9	37.8	38.4	1.1
Gate	41.9	36.2	39.1	5.7
Linga	36.3	36.9	36.6	0.6
Malva	35.6	30.7	33.2	4.9
Klinta	40.4	39.0	39.7	1.4

as the most important predictor of the nutritive value in utilisation of barley for nonruminants (Beames et al., 1996). The desirable value of β-glucan regarding utilisation for poultry might not exceed 60 mg kg^{-1} (Fox et al., 2003). Nevertheless it was observed that β-glucan in barley is highly digestible and has no detectable adverse effect on digestion and utilisation for ruminants (Engstrom et al., 1992). For that reason, all Latvian varieties and other covered two-row, six-row as well as part of hulless genotypes included in this study meet requirements of animal feeding and could be well utilized in the breeding of varieties for feed.

As β-glucan is included in the soluble dietary fibre fraction, barley varieties with a high β-glucan content may be useful for human food (Klopfenstein, 1988). Therefore hulless barley genotypes in this study have been recognized as more valuable in food industry if compared to covered barley. The highest β-glucan content was observed for hulless genotypes with waxy endosperm - 'Merlin' (Canada), 'Sumire Mochi', and 'Wanubet' (Japan) (53.0, 57.6, and 62.0 mg kg^{-1} respectively).

Conclusions

The data presented in this paper demonstrate considerable variation in β-glucan content of different types of barley. A significant difference between the genotypes in β-glucan content was observed. Agro-ecological conditions of two experimental years did not affect the β-glucan content of barley significantly, and on average the results were similar. Hulless genotypes had a significantly higher β-glucan content than the covered ones (38.9 and 49.3 mg kg^{-1}). No significant differences were found between the two-row and six-row barleys, however, the six-row genotypes had a tendency to a slightly higher β-glucan content. According to the results varieties bred in Latvia are characterized by a medium content of β-glucan (33.2 to 46.0 mg kg^{-1}) and are suitable to utilise for both malt and feed. Hulless barley genotypes in this study have been recognized as more valuable in food industry if compared to covered barley. The highest β-glucan content was observed for hulless genotypes with waxy endosperm - 'Merlin' (Canada), 'Sumire Mochi', 'Wanubet' (Japan). The above listed differences may be well utilised in the barley breeding program to produce varieties for specific purposes.

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References

1. Aman P., Graham H., Tilly A.C. (1989) Content and solubility of mixed-linked β-glucan in barley and oats during kernel development and storage. Journal of Cereal Science, 10, pp. 45-50.
2. Annison G., Choct M. (1991) Anti-nutritive activities of cereals non-starch polysaccharides in broiler diets and strategies minimizing their effects. World's Poultry Science Journal, 47, pp. 232-242.
3. Beames R.M., Helm J.H., Eggum B.O., Boisen S., Back-Knudsen K.E., Swift M.L. (1996) A comparison method for measuring for nutritive value for pigs of a range of halled and halless barley cultivars. Animal feed Science Technology, 62, pp. 189-201.
4. Bhatty R.S. (1999) The potential of hulless barley. Cereal Chemistry, 76, pp. 589-599.
5. Bhatty R.S., Christison G.I. (1975) Chemical composition and digestable energy of barley. Canadian Journal of Animal Science, 55, pp. 759-764.
6. Evers A.D., Blakeney A.B., Brien L.O. (1999) Cereal structure and composition. Australian Journal of Agricultural Research, 50, pp. 629-650.

7. Engstrom D.F., Mathison G.W., Goonewardene L.A. (1992) Effect of beta-glucan, starch, and fibre content and steam vs. gry rolling of barley grain on its degradability and utilization by steers. Animal feed science and Technology, 37, pp. 33-46.
8. Fox G.P., Panozzo J.F., Li C.D., Lance R.C.M., Inkerman P.A., Henry R.J. (2003) Molecular basis of barley quality. Australian Journal of Agricultural Research, 54, pp. 1081-1101.
9. Fregeau-Reid J., Thin-Meiw C., Ho K., Martin R.A., Konishi T. (2001) Comparison of two-row and six-row barley for chemical composition using doubled-haploid lines. Crop Science, 41, pp. 1737-1743.
10. Grausgruber H., Schoenlechner R., Zahlner V., Berghofer E., Ruckenbauer P. (2004) Beta-Glucan content of old and modern spring barleys. In: Logue S. (eds) 9th International Barley Genetic Symposium, Brno, Czech Republic, pp. 442-448.
11. Klopfenstein C.F. (1988) The role of cereal of beta-glucan in nutrition and health. Cereal Foods World, 33, pp. 865-969.
12. Lextonen M., Aikasalo R. (1987) Beta-glucan in two- and six – rowed barley. Cereal chemistry, 64, pp.191-192.
13. McCleary B.V., Glennie-Holmes M. (1985) Enzimatic quantification of (1-3)-(1-4) - β-glucan in barley and malt. Journal of Institute of Brewing, 9, pp. 285-295.
14. Miller M.C., Froseth J.A., Wyatt C.L., Ullrich S.E. (1994) Effect of starch type, total beta-glucan, and acid detergent fibre level on the energy content of barley (Hordeum vulgare L.) for poultry and swine. Canadian Journal of Animal Science, 74, pp. 679-686.
15. Munk L. (1981) Barley for food, feed and industry. In: Pomeranz Y. and L. Munk (eds) Cereals. A renewable Resource, Theory and Practice, MN:American Association of Cereal Chemists, St. Paul, USA, pp. 427-459.
16. Narasimhalu P., Kong D., Choo T.D., Ferguson T., Therrien M.C., Ho K.M., May K.W and Jui P. (1995) Effect of environment and cultivar on total mixed-linkage glucan content in eastern and western Canadian barleys (Hordeum vulgare L.). Canadian Journal of Plant Science, 75, pp. 371-376.
17. Newman C.W., Newman, R.K. (1992) Characteristics of the ideal barley for feed. In:Munk L. (eds) Barley Genetics VI. Sixth International Barley Genetic Symposium, Munksgaard International Publishers Ltd., Copenhagen, DK, pp. 925-939.
18. Oscarsson M., Parkkoen T., Auto K., Aman P. (1997) Composition and microstructure of normal, waxy and high-amylose barley samples. Journal of Cereal Science, 26, pp. 259-264.
19. Perez-Vedrell A.M., Brufau J., Molina-Cano J.L., Francesch M., Guasch J. (1996) Effect of cultivar and environment on (1-3), (1-4)-D-glucan content and acid exstract viscosity of Spanish barleys. Journal of Cereal Science, 23, pp. 285-292.
20. Svihus B., Gullord M. (2002) Effect of chemical content and physical characteristics on nutritional value of wheat, barley and oats for poultry. Animal Feed Science and Technology, 102, pp. 71-92.
21. Washington J.M., Box A., Karakousis A., Barr A.R. (2000) Developing Waxy Barley cultivars for food, feed and malt. In: Munk L. (eds) Barley Genetics VIII. Sixth International Barley Genetic Symposium, Munksgaard International Publishers Ltd., Copenhagen, DK, pp. 303-306.

THE IMPORTANCE OF AQUACULTURE IN THE SOUTHEASTERN ANATOLIA PROJECT IN TURKEY

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Abstract

The Southeastern Anatolia Project (GAP) is a multi-sector and integrated regional development project in Turkey. The project area covers 9 administrative provinces - Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa, and Sirnak - in the basins of the Euphrates and Tigris. The GAP planned in the 1970s consists of projects for irrigation and hydraulic energy production on the Euphrates and Tigris rivers. The development program encompasses such sectors as irrigation, hydraulic energy, agriculture, fish farming, rural and urban infrastructure, forestry, education, and health. This project envisages the construction of 22 dams and 19 hydraulic power plants and irrigation of 1.7 million hectares of land. The total cost of the project is estimated as US$ 32 billion. The construction of several dams will cause an increase in total capacity of more than 600.000 tons of fish in the region. Aquaculture will be an important source of income for the people and the economy of the country, a sum of US$ 1.8 billion of income will be obtained each year.
Key words: Turkey, aquaculture, fish farming.

Introduction

Situated at the junction of two continents - Asia and Europe - Turkey is surrounded by sea on three sides: the Black Sea in the north, the Mediterranean in the south, and the Aegean in the west. There are two important rivers in Turkey, named Firat (Euphrates) and Dicle (Tigris). Euphrates is rising in Turkey, passing through Syria before it ends in Iraq. Euphrates is 2,735 km long and has a discharge of 900,000 litres per second. The Euphrates gets 90% of its water from Turkey, through a set of tributary rivers like Karasu, Murat, and Khabur. The Tigris is 1,850 km long, and it has two principal sources, - Lake Hazer and Lake Van in Turkey. Tigris joins with the Euphrates for the remaining 170 km to the outlet in Persian Gulf (Acma, 2005; Çelebi, 2005).

Covering the provinces of Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa and Sirnak, the GAP region has a surface area of 75,358 km^2, which corresponds to 9.7 % of the total surface area of Turkey. According to the provisional results of the 2000 General Population Census, the population of the GAP region is 6,604.205, which corresponds to 9.7 % of the total population of the country (67,844.903). A total of 63 % of regional population live in urban settlements and 37 % - in rural areas (GAP, 2006).

Materials and Methods

What is the Southeastern Anatolia Project (GAP)

The GAP is the largest investment ever launched in Turkey for regional development. When the project is completed, facilities on the Euphrates and Tigris, which together flow more than 52.9 billion cubic meters of water a year, will bring 28.5 % of the total water potential of Turkey under control. In all 17 000 km^2 of land will be brought under irrigation and 27 billion kWh of energy will be produced with an installed capacity of 7485 MW. The area to be brought under irrigation corresponds to 20 % of total land economically irrigable in Turkey and energy production to 22 % of the total hydraulic energy potential of Turkey (GAP, 1992; 1993a; 1993b; 2006).

As of the end of 2001, 215.080 hectares of land has been brought under irrigation by the General Directorate of State Hydraulic Works (DSI). In terms of physical realization, 12 % of irrigation projects is already in operation, 8 % is under construction, 25 % is at the stage of contracting out and finally 55 % is at planning stage. When all these projects are completed, the new area brought under irrigation will be equal to the total size of land so far opened to irrigation by the State. Thus, this high agricultural and industrial potential created by the GAP will significantly contribute to the economic output of the region and generate employment for about 3.5 million people. Irrigation will naturally increase agricultural output as well (Aksoy at al., 1995; Dursun, 1999; Ozaslan, 1998). The Expected high potential in both industry and agriculture will increase the income level of the region fivefold and create employment for 3.5 million people in the region whose population is projected to reach more than 9 million in 2005.

Background of Southeastern Anatolia Project

In the region of Southeastern Anatolia, the area encompassing the provinces of Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa and Sirnak is referred to as the 'GAP Region'. This region surrounded by Syria in the south and Iraq in the southeast has a surface area of 75,358 km^2, which corresponds to 9.7 percent of the total surface area of the country. Out of the total, 20 percent of a total of 8.5 million hectares of irrigable land in Turkey is in the GAP which is region made up of wide plains in the basins of Lower Euphrates and the Tigris.

Both of these rivers originate from Eastern Anatolia and flow to the Persian Gulf. Southeastern Anatolia receives less precipitation than the other regions of the country. It

was thus considered to develop water resources in the basins of these two rich rivers for irrigation and energy generation purposes and to bring these two rivers with irregular flow regimes under control.

13 projects were prepared to develop the rich water resources (the rivers of Euphrates and Tigris) of the region for land irrigation and power generation purposes. Seven of these projects - Karakaya, Asagi Firat, Sinir Firat, Suruç-Yaylak, Adiyaman, Goksu-Araban, and Gaziantep projects - are in the basin of the Euphrates, and 6 of them - Dicle-Kralkizi, Batman, Batman-Silvan, Garzan, Ilisu, and Cizre projects - are called as Tigris projects. These projects envisage the construction of 22 dams and 19 power plants. As a result of this development in water and land resources, there will be improvements and corresponding developments in the sectors of agriculture, forestry, fish farming, industry, rural-urban infrastructure, education, and health services (GAP, 1993a; 1993b; 2006).

Organizational Structure of GAP

Starting as an energy and irrigation project to develop the rich land and water resources of the region, the GAP was transformed into an integrated regional development project with the completion of the GAP Master Plan in 1989.

Today, GAP is a regional development project carried out within the framework of sustainable human development. In this sense, it targets to create opportunities for the people of the region to enable them to materialize their economic potential and preferences fully.

The mandate of carrying out the project along the lines of integrated regional development and ensuring required coordination was given to the GAP Regional Development Organization as an entity established in 1989 under the Prime Ministry. The decision making body is the GAP Higher Council presided by the Prime Minister and consisting of the State Minister in Charge of GAP, State Minister in Charge of State Planning Organization, and Minister of Public Works and Settlement. The GAP Administration has its Central Office in Ankara and a Regional Directorate in Sanliurfa (GAP, 2006).

GAP Program for the Development of Land and Water Resources

The State Hydraulic Works (DSI) is engaged in the program for developing land and water resources in the region. The program consists of two parts each of them covering projects related to the basins of either the Euphrates or the Tigris. The program envisages the construction of 22 dams, 19 hydraulic power plants and an irrigation system that will bring 1.7 million hectares of land under irrigation. Upon the completion of the project, 29 % of the total water potential of Turkey will be managed through the facilities on the Euphrates and the Tigris, which together flow more than 52.9 billion cubic meters of water a year. The planned irrigation area corresponds to 20 % of total irrigable land in Turkey and the annual energy production to 22 % of total electric energy potential in Turkey (GAP, 2006).

GAP and International Cooperation

The year 1997 was a starting date when the project package Program for Sustainable Development in the GAP Region was launched in cooperation with the UNDP. The program consists of 28 sub-projects and its total budget is USD 5.2 million

The World Bank issued grants for two projects related to the development of urban and rural infrastructure. A total grant of USD 650,000 was secured from the World Bank for these two projects.

The GAP-RDA had its relations with the European Union (EU) starting in 1996. The EU granted EUR 47 million for projects targeting the reduction of regional disparities, regional economic growth, improvement of environmental conditions, and preservation of cultural heritage.

The GAP Administration is engaged in cooperation with many international organizations, universities and civil society organizations to share information and experience in the process of integrated regional development. These organizations and universities include Arizona State University (ASU), San Diego University (SDSU), Tennessee Valley Authority (TVA), Kent State University (KSU), Portland State University (PSU), Oklahoma State University (OSU), Packard Humanities Institute (PHI), HASNA Inc; Syria based International Center of Agricultural Research in Dry Areas (ICARDA); Sri-Lanka based International Water Management Institute (IWMI), Egypt Southern Valley Development Administration (TOSHKA), Bari (Italy) based Mediterranean Agricultural Research Organization (CHIEAM-IAMB), and Syrian General Organization for Land Development (GOLD). Protocols have been acted with these organizations for cooperation (GAP, 2006).

There is a protocol of cooperation with the International Cooperation Center of the Foreign Ministry of Israel (MASHAV) focusing on rural development issues.

The GAP Administration is involved in joint training programs with participants from many other countries including Egypt, China, Bosnia, Macedonia and Bangladesh that have their projects similar to the GAP.

Financing the GAP

GAP investments consist of the sum total of various economic and social projects and activities of different organizations. Allocations for these investments by various organizations are made from the budgets of respective organizations in change of implementing projects and actually used by them. The cash realization in the project has reached 54.1 %. Considering by sectors, the rate of

realization is 81.1 % in energy projects, 22.9 % in agriculture projects, and 79.3 % in other sectors. Even at this stage, the project has contributed a lot to the economy of the country.

Together with Karakaya and Atatürk Dams, which together generate a considerable part of energy in the national interconnected system, Kralkizi, Karkamis, Dicle, Birecik and Batman Dams produced 234 million kWh as of the end of 2004. The monetary equivalent of this energy is about 14 billion dollars. The energy produced in the GAP region in 2001 (about 11.5 billion kWh) comes up about a half of all hydraulic energy produced in Turkey. The GAP share in the total energy production of the country (thermal, plus hydraulic, plus wind) is 9.3 %.

Irrigation in Harran Plain started in 1995. Upon the completion of all irrigation projects in the GAP, 1.7 million hectares of land will brought under irrigation. At least USD 2 billion each year will be needed for the completion of the projects until 2010. As of the level it reached today, the GAP has already brought along significant changes in the life of people living there. The GAP is also a unique model of international significance in terms of water management for human and social-economic development (GAP, 2006).

Results and Discussion

Fish Farming Potential of GAP

Total fisheries production of Turkey is 594,977 tonnes (484,410 marine fish, 67,244 aquaculture, and 43,323 freshwater fish). Due to the rich freshwater resources that consist of 177,714 km of rivers, 906,118 ha of natural lakes, 342,377 ha of reservoirs, 70,000 ha of lagoons and 750 small reservoirs, inland fishery has always had a big potential of fish production (Canyurt, 2005). With the completion of the Atatürk Dam and the other dams involved in the Southeast Anatolian Project, the potential for inland fisheries will greatly increase. Within the framework of this huge project a total capacity of nearly 223,000 ha will be added to the inland fresh water capacity of Turkey. The construction of several dams will increase the total capacity to more than 600,000 tons of fish in that region.

Aquaculture will also be important in the GAP region of Turkey and will even exceed the production gained from fishery in that region. At present there are eight commercial trout cage-culture farms. These farms buy fish fingerlings from other farms for ongrowing to marketable size within 5-6 months. There are two hatcheries in the GAP region that belong to the General Directorate of State Hydraulic Works (DSI). One of them is located near the Ataturk Dam's reservoir, the other one is at the Keban. Atatürk Dam Production Center is accepted as "The biggest aquacultural establishement of The Middle East". It is planned on 134 ha of land and its fish production capacity is 40 million of fish fingerlings by year. Both hatcheries produce fingerlings of trout and carp species for stocking the reservoirs as well as other waterbodies (Celebi, 2006). The number of fingerlings stocked in the reservoirs and the Tigris River is shown in

Table 1

Fish stocked in 1999 in the GAP reservoirs and the Tigris River (Safak, 2000)

Reservoir/River	Fingerlings (x1000)	Species
Ataturk reservoir	15,500	Common carp
Karakaya reservoir	2,800	Common carp and Rainbow trout
Devegeçidi reservoir	1,630	Common carp
Hancagiz reservoir	680	Common carp
Haci Hidir reservoir	800	Common carp
Dumluca reservoir	980	Common carp
Göksu reservoir	960	Common carp
Çamgazi reservoir	325	Common carp
Kral Kizi reservoir	500	Common carp
Tigris river	200	Common carp
Batman reservoir	100	Common carp
Total	24,475	Common carp and Rainbow trout

Table 2

List of fish species in Ataturk Dam (Yuksel et al., 1998)

Family	Species
Bagridae	*Mystus halepensis*
Poecilidae	*Gambusia affinis*
Mugilidae	*Mugil abu*
Mastacembelidae	*Mastacembelus simack*
Cobitididae	*Nemacheilus (Paragobitis) tigris*
Siluridae	*Silurus (Parasilurus) triostegus*
Cyprinidae	*Carassius carassius* *Chalcalburnus Acanthalburnus microlepis* *Acanthobrama marmit* *Acanthobrama terrae-sanctae* *Aspius aspius* *Aspius vorax* *Barbus rajanorum mystaceus* *Barbus xanthopterus* *Capoeta capoeta umbla* *Capoeta trutta* *Carassobarbus luteus* *C. mossulensis* *Chondrostoma regium* *Cyprinion macrostomus macrostomus* *Cyprinus carpio* *Garra rufa obtusa* *Garra (Discognatus) variabilis* *Leuciscus cephalus orientalis* *Leuciscus lepidus* *Tor grypus*

Table 1. A list of fish species living in Ataturk Dam's reservoir is given in Table 2 (Safak, 2000 and Yuksel et al., 1998). The number of fish fingerlings stocked in the Dam's lakes and Rivers increase each year. Several species have been released in these lakes in order to create the potential for fishery production; among these, carp, trout, mullet and eel have proved themselves to be the most suitable ones for these artificial lakes (Ozaslan, 1998; Safak, 2000).

The GAP represents almost 17 percent of the total inland water resources potential, but the region has a low fish consumption and low fish production. In 1998, capture fisheries harvested 1,842 tonnes, and aquaculture produced 290 tonnes in the GAP region. This was equal to 3.3 % of capture from inland waters of Turkey, and to 1.5 % of freshwater aquaculture (Celikkale et al., 1999). Carp (*Cyprinus carpio*) dominated the fish production, with 1,200 tonnes, followed by *Capoeta trutta* (320 tonnes), and *Leuciscus cephalus* (78 tonnes) (Çelebi, 2006). According to Eurofish (2006), the quantity of captured fish products will exceed 45,000 tons by year when this project is completed. But it is estimated that 600,000 tons of fish will be obtained each year by using new techniques and technologies in aquaculture in near future.

Conclusions

The surface area of Ataturk reservoir is 81,700 ha; this is the biggest reservoir of Turkay as well as of the South-eastern Anatolia. The hatchery of this dam is the biggest one in Turkey and produces millions of fingerlings each year. Fish stocks of the reservoirs need better protection and rational management and the local fishermen and farmers should be trained regularly in capture methods and new technologies as well as in aquaculture practices. The existing fishery regulations need to be adapted to the GAP region and a local administration sould be established to facilitate the development of aquaculture and fisheries in the region. Aquaculture technologies, such as cage

culture, should be more widely applied. Finally, the aquaculturists and related activities need to be supported financially.

By the construction of several dams in the GAP region the total capacity of fish production in the region will be increased more than 600,000 tons year. Aquaculture will be an important source of income for the people and the economy of the country, a sum of USD 1.8 billion of income will be obtained each year.

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References

1. Acma B. (2005) Southeastern Anatolia Project (GAP) in Turkey As a Case Study of Water Resources Management. Available at: http://balwois.mpl.ired.fr/balwois/administration/full_paper/ffp-741pdf, 30.03.2006.
2. Aksoy S., Ariturk S., Armstrong M.Y.K., Chang K.P., Dörtbudak Z., Gottlieb M., Ozcel M.A., Richards F.F. and Western K. (1995) The GAP Project in Southeastern Turkey: The Potential for Emergence of Diseases. EID Volume 1, Number 2. pp. 29-36.
3. Celebi R. (2006) The Use Of Irriation Systems For Sustainable Fish Production In Turkey. Available at: http://www.fao.org//docrep/007/y5082e/5082e06.htm, 01.04.2006.
4. Canyurt M.A. (2005) The Development of Aquaculture in Turkey. Research for Rural Development 2005. 11 International Scientific Conference Proceedings, Latvia University of Agriculture, Jelgava, Latvia, 260 pp. 19-22.
5. Celikkale M.S., Duzgunes E. and Okumus O. (1999) Turkiye su urunleri sektoru, potansiyeli, mevcut durumu, sorunlari ve cozum onerileri. (Fisheries sector of Turkey, situation and constraints). Istanbul Ticaret Odasi Yayin No. 2, pp. 199-207. (in Turkish).
6. Dursun H. (1999) Turkiye'nin toprak kaynaklari ve kullanimi. Tarimda su kullanimi ve yonetimi sempozyumu (Land use in Turkey. Symposium on water use in agriculture). Turk Yuksek Ziraat Muhendisleri Birligi ve Vakfi, Ankara. Available at: http://www.fao.org//docrep/007/y5082e/5082e06.htm, 01.04.2006.
7. Eurofish (2006) A member of The Fish Infonetwork, Turkey. Available at: http://www.eurofish.dk/ indexsub.php?id=300, 01.04.2006.
8. GAP (1992) Republic of Turkey Prime Ministry. Agricultural commodities marketing survey and planning of crop pattern for GAP. Ankara, Turkey. GAP Regional Development Administration. Available at: http://www.gap.gov.tr/gap_eng.php?sayfa=English/Ggbilgi/gnedir.html, 01.04.2006
9. GAP (1993a) Republic of Turkey Prime Ministry. GAP action plan. Ankara, Turkey: GAP Regional Development Administration. Available at: http://www.gap.gov.tr/gap_eng.php?sayfa=English/Ggbilgi/gnedir.html, 01.04.2006.
10. GAP (1993b) Republic of Turkey Prime Ministry. GAP status report. Ankara, Turkey: GAP Regional Development Administration. Available at: http://www.gap.gov.tr/gap_eng.php?sayfa=English/Ggbilgi/gnedir.html, 01.04.2006.
11. GAP (2006) Republic of Turkey Prime Ministry. GAP Regional Development Administration, Available at: http://www.gap.gov.tr/gap_eng.php?sayfa=English/Ggbilgi/gnedir.html, 01.04.2006.
12. Ozaslan I. (1998) Natural resources of Turkey. Vol. 1. Istanbul Chamber of Commerce. Publication No. 1998-77. Available at: http://www.fao.org//docrep/007/y5082e/5082e06.htm, 01.04.2006.
13. Safak N. (2000) Bolgesi'ndeki baraj gollerinde DSI Genel Mudurlugunce Yurutulen ve Planlanan Su Urunleri Calismalari (Aquaculture Activities in Dams Directed by DSI). DSI Genel Mudurlugu, Ankara. Available at: http://www.fao.org//docrep/007/y5082e/5082e06.htm, 01.04.2006.
14. Yuksel M., Sevik R. Yapalak S. and Hartavi S.M. (1998) Ataturk baraj golunun su kalitesi ve bu sulara uyum gosteren balik turlerinin tesbiti (Water quality of Ataturk Dam and fish species adapted to this water). GAP 2. Engineering Congress Proceedings, Sanliurfa. pp. 220-232. (in Turkish).

THE ANALYSIS OF MELONS GROWTH IN OPEN FIELDS OF LATVIA

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Abstract

The research was done to observe open-field cultivation potential for growing melons *Cucumis melo* L. without covering in two regions of Latvia: Tukums and Cesis. Three varieties of melons 'Zolotistaya', 'Galiley' and 'Kolhoznica' were used. In all, 15 individuals of each variety were grown at each place - Tukums region and Cesis region.

To evaluate growth and development intensity for each variety in each region, the following parameters were measured: length of the main shoot, number of leaves per plant, time of appearance of the first male and female blossom, and number of perished plants. The most suitable variety for the Cesis region was found variety 'Kolhoznica', but for Tukums region – 'Zolotistaya'. The research suggests that variety 'Galiley' is the least suitable for growing in both regions.

It was established that successful open-field cultivation of melons in Tukums and Cesis regions is possible only in case of favourable weather conditions. In the year of the investigation, 2004, insufficient sum of effective temperatures limited successful development and yielding of melon.

Key words: *Cucumis melo*, open field, Latvia.

Introduction

Melons *Cucumis melo* L. are cultivated plants that originate from South Asia and central part of Africa. From these regions melons have spread around the world - not only in the regions with warm climate, but also in areas of temperate zone (Белик, 1998; Лебедева, 2000). The recommended sum of effective temperatures (temperature =+10 °C) for melon growth is 3000 °C. The sum of effective temperatures in the regions of research according to long-term data is between 2300 … 2700 °C (Taranovs, 1968).

There is a century-old melon growing history in Latvia: melons are grown in this country since 1910. First growing attempts were made in hotbeds with the variety bred by I. Michurin - 'Komunarka' (that melon was called "Latvia outdoor melon"). Many new hybrids have been created by hybridization of variety 'Komunarka' with other open-field melon varieties (Sukatnieks, 1954).

The first notable outdoor melon breeder in Latvia was N. Demuts, who was a gardener of an agriculture school of Leči at the beginning of the past cetury. Demuts, the father and son, in succession of two generations have developed many melon varieties. Those varieties are suitable for the humid seaside climate of Ventspils region. Second successful breeder was A. Pļavnieks, who grew melons in his family garden in Riga at the first part of the past century. He created many melon varieties suitable for sandy soil and specific climate of Riga. Gardeners-breeders like A. Vīksne, P. Bleiers, R. Auziņš and others made new melon varieties too. One of the famous melon growers in Latvia was Pauls Sukatnieks (50-ties, 60-ties of the 20th century). He worked in Dviete, Latgale region, and selected such varieties as 'Dvietes oranza' and 'Dvietes bananu'. He also developed the growing systems for these vegetables (Sukatnieks, 1954).

The aim of this research was to test the possibilities of melon growing in open-field conditions in Cesis and Tukums regions, in Latvia.

Materials and Methods

The melons under research interest were grown in Pūre Horticultural Research Centre in Tukums region and in farm 'Grīvas' in Cesis region. The research was done in 2004. Three varieties of melons (most popular on the market) - 'Zolotistaya', 'Kolhoznica', and 'Galiley' - were used. For every variety, 30 plants were planted, 15 in each region.

'Zolotistaya' is a medium early variety which reaches its technical maturity in 71-84 days. The fruits are roundish, 1.5-2 kg in weight. The skin is smooth, apricot-colored, cream white, with sweet flesh and light aroma. The fruits are perfect for the market as well as for home consumption (Мамонов, 2001).

'Kolhoznica' is a medium early variety, which reaches its technical maturity in 75-77 days. The fruits are balloon-shaped or roundish, 0.7-1.3 kg in weight. The skin is smooth or netted, apricot- or orange-colored, with white, sweet and juicy flesh. The fruits are perfect for the market as well as for home consumption (Мамонов, 2001).

'Galiley' is a medium late hybrid variety which reaches its technical maturity in 80-85 days. The fruits are roundish, 1-1.5 kg in weight. The skin is smooth, with greenish sweet flesh and strong aroma (Мамонов, 2001).

The melons were sown at the 21 May in cassettes of 8 cm diameter, in peat substrate with pH_{CaCl2} -5.5±0.5, total N- 100-140 mg kg^{-1}, P - 48-74 mg kg^{-1}, and K - 158-241 mg kg^{-1}. The seedlings were grown in cassettes in a greenhouse till the end of June, then they were planted in a field. The melons in both places were grown in sandy loam soil. Agrochemical content of soil in the experimental field of

Tukums region was following: organic matter – 20 g kg^{-1}, pH_{KCl} - 6.2, K - 144 mg kg^{-1}, P - 144 mg kg^{-1}, Mg - 183 mg kg^{-1}, and Ca - 846 mg kg^{-1}. In the region of Cesis, the parameters of soil were the following: organic matter - 5 g kg^{-1}, pH_{KCl} - 5.6, K - 62 mg kg^{-1}, P - 90 mg kg^{-1}, Mg - 100 mg kg^{-1}, and Ca - 1088 mg kg^{-1}.

The plants were planted in the field with 1.5 m between the rows and 0.8 m between plants in the row. Plants were grown without covering. Top-dressing was done with Ca $(NO_3)_2$ 80 kg ha^{-1} once per growing season. Weeding was done 3 times per growing season.

The plant length was measured and number of leaves was counted once per two weeks starting from the 3 June. The first male and female flower blossom time was fixed in days from sowing, when petals were fully opened.

Average temperature of the vegetation period of 2004 was lower in comparison with long–term data registered in Latvia. The average temperature in June and July was of 0.2 - 1.7 °C less than temperature in long-term. Only the 1st and 2nd decades of August were warmer in comparison with long-term average data. The melon growth was depressed under such climatic conditions (Figure 1).

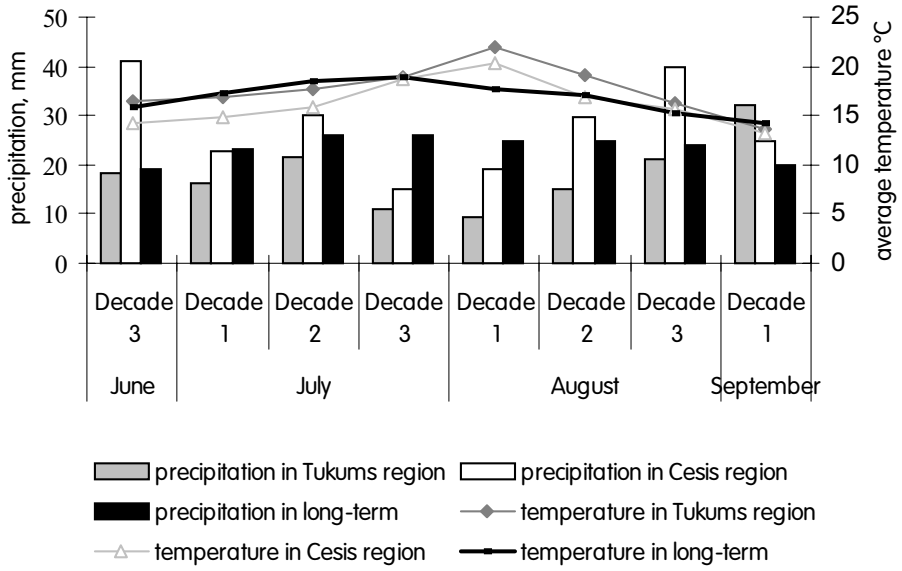

Figure 1. Meteorological data of the regions included in the experiment.

A low temperature and high precipitation were observed in the vegetation period in both experimental fields. The highest temperature was registered in Tukums region. Only in some days in July and August the temperature exceeded +20 °C. High precipitation in both regions was one of the reasons that caused plant extinction.

Differences between vegetative development of varieties was evaluated according to ANOVA. The coefficient of variation was calculated to evaluate the florescence time and to determine the differences between the varieties.

Results and Discussion

The climatic conditions of the year 2004 were unfavorable for melon growth. The sum of effective temperatures was 2100 °C in Cesis region and 2200 °C in Tukums region. Melons require the sum of effective temperatures of 2800 - 3200 °C (Фурса et al., 1985; Борисова et al., 1984). Therefore lack of sufficient temperature had significant influence on the plants development and caused their extinction.

The better vegetative growth parameters were observed in Tukums region. The plants of variety 'Zolotistaya' at the end of vegetation period were longer by 55.7%, 'Galiley' - by 38.3%, and 'Kolhoznica' - by 23.8% in comparison to the plants in Cesis region (Figure 2). The data mathematical analyses showed that there was a significant difference between the length of plants, the region, and the variety. Length of plants is determined by the variety. In Cesis region variety 'Kolhoznica' had significantly longer main shoot ($F=3.4975>F_{crit}=3.0316$, P=95%), but in Tukums region - 'Zolotistaya' ($F=17.8435>F_{crit}=3.0316$, P=95%). In better weather conditions, as it was in Tukums region, differences between varieties were more expressed because plants could realize their growth potential which is determined by the genotype.

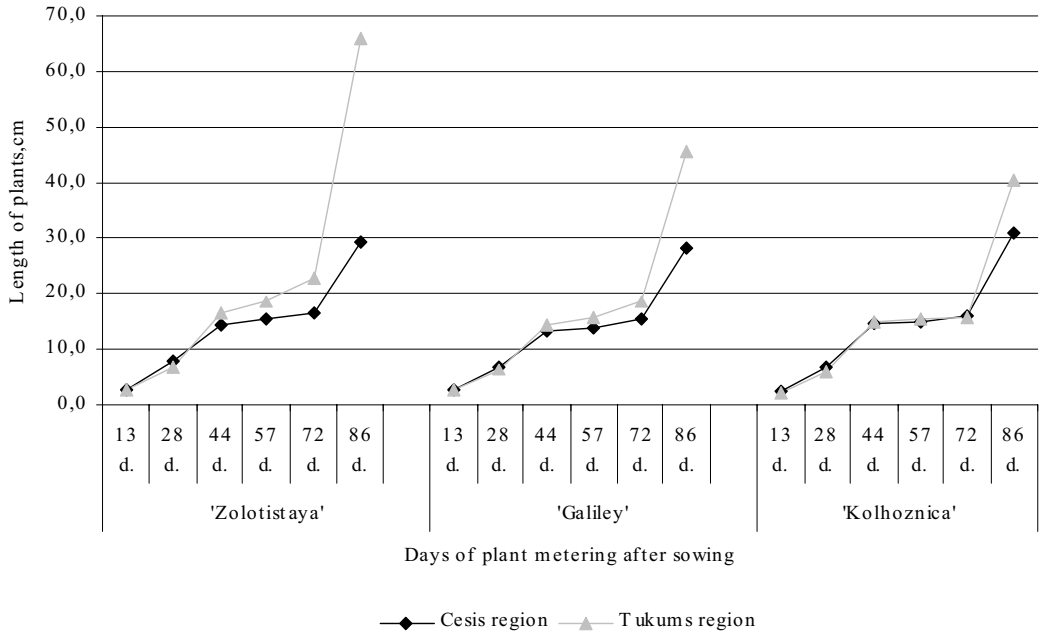

Figure 2. The length of melons during growth time, cm.

The intensive growth of leaves and number of leaves are important indicators for good development of the plants. The plants with more leaves were registered in Cesis region (Figure 3). It was affected by variety and temperature. In Cesis region, the temperature excesses were not so sharply expressed. Variety 'Zolotistaya' had significantly more leaves in Tukums region ($F=62.7997>F_{crit}=3.0265$, P=95%), 'Galiley' had less leaves (on average 48). The data mathematical analyses showed that there was a significant difference between the numbers of leaves of variety 'Galiley' in both places. It means that vegetative development of variety 'Galiley' was negatively affected by sharp temperature fluctuations as it was in Tukums region. In Cesis region 'Kolhoznica' had significantly more leaves ($F=3.5326>F_{crit}=3.0265$).

A part of melons perished due to unfavorable meteorological conditions. A comparatively larger number of perished plants were observed in Tukums region (Figure 4), which probably might be explained by lower minimal temperatures in Tukums region compared to Cesis region.

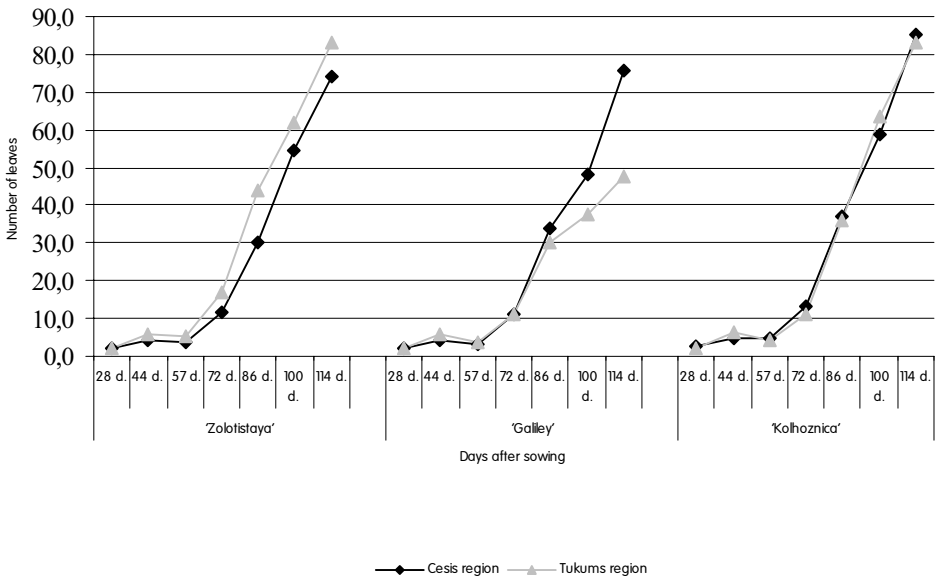

Figure 3. The number of melons leaves during vegetation.

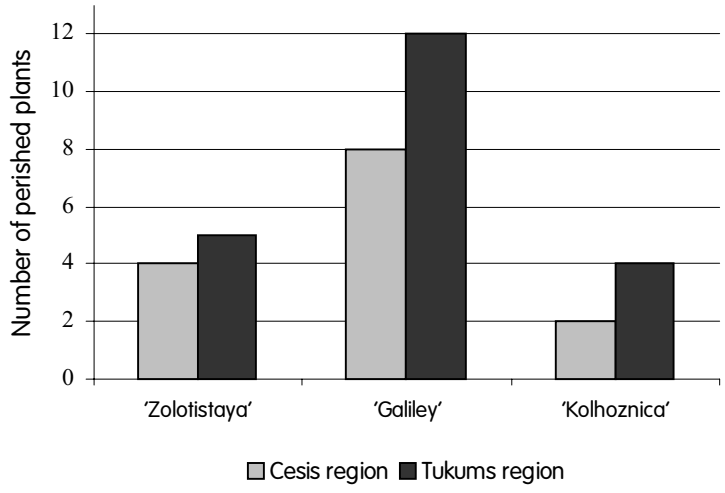

Figure 4. The number of perished plants.

The first opened melon's flowers were observed for variety 'Galiley' in Tukums region at 5 July, but in Cesis region the first blossom was registered for plants of 'Kolhoznica' variety at 4 July (Table 1). Blossom time of male flowers was more various for variety 'Kolhoznica', but that of female flowers - for variety 'Galiley'. Blossom was late in both places because of meteorological conditions. The differences between varieties in blossoming time were significant.

In Latvia, melon growing in open fields is threatened by meteorological conditions. It is possible only in summers with a sufficient sum of effective temperatures. In the trial, unfavorable weather conditions were the limiting factor for obtaining a satisfactory melon yield. At the year of investigation the yield was not obtained because of unfavorable weather conditions.

Conclusions

1. The melons cultivation in open-field conditions in Latvia is problematic. Yielding is significantly influenced by weather conditions in the vegetation period.
2. 'Zolotistaya' in Tukums region and 'Kolhoznica' in Cesis region developed the longest shoots.
3. 'Kolhoznica' in Cesis region and 'Zolotistaya' and 'Kolhoznica' in Tukums region developed the highest number of leaves.
4. The highest percentage of perished plants was registered for variety 'Galiley' in both regions.
5. 'Galiley' in Tukums region and 'Kolhoznica' in Cesis region had the earliest blossom.

Table 1

Blossoming time of melons

Sex	Variety	Blossoming time, days after sowing		Coefficient of variation, %	
		Tukums region	Cesis region	Tukums region	Cesis region
♂	'Zolotistaya'	47.0	49.0	13.0	23.1
	'Galiley'	45.0	49.0	23.1	27.7
	' Kolhoznica'	49.0	44.0	21.3	32.1
♀	'Zolotistaya'	56.0	59.0	13.5	14.6
	'Galiley'	47.0	54.0	51.2	19.4
	'Kolhoznica'	58.0	57.0	15.8	19.1

References

1. Sukatnieks P. (1954) Meloņu un arbūzu audzēšana lauka apstākļos (Melon's and watermelon's growth in open fields) Latvijas Valsts Izdevniecība, Rīga, 56 pp. (in Latvian).
2. Taranovs V. (1968) Dārzeņkopība Latvijā (Vegetable-growing in Latvia) Izdevniecība 'Liesma', Rīga, 236 pp. (in Latvian).

3. Белик В.Ф. (1998) Ваш огород (Your garden) Большая Российская энциклопедия, Москва, 480 с. (in Russian).
4. Лебедева А. (2000) Секреты тыквенных культур (Secrets of squash culture) ЗАО Фитон +, Москва, 224 с. (in Russian).
5. Мамонов Е.В. (2001) Сортовой каталог. Овощные культуры (Sort catalogue. The vegetable crop) Изд-во ЭКСМО – Пресс, Изд-во Лик пресс, Москва, 496 с. (in Russian).
6. Фурса Т.Б., Малинина М.И., Артюгина и др. (1985) Руководство по апробации бахчевых культур (Handbook for aprobation of squash culture) Агропромиздат, Москва, 181 с. (in Russian).
7. Борисова Р.Л., Огінська А.А., Осипова Т.О., Нэмтинов В.І. (1984) Вирощування динь і кавунів у плівкових теплицях в Криму (Melon's and watermelon's growth in greenhouses at Crimea). Овочівництво і баштанництво, 29, pp. 25.-28. (in Byelorussian).

GENETIC EVALUATION OF DAIRY CATTLE USING TEST DAY YIELDS

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Abstract

Genetic evaluation of dairy cattle for milk production based on 305-day lactation yields was compared to the evaluation based on the corresponding test day (TD) yields from the first lactation. The heritability estimates were 0.19, 0.13 and 0.15, respectively for milk yield, fat yield and protein yield, and these parameters are lower than the corresponding ones used for the routine genetic evaluation with the lactation model in Latvia. The results of estimated breeding values (EBV) and relative breeding values (RBV) showed relatively high variance for all traits: higher for fat yield and lower for protein yield. The calculation of reliabilities showed that the use of test day model gives higher reliabilities of the estimated breeding values. The reliabilities are higher (about 2 – 4 %) for all traits using TD model on average for all animals and cows. For bulls group with calculated reliabilities of breeding values of at least 50 % for all traits, the measure of accuracy is higher with TD model from 7 % for protein yield to 17 % for fat yield. The ranking of the best Top 10 sires by TD model is similar to the lactation model. A total of 3 bulls for three traits and 3 bulls for fat and protein yield are included in rankings of Top 10 both by TD and lactation models. TD yields could be used instead of 305-day yields for the genetic evaluation of dairy cattle. It helps to improve the accuracy of genetic evaluation and does not change ranking of the best sires drastically.
Key words: test day (TD), regression model (RM), breeding value (BV).

Introduction

Test day models have been suggested for the genetic evaluation of dairy cows and bulls. TD models have been proposed to model TD yields directly, accounting for factors that could affect TD yields.

Test day models have recently gained considerable interest because they are more flexible in handling records from different recording schemes. Compared with only using records of complete lactations they can reduce the generation interval through frequent genetic evaluation with the latest data. TD models can predict total production more accurately by accounting for time–dependent environmental effects (Swalve, 2000).

One reason for this interest is a trend in all major dairy cattle performance. Second, in dairy cattle breeding plans the trend is toward the use of early predictors of genetic merit for selection of decisions to decrease the generation interval. Decreasing the generation interval has been identified as a main tool to increase genetic progress in dairy cattle breeding schemes (Nicholas et al., 1983).

The main advantages of using TD models for genetic evaluation are (Pool et al., 1999): 1) individual test date effects can be included in the model, which affects the test day yield substantially (Reents et al., 1996); 2) the number of records per cow and the interval between records can be accounted for; 3) the number of cows with records at the same test date exceeds the number of cows that enter a herd–year–season class in a full lactation model, which increases the accuracy of the adjustment for fixed effects, especially in small herds; 4) TD models can account for individual differences in the shape of lactation curves of cows, which includes the persistency of the lactation (Schaeffer et al., 1994).

Ptak and Schaeffer (1993) suggested a repeatability TD model, which assumes that covariances between successive test days are equal to those between test days that are far apart.

Fixed regression model developed in the early stages of modelling test day data (Ptak et al., 1993) was a simplified version of the random regression model.

It is assumed in the FR model that there are constant animal and permanent environmental effects throughout the course of the lactation. The heterogeneous variances at different lactation stages are not taken into account and correlations between any two tests are assumed to be equal. Although cows belonging to different sub-groups, e.g. age–parity–season classes, are allowed to have different average lactation curves; deviations from the average curves are not modelled by the FR model (Liu et al., 1998).

The main objective of this study was to use a repeatability test day model to estimate genetic parameters and breeding values of monthly test day milk production traits in the first parity Latvian brown cows.

Materials and Methods

The data for studies were obtained from the state agency 'Agricultural Data centre' which organizes milk recording in Latvia and is responsible for the genetic evaluation of dairy cattle.

A total of 175 973 first lactation test day records were used from 21 487 Latvian Brown (LB) breed cows (on average 8 test day records per cow). Cows test day data of 2000 – 2004 were used in the study. LB is the main cattle breed in Latvia (totally 68 % of all cows under milk recording) with average milk yield of 4866 kg, fat content – 4.46 % and protein content – 3.36 % in 305 days for the 2004/2005 recording year. There were included daughters of 599 sires

Table 1

Phenotypic means and standard deviations for productivity of test days

Test day	Milk yield, kg		Fat, %		Protein, %	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
1	16.6	5.40	4.55	0.973	3.21	0.371
2	17.1	4.99	4.43	0.894	3.17	0.381
3	16.9	5.11	4.35	0.874	3.15	0.336
4	15.7	4.51	4.35	0.815	3.20	0.322
5	15.4	4.28	4.40	0.826	3.25	0.315
6	14.8	4.41	4.43	0.807	3.28	0.332
7	13.9	4.52	4.50	0.853	3.32	0.390
8	13.7	4.46	4.53	0.854	3.32	0.411
9	13.7	4.45	4.55	0.874	3.32	0.409
10	13.6	4.51	4.60	0.861	3.36	0.438
11	13.7	4.34	4.57	0.853	3.34	0.433

(on average 36 daughters per sire) and cows of 1811 herds (on average 11.9 cows per herd) in the studies. The main breeds of sires were Latvian Brown (LB), Danish Red (DS), Angler (AN), Swedish Red and White (ZS) and Holstein Red and White (HS).

The average milk yield of the 1st lactation cows in test day was 14.5 kg with standard deviation 5.11 kg, fat yield – 0.66 kg with standard deviation 0.249 kg, protein yield – 0.481 kg with standard deviation 0.163 kg and fat and protein content – respectively 4.57 % and 3.36 %. The average productivity results in different TD are demonstrated in Table 1. The highest milk yield is obtained on the second TD (17.1 kg), fat content (4.60 %) and protein content (3.36 %) on the 10th TD. The lowest values are obtained on the 3rd TD for fat and protein content (respectively, 4.35 % and 3.15 %) and for milk yield – on the 10th TD (13.6 kg). Test day yields showed higher standard deviations for milk yield and fat content on the first test day, but for protein content – at the end of lactation.

The following test day model was used for variance component and breeding value estimation:

$$y_{ijkl} = \mu + HT_i + a_j + pe_j + KASRZJ_k + b_{k1}(D/c) + b_{k2}(D/c)^2 + b_{k3}\ln(c/D) + b_{k4}[\ln(c/D)]^2 + e_{ijkl}, \quad (1)$$

where

y_{ijkl} – n^{th} test day observation (milk yield, fat yield, protein yield) for cow (j);

μ – mean;

HT_i – fixed effect of Herd–Test day (i);

a_j – random additive genetic effect (breeding value) of an animal (j);

pe_j – random permanent environment effect to account for repeated measures within a cow (j);

$KASRZJ_k$ – fixed (calving age*calving season* calving interval class*calving year class) effect;

b_{k1} and b_{k2} – regression coefficients on the linear and quadratic effect of the ratio D/c, in which D is the day in lactation and c is a constant, in this case c = 380;

b_{k3} and b_{k4} – regression coefficients on the linear and quadratic effect of ln(c/D);

e_{ijkl} – random residual effect (random error).

The following factors were used in the model and divided into classes: calving years from 1995 till 2004 were divided into 5 classes, calving age from 19 months till 40 months were divided into 5 classes, and calving interval from 240 days till 999 days were divided into 5 classes. Calving seasons were divided into 2 classes: 1) from March till August and 2) from September till February. Minimum days in milk of test day were 5 days and a maximum number of test days were 11 per cow in the studies.

The results were compared with breeding values calculated with lactation model used by 'Agricultural Data Centre' in a routine genetic evaluation to analyze correlations between estimated breeding values and the improvement of reliabilities using different models. The following statistical lactation model is used for the present genetic evaluation in Latvia:

$$y_{ijkl} = HYS_i + ca_j + ci_k + a_{ijkl} + e_{ijkl}, \quad (2)$$

where

y_{ijkl} – yield of a cow;

HYS_i – fixed herd–year–season effect;

ca_j – fixed calving age class effect;

ci_k – fixed calving interval class effect;

a_{ijkl} – a random additive genetic effect of an animal;

e_{ijkl} – a random residual effect.

The data were processed using SAS 8.2. software (SAS, 1998). PEST (Groeneveld, 1990) and VCE 4.2.5. (Groeneveld, 1998) software were used to obtain genetic parameters and the results of genetic evaluation.

Results and Discussion

The heritability estimates of productivity traits ($h^2 \pm s_{\bar{x}}$) were 0.19 ± 0.010, 0.13 ± 0.007, and 0.15 ± 0.008, respectively for milk yield, fat yield, and protein yield. The parameters are lower than the corresponding ones used for the routine genetic evaluation with the lactation model in Latvia. The heritability estimates are generally lower in this study than those obtained by other studies (Strabel et al., 1997; Rekaya et al., 1999) and used in Germany by VIT organization (Vereinigte Informatiomssysteme Tierhaltung w. V.) until May, 2003 for the routine genetic evaluation with fixed regression TD model. German heritability estimates for the 1st lactation TD productivity traits were 0.30, 0.25, and 0.25, respectively for milk yield, fat yield, and protein yield. Also a fixed regression TD model is used in the present routine genetic evaluation of dairy cattle in Estonia where heritabilities for the 1st lactation TD yields are 0.19 for milk yield, 0.13 for fat yield, and 0.15 for protein yield as shown in this study. Lower heritability estimates of test day milk production traits could be attributed to several factors such as structure of the data and the model used for the analysis of the data. The differences between the estimates obtained by others and the present ones could be partly explained by greater environmental changes in milk production which are mainly caused by different systems of feeding, keeping, housing and any other factors of the environmental origin influencing performance of dairy cows in Latvia.

The correlations between estimated breeding values from the first lactation test day models with those from a lactation model are given in Table 2. Correlations between breeding values range from 0.56 to 0.89. Higher correlations are for milk yield (from 0.73 to 0.89), but lower – for protein content and yield (from 0.56 to 0.73). Between the groups, higher correlations are shown for bulls group with reliability for estimated breeding values of at least 50 %: from 0.70 for fat content to 0.89 for milk yield. It is found out in other studies that these correlations are very high (Kaya et al., 2003; Ptak et al., 1993; Swalve, 1995).

The variances of estimated breeding values and relative breeding values of bulls and cows are given in Table 3. The results show that estimated breeding values using test day records showed good variance and there is a relatively high variation between animals. The comparison of relative breeding values in cows group shows that the highest variance is for fat yield (45.1 points), similar for milk yield

Table 2

Correlations between estimated breeding values from test day model and from lactation model

Group	n	Traits				
		milk yield	fat, %	fat yield	protein, %	protein yield
Cows	27531	0.75	0.75	0.71	0.62	0.71
Bulls 1	601	0.73	0.74	0.70	0.56	0.67
Bulls 2*	120	0.89	0.88	0.81	0.70	0.73
Total	28189	0.75	0.75	0.71	0.62	0.70

**A group of bulls with reliability at least 50 %*

Table 3

Variance of estimated breeding values (EBV) and relative breeding values (RBV) of cows and bulls

Trait	Breeding values	Cows				Bulls			
		$\bar{x}$	s	min	max	$\bar{x}$	s	min	max
Milk yield	EBV	8.6	166.61	- 806.2	1033.0	- 6.2	229.23	- 829.7	856.3
	RBV	100	3.9	80.9	124.4	100	5.4	80.4	120.3
Fat yield	EBV	0.54	7.504	- 39.19	46.21	- 0.24	10.673	- 35.29	66.29
	RBV	100	4.0	79.3	124.4	100	5.6	81.4	134.9
Protein yield	EBV	0.20	4.137	- 23.55	29.99	- 0.18	5.756	- 21.38	27.81
	RBV	100	3.0	83.0	121.7	100	4.2	84.6	120.1

Table 4

Calculated reliabilities using lactation (LM) and test day model (TDM)

Group	Model	n	Reliabilities, %		
			milk yield	fat yield	protein yield
Cows	LM	27531	23	20	21
	TDM		25	24	21
Bulls 1	LM	601	35	31	31
	TDM		42	40	34
Bulls 2*	LM	120	67	61	62
	TDM		79	78	69
Total	LM	28189	23	20	21
	TDM		25	24	21

**A group of bulls with reliability of at least 50 %*

(43.5 points), but lower for protein yield (38.7 points). Based on the results shown in bulls group, estimated breeding values (EBV) and relative breeding values (RBV) of bulls have good variance of data from the lowest value of 35.5 points for protein yield to the highest value of 53.5 points for fat yield.

It was found out that generally higher standard deviations are shown for bulls group because of the smaller number of animals. Between relative breeding values of traits, fat yield shows higher variance from 45.1 points to 53.5 points, but lower for protein yields from 35.5 points to 38.7 points. Between estimated breeding values, higher variance is shown for milk yield (1839.2 kg) and protein yield (53.54 kg) in the cows group, but for fat yield (101.58 kg) in the group of bulls.

The calculation of reliability is a measure of accuracy which is desirable for any evaluation system. It provides a measure of the degree of risk associated with the evaluation. Calculated reliabilities in this study using test day model and lactation model are shown in Table 4. Average reliabilities for all animals are in range from 20 % for fat yield using lactation model to 25 % for milk yield using test day model. The reliabilities are higher, about 2–4 %, using test day model. The reliabilities are different in the 3 groups. The same reliabilities are calculated for cows compared to all animals. Higher values are shown for bulls: on average from 31 % for fat and protein yield using lactation model to 42 % for milk yield using test day model. Other studies showed that using TD model it is possible to increase accuracy for bulls from 2 % to 3 % and for cows from 6 % to 8 % (Jamrozik et al., 1997).

Separately reliabilities were calculated for the group of bulls with reliability of at least 50 % for all traits. These are the highest reliabilities for all traits using both models: from 61 % for fat yield and 62 % for protein yield using lactation model to 78 % for fat yield and 79 % for milk yield using test day model. Totally for these bulls reliabilities were higher, about 7 % to 17 % respectively, for protein yield and fat yield.

Table 5 shows the ranking of the best Top 10 sires by estimating breeding values of productivity traits using TD

Table 5

Ranking of best bulls with reliabilities of at least 50 %

Top by TDM	Milk yield			Fat yield			Protein yield		
	herd book number	breed	ranking by LM	herd book number	breed	ranking by LM	herd book number	breed	ranking by LM
1	31454	DS	4	31488	DS	***	31352	HS	***
2	31476	HS	***	31393*	ZS	2	31393*	ZS	1
3	31470	DS	***	31485	HS	***	31396**	DS	50
4	31332	ZS	5	31489	DS	***	31413*	ZS	5
5	31442	LB	2	31277*	DS	1	31108	ZS	***
6	31413*	ZS	6	31109**	ZS	5	31277*	DS	2
7	31349	AN	1	31396**	DS	7	31405**	AN	20
8	31412	ZS	9	30183	LB	***	31289	HS	29
9	31393*	ZS	7	31405**	AN	3	31367	DS	39
10	31277*	DS	3	31413*	ZS	6	31109**	ZS	7

(*) – top bull for 3 traits; (**) – top bull for fat yield and protein yield; (***) – reliability below 50 %
LB: Latvian Brown, DS: Danish Red, AN: Angler, ZS: Swedish Red and White, HS: Holstein Red and White

model and the comparison of the results of the estimated breeding values calculated by LM. The results showed that 8 bulls for milk yield, 6 bulls for fat yield, and 4 bulls for protein yield are included in the Top list of the best 10 bulls using both models. The same ranking has one ZS bull for milk yield and two (ZS and DS) bulls for fat yield using both models. Totally 3 bulls from ZS and DS breeds are included in the top list for three traits using both models and 3 bulls for fat and protein yield using lactation model.

Using lactation model, some bulls are not included in the list to compare with results of the TD model because of the low reliabilities of the estimated breeding values: below 50 %. These are two bulls for milk and protein yield and four bulls for fat yield. These bulls mainly have later date of assignment of herd book number.

The analysis of the estimated breeding values of bulls by birth year shows that on average there is a genetic progress for younger bulls using both models.

Conclusions

The introduction of test day model in the national genetic evaluation system is a relevant step in many countries. It is very important to get early evaluation of young bulls in Latvia because in some cases it takes so much time with lactation model to get the results of the evaluation for bulls.

Heritabilities were 0.19 for milk yield, 0.13 for fat yield, and 0.15 for protein yield.

The correlations between breeding values using test day and lactation model range from 0.56 % to 0.89 %. High correlations are shown for the bull group with calculated reliabilities of the breeding values of at least 50 % for all three traits: from 0.70 % and 0.73 % for protein content and yield to 0.88 % and 0.89 % for fat content and milk yield.

The results of the breeding values showed satisfactory variances. Higher variances between EBVs are shown for milk yield (1839.2 kg) and protein yield (53.54 kg) in the cow group, but for fat yield (101.58 kg) – in the group of bulls. Standard deviations of relative breeding values were consistently higher for fat yield for both bulls and cows.

For all groups, higher reliabilities are calculated using a test day model: from 2 % to 4 % on average for all animals and separately for cows, and from 3 % to 9 % for bulls. Also reliabilities are analysed for a group of bulls with reliabilities for breeding values of at least 50 % for all three traits. These values are higher, from 7 % to 17 % respectively, for protein yield and fat yield.

The ranking of best 10 Top sires showed similar results with both models: better for milk yield (8 sires in both tops), but more different for protein yield (4 sires in both tops). The results showed that 1 bull for milk yield and 2 bulls for fat yield have the same ranking using lactation and TD models.

The results of studies showed that the use of the TD model for the genetic evaluation gives better results of reliabilities of breeding values and it is possible to get early evaluation of bulls.

References

1. Ali T.E., Schaeffer L.R. (1987) Accounting for covariances among test day milk yields in dairy cows. Can. J. Anim. Sci., 67, pp. 637 – 644.
2. Groeneveld E. (1990) PEST User's Manual, Germany, 80 pp.
3. Groeneveld E. (1998) VCE4 User's Guide and Reference Manual Version 1.3, Mariensee, Germany, 58 pp.
4. Jamrozik J., Schaeffer L.R., Liu Z., Jansen G. (1997) Multiple Trait Random Regression Test Day Model for Production Traits. Proceedings of the 1997 Interbull Meeting: Interbull bulletin 16, pp. 43 – 47.
5. Kaya I., Akbas Y., Uzmay C. (2003) Estimation of Breeding Values for Dairy Cattle Using Test – Day Milk Yields. Turk. J. Vet. Anim. Sci., 27, pp. 459 – 464.
6. Liu Z., Jamrozik J., Jansen G.A. (1998) Comparison of Fixed and Random Regression Models Applied to Dairy Test Day Production Data. Proceedings of 1998 Interbull Meeting: Interbull bulletin 17, pp. 60 – 63.
7. Nicholas F.W., Smith C. (1983) Increased rate of genetic change in dairy cattle by embryo – transfer and splitting. Anim. Prod., 36, pp. 341 – 353.
8. Pool M.H., Meuwissen T.H.E. (1999) Prediction of Daily Milk Yields from a Limited Number of Test Days Using Test Day Models. J. Dairy Sci., 82, pp. 1555 – 1564.
9. Ptak E., Schaeffer L.R. (1993) Use of test day yields for genetic evaluation of dairy sires and cows. Livest. Prod. Sci., 34, pp. 23 – 34.
10. Reents R., Doop L. (1996) Genetic evaluation for dairy production traits with a test day model for multiple lactations. Proceedings of the 1996 Interbull Meeting: Interbull bulletin 14, pp. 113 – 117.
11. Rekaya R., Carabano M.J., Toro M.A. (1999) Use of test day yields for the genetic evaluation of production traits in Holstein-Friesian cattle. Livestock Production Science, 57, pp. 203 – 217.
12. SAS 1998. SAS User's guide SAS Institute Inc., Gary, North Carolina.
13. Schaeffer L.R., Dekkers J.C.M. (1994) Random regression in animal models for test – day production in dairy cattle. Proc. 5th World Congress on Genetics Applied to Livestock Production, Guelph, Canada, 18, pp. 443 – 446.
14. Strabel T., Szwaczkowski T. (1997) Additive genetic and permanent environmental variance components for test day milk traits in black – white cattle. Livestock Production Science, 48, pp. 91 – 98.
15. Swalve H.H. (1995) The effect of test day models on the estimation of genetic parameters and breeding values for dairy yield traits. J. Dairy Sci., 78, pp. 929 - 938.
16. Swalve H.H. (2000) Theoretical Basis and Computational Methods for Different Test – Day Genetic Evaluation Methods. J. Dairy Sci., 83, pp. 1115 – 1124.

HERBS ADDITIVE PROJECTION ON PIGS GROWTH INTENSITY AND DIGESTIVE TRACT MICROFLORA

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Abstract

A study was conducted to determine efficiency of an a phytoadditive on pigs growth processes and digestive tract microflora. The pigs of control group were fed without the phytoadditive. The feed of the trial group piglets contained 0.5 % of the phytoadditive per tonne feed, for starter pigs and finished pigs – 0.2 % per tonne feed. The study indicated that at the age of 170 days, pig mass in the trial group was 111.67±1.22 kg on average, but in the control group – 101.79±0.81 kg, which showed that pigs from the trial group had by 9.7 % higher average mass than in the control group ($p < 0.05$). Average daily gain for the trial group was 0.777±0.009 kg, which was by 12 % more than for the control group pigs ($p<0.05$). Feed conversion in the trial group was 2.928 kg, but in the control group – 3.129 kg, which was by 6.4 % higher than in the trial group. Gastric microflora analyses showed that use of phytoadditive reduced Mould colony forming units (CFU) amount by 80% in the trial group, *Staphylococcus* species CFU amount in the trial group decreased by 24 times. Duodenum microflora analyses showed that use of fito additive reduced Mould CFU amount by 25 %, Yeast CFU amount by 34 %, *Escherichia coli* mesophilic and termophilic forms CFU by 16.3 % compared to the control. Lactic acid bacteria CFU in the trial group was 2.5 times higher compared to the control. Rectum microflora analyses showed that use of phytoadditive reduced Mould CFU amount by 31.6 %, Yeast CFU amount – by 62 %, *Escherichia coli* mesophilic and termophilic forms by 57 % and 15.6 % respectively. Lactic acid bacteria CFU amount in 1 g of sample in the trial group increased by 5.1 times.

Key words: pigs, phytoadditive, digestive tract microflora.

Introduction

The use of herbs as additives in livestock nutrition as an alternative to antibiotics is becoming a new goal in animal production. Natural herbs are being explored as alternatives to antimicrobials (Couladis, 2005). In addition to the specific properties of each essential oil (antispasmodic, analgesic, tissue healing, cicatrizing, tonic, relaxing, digestive, hormonal, etc.), they may stimulate the immune defence system (Alexander, 2001).

The mode of action of essential oils is similar to that of antibiotics, but they also act by different mechanisms. In fact, essential oils influence the ecological environment (Langenheim, 1994), preventing survival of microorganisms and reinforcing the patient's terrain. Furthermore, they regulate imbalance in the intestinal flora. Some essential oils may also be useful to treat methicillin-resistant *Staphylococcus aureus*. (Panizzi, 1993).

Essential oils are known for their antibacterial activity (Boatto et al., 1994), but they also possess antiviral and antifungal properties, that antibiotics do not have (Arnal-Schnebelena et al., 2004).

Research demonstrates that specific combinations of organic acids plus essential oils of plants can be effective in improving animals performance: weight gain, feed consumption, and feed conversion rates by 10 %, 8 % and 2 % respectively (Peris et al., 2002).

The aim of the research was to detect phytoadditive projection on pigs growth intensity and digestive tract microflora.

Materials and Methods

The studies were carried in the pig breeding farm 'Pakalni' of Kraslava region, at the Biochemistry laboratory of the Research Institute of Biotechnology and Veterinary Medicine 'Sigra'. With the aim to carry out the studies, two groups of pigs were formed. The feed of the control group did not contain the phytoadditive. The feed of the trial group contained 0.5 % of phytoadditive per tonne feed for pigs after weaning,and 0.2 % per tonne feed for grower and finished pigs. The phytoadditive contains *Urtica Dioica* L. leaves, Q*uercus Robur* cortex grinded, *Melissa officinalis* L. leaves*, Thymus vulgaris* L. leaves. The investigation was made with 30 pigs from 42 days of age till slaughtering at the age of 170 days. Pig mass was detected on the 42nd day, 78th day, and 114th day after birth, and before slaughtering on the 170th day. During the feeding experiment, the consumed feed and feed conversion were analysed. Gastric, small intestine and rectum substances were taken for microbial tests after slaughtering. Microbial tests were made by standard methods.

The data were statistically evaluated using F - test (MS Excel).

Results and Discussion

At the beginning of the investigations, when the piglets start mass was compared, in both groups indices of mass did not show an essential difference ($p>0.05$). At the age of 170 days, pigs mass in the trial group was on average 111.67±1.22 kg, but in the control group – 101.79±0.81 kg, which demonstrated that pigs from the trial group had by 9.7 % higher mass (Fig. 1). An essential difference between both groups was found ($p<0.05$).

The daily gain indices (Table1) for pigs from the trial group at 42 to 78 days was 0.657±0.024 kg, which was by

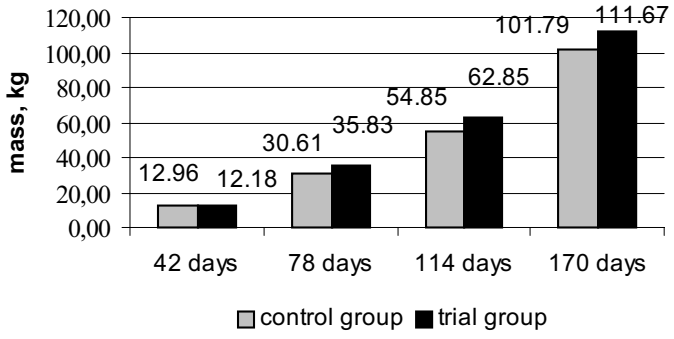

Figure 1. The dynamics of pigs mass.

34 % higher than for pigs in the control group. Daily gain indices from the trial group at 78 to 114 days was 0.751±0.022 kg, which was by 11.5 % higher than for pigs in the control group. Daily gain indices from the trial group at 114 to 170 days was 0.904±0.017 kg, which was by 3 % higher than for pigs in the control group. Daily gain indices from the trial group at 42 to 170 days was 0.777±0.009 kg, which was by 12 % higher than for pigs in the control group. An essential difference between both groups was found at 42 to 78 days, 78 to 114 days, and at 42 to 170 days ($p<0.05$).

Pigs from the trial group consumed 291.4 kg of feed, and from the control group – 276.5 kg. The bests results of feed conversion were found in the trial group: 2.928 kg of feed ration were necessary to obtain 1 kg of body mass, but in the control group 3.129 kg were necessary, which was by 6.4 % more (Table 2).

The results of Gastric microflora analyses (Table 3) showed that use of phytoadditive reduced Mould colony forming units – CFU amount in 1 g of sample. In the control group, CFU amount was 5000 in 1 g of sample, but in the trial group 80 % less. A significant decrease was observed to *Staphylococcus* species, in the trial group – 5000 CFU in 1 g of sample, but in the control group – 120000 CFU, i.e., 24 times higher than in the trial group. Lactic acid bacteria CFU amount in 1 g of sample in the trial group was by 1 % higher compared to the control.

Table 1

The phytoadditive projection on pigs' mass dynamics

Traits	Control group	Trial group
	n=15	n=15
	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$
Daily gain, 42 to 78 days, kg	0.490±0.018	0.657±0.024
Daily gain, % to control	100	134.0
Daily gain, 78 to 114 days, kg	0.673±0.023	0.751±0.022
Daily gain, % to control	100	111.5
Daily gain, 114 to 170 days, kg	0.869±0.021	0.904±0.017
Daily gain, % to control	100	103.9
Daily gain, 42 to 170 days, kg	0.694±0.009	0.777±0.009
Daily gain, % to control	100	112.0

Table 2

The phytoadditive projection on pigs' productivity

Traits	Control group	Trial group
	n=15	n=15
Feed consumption, kg	276.5	291.4
Feed conversion, kg	3.129	2.928
Feed conversion, % to control	100	93.58

Table 3

The results of pigs' Gastric microflora analyses

Traits	Control group	Trial group
Total mesophylic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	762500	257500
Total thermophylic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	4027500	10637500
Lactic acid bacteria CFU amount in 1 g of sample	59900	60500
Mould CFU amount in 1 g of sample	5000	1000
Yeast CFU amount in 1 g of sample	750	-
Escherichia coli mesophylic forms CFU amount in 1 g of sample	30000	-
Escherichia coli termophylic forms CFU amount in 1 g of sample	10000	-
Coliforms mesophylic forms CFU amount in 1 g of sample	10000	-
Staphylococcus sp. CFU amount in 1 g of sample	120000	5000

The results of Duodenum microflora analyses (Table 4) showed that use of the phytoadditive reduced Mould colony forming units – CFU amount – in 1 g of sample. In the control group, CFU amount was 5000 in 1 g of sample,but in the trial group – 25 % less. Yeast CFU amount in 1 g of sample in the control group was 4500 CFU, but in the trial group – 34 % less. *Staphylococcus* species in the control group was 17500 CFU, but in the trial group – 10000 CFU which was by 43 % less. *Escherichia coli* mesophylic and termphylic forms in the trial group, were by 16.3 % and 6.2 % less respectively. Lactic acid bacteria CFU amount in 1 g of sample in the trial group increased by 2.5 times compared to the control.

The results of Rectum microflora analyses (Table 5) showed that use of the phytoadditive reduced Mould CFU amount in 1 g of sample, in the control group CFU amount was 4750 in 1 g of sample, but in the trial group – 31.6 % less. Yeast CFU amount in 1 g of sample was 660 CFU in the

Table 4

The results of pigs' Duodenum microflora analyses

Traits	Control group	Trial group
Total mesophylic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	505000	865000
Total thermophylic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	15410000	997500
Lactic acid bacteria CFU amount in 1 g of sample	138500	346750
Mould CFU amount in 1 g of sample	5000	3750
Yeast CFU amount in 1 g of sample	4500	3000
Escherichia coli mesophylic forms CFU amount in 1 g of sample	740000	620000
Escherichia coli termophylic forms CFU amount in 1 g of sample	805000	755000
Coliforms mesophylic CFU amount in 1 g of sample	215000	5000
Coliforms termophylic CFU amount in 1 g of sample	155000	55000
Staphylococcus sp. CFU amount in 1 g of sample	17500	10000

Table 5

The results of pigs' Rectum microflora analyses

Traits	Control group	Trial group
Total mesophylic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	2712500	1237500
Total thermophylic aerobic and facultative anaerobic microorganisms CFU amount in 1 g of sample	910000	2227500
Lactic acid bacteria CFU amount in 1 g of sample	56000	287500
Mould CFU amount in 1 g of sample	4750	3250
Yeast CFU amount in 1 g of sample	660	250
Escherichia coli mesophylic forms CFU amount in 1 g of sample	870000	375000
Escherichia coli termophylic forms CFU amount in 1 g of sample	432500	365000
Coliforms mesophylic forms CFU amount in 1 g of sample	110000	-
Coliforms termophylic forms CFU amount in 1 g of sample	30000	230000
Staphylococcus sp. CFU amount in 1 g of sample	20000	-

control group, and in the trial group – 62 % less. *Staphylococcus* species in the control group was 20000 CFU, but in the trial group no *Staphylococcus* species was found.

Escherichia coli mesophylic and termphylic forms in the trial group, were by 57 % and 15.6 % less respectively. Lactic acid bacteria CFU amount in 1 g of sample in the trial group increased by 5.1 times compared to the control.

Conclusions

1. The phytoadditive improved pigs' growth intensity: pigs daily gain in the trial group was by 12 % higher than in the control group.
2. The best results of feed conversion were in the trial group – 2.93 kg, which was by 6.4 % less than in the control group.
3. Gastric microflora analyses showed that use of acidifiers additive reduced Mould CFU amount by 80 % in the trial group. *Staphylococcus* species amount in the trial group decreased by 24 times. Lactic acid bacteria CFU amount in 1 g of the trial group sample was by 1 % higher compared to the control group.
4. Duodenum microflora analyses showed that use of phytoadditive in the trial group reduced Mould CFU amount by 25 %, Yeast CFU amount – by 34 %, *Escherichia coli* mesophylic and termophylic forms CFU – by 16.3 % and 6.2 % respectively, and *Staphylococcus* species amount by – 43 % compared to the control. Lactic acid bacteria CFU amount in 1 g of sample was 2.5 times higher in the trial group compared to the control group.
5. Rectum microflora analyses showed that use of phytoadditive reduced Mould CFU amount by 31.6 %, Yeast CFU amount – by 62 %, *Escherichia coli* mesophylic and termophylic forms – by 57 % and 15.6 % respectively. Lactic acid bacteria CFU amount in 1 g of sample in the trial group increased by 5.1 times compared to the control.

References

1. Alexander M. (2001) Aromatherapy and immunity: how the use of essential oils aid immune potential, International Aromatherapy, 11, pp. 152–156.
2. Arnal-Schnebelena F.B., Hadji-Minagloub J.F., Peroteauc F., Ribeyred and de Billerbecke V.G. (2004) Essential oils in infectious gynaecological disease: a statistical study of 658 cases. International Aromatherapy Volume 14, Issue 4, pp. 192-197.
3. Boatto G., Pintore G., Palomba M., De Simone F., Ramundo E. (1994) Iodice, Composition and antibacterial activity of I. helenium and R. officinalis essential oils. Fitoterapia 65, pp. 279–280.
4. Couladis M., Tzakou O., Kujundzic S., Sokovic M., and. Mimica-Dukic N. (2004), Chemical analysis and antifungal activity of Thymus striatus, Phytotherapy Research 18, pp. 40–42.
5. Langenheim I.H, (1994) Higher plant terpenoids: A phytocentric overview of their ecological roles, Chemical Ecology 20, pp. 1223–1280.
6. Panizzi L., Flamini G., Cioni P.L. and Morelli I., (1993) Composition and antimicrobial properties of essential oils of flavour mediterranean Lamiaceae. Ethnopharmacol 39 (1993), pp. 167–170.
7. Peris S., Asensio J.J. (2002) Organic acids plus botanicals. Feed International, March, pp. 17-19.

AGRICULTURAL ENGINEERING SCIENCES

ACQUISITION OF SOME METEOROLOGICAL PARAMETERS FOR THE DEVELOPMENT OF SOLAR COLLECTORS

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Abstract

In order to get maximum economic effect, when setting a solar collector in a peasant yard, it is important to choose the correct place. The yield of obtained heat energy will be at its maximum, if the temperature of surrounding air and solar radiation are higher but the relative humidity of the air – lower. To define these parameters, a special device 'Meteorological Device' (MD-4) was developed. The device was supplied with a mechanism which tracks the sun all day round. So the direct solar radiation on the surface perpendicular to the sun beams was measured. The second measuring of the solar radiation was made in relation to the surface, which was perpendicular to the sun beams only at the middle of a day time. For the measuring of the air temperature and relative humidity, corresponding sensors were used. In every 15 minutes the data of these four meteorological parameters were automatically measured and the results were saved into a logger – the device for data accumulation. After a certain period of time the information was brought into the memory of a computer and analysed.

Key words: solar collector, air temperature, relative humidity, solar radiation.

Introduction

For the transformation of solar radiation into heat energy, the so called flat - plate solar collectors are widely used. They are simpler by construction and therefore cheaper in comparison with other kinds of solar collectors. In Latvia, more than three hundred m^2 of such collectors are installed. A flat - plate solar collector consists of a wooden, plastic, or metal collector box (3), into which a layer of heat insulation (4) and a metal (steel, copper) sheet with a heat exchanger (bended metal tube) (2) are placed. From the front side, the box is covered with a pane of glass (1) but from rare side the box is covered with a sheet of veneer (5) (Fig.1).

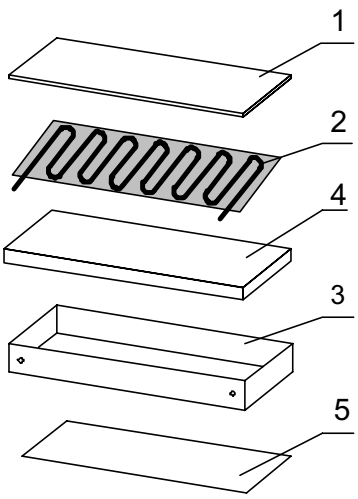

Figure 1. A flat - plate solar collector: 1 – pane of glass; 2 – absorber with heat exchanger; 3 – collector box; 4 – heat insulation; 5 – rare cover (a sheet of veneer).

A flat - plate solar collectors usually are placed on the sloping roof of a house. The maximum of solar energy can be obtained, when the solar collector is oriented in the South direction and direct solar rays are striking the collector plane perpendicularly. For this the optimal tilt angle δ between horizontal line and collector's plane has to be calculated by formula (Шукстерис et al., 1989);

$$\delta = \varphi - 15°, \quad (1)$$

where

φ – degree of latitude of the place.

At such a tilt angle it is possible to obtain maximum heat energy during spring and autumn, but for maximum heat yield during the whole season it is recommended to figure this angle by coherence (Шукстерис et al., 1989);

$$\delta = \varphi - 27°. \quad (2)$$

For Riga it means $\delta = 57° - 27° = 30°$. In order to keep the solar collector's plane perpendicularly to the direct radiation of solar beams all day round, it is necessary to provide the collector with a mechanism for tracking the sun.

For the experimental investigation of difference between the heat energy obtained by a solar collector focused to the sun and solar collector placed at every angle to the horizon, by means of the device MD-4 during the period of time from 21 July till 3 August, 2004, and registered the power of solar radiation, air temperature and

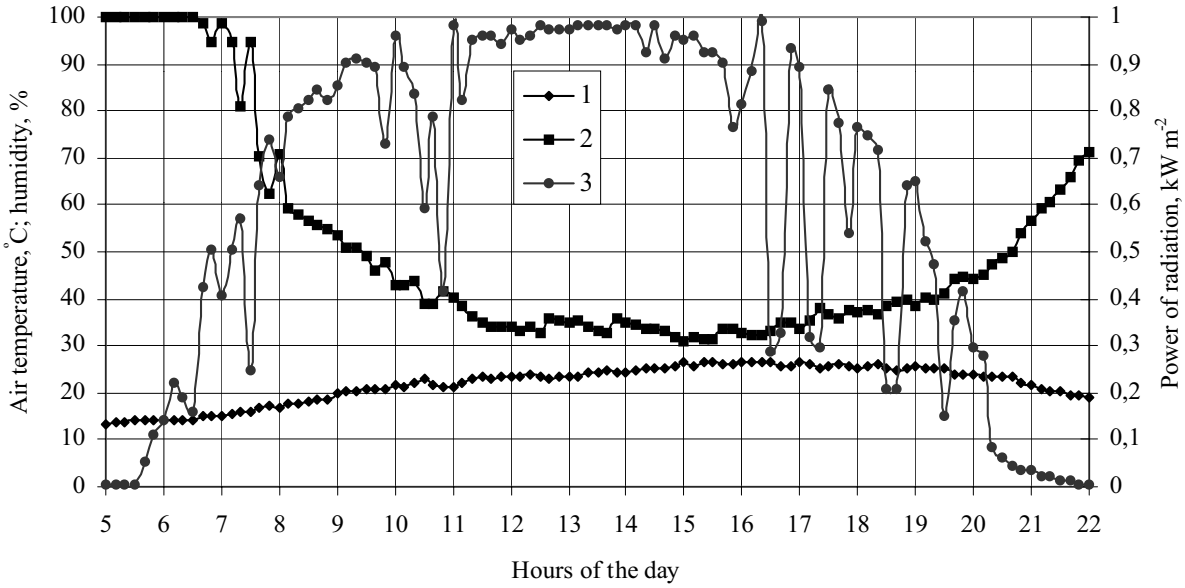

Figure 2. Air temperature, humidity and power of solar radiation on July 26, 2004:
1 – air temperature; 2 – humidity; 3 – power of radiation.

relative humidity continuously were measured. The obtained data were recorded into four measuring channel module HOBO H08, then stored into the computer program 'BoxCar', after wards transported to 'Excel' program, processed and analyzed. The results were positive. It was stated that the solar collector tracking the sun is able to produce by 34% more heat energy in comparison with the stationary located one (Putans et al., 2005). The obtained data testifies the value of air temperature, relative humidity, and the power of solar radiation (Figs.2).

The goal of the investigation was to clarity heat energy additionally gained from using the solar collector, which follows the sun, for a longer period of time – during summer and autumn months from April till November.

Materials and Methods

To orientate the solar collector in a direction perpendicular to the sun beams, it is possible to turn the collector's plane:

- only in a vertical plane, that is, to change the angle of the slope of a collector in relation to the horizon;
- in two planes – horizontal and vertical – in order to follow the collector's working surface to the sun.

If the solar collector is not built into the roof of a house but is put on the flat roof of a building, it is technically and economically simply with small additional payments to realise the first variant. In this case, the solar collector has to be mounted on a special pad and placed on the ground or flat roof with easy access for service. When the second type of collector installation is used, the collector should be provided with a mechanism turning the collector along the sun in its orbit. The implementation of this principle makes the collector more expensive, but increased additional amount of heat energy obtained by such a collector will soon cover the additional investments.

In order to determine the additional gain of heat energy by the solar collector, which tracks the sun, a special device MD-4 was developed in 2004 (Fig.3).

The data acquisition device MD-4 consists of the base (23) into which the steel bar (9) is fixed. At the upper part of the bar, a slanting axle (10) with a fixed cog-wheel (11) is attached. On the axle, a driving drum (6) having a clock drive and cog-wheel (7) is put on. The cog-wheel (7) has an engagement with a cog-wheel (11). The cog-wheel (7) turns the drum (6) with protecting cylinder (5), on which a thermo-battery (1) with back-sight (2) and fixation button (4) are fastened. When the protecting cylinder is put on the driving drum, they are jointed immovably. The cog-wheel (7) has a fixation coupling, therefore for orientation the thermo-battery to the sun, the driving drum is turned around the axle (10). At the upper part of the driving drum, the thermo-battery operational voltage amplifier plate, the amplifier's feeding battery and a handle for winding up the clock spring are placed. The stationary thermo-battery (14) is fixed on the holder (17), which is immovably linked with the bar (9). This thermo-battery has a scale (15) and position fixation button (18). On the holder (17), the compass (16) is fastened. A plumb (19) (details 12, 13, 20, and 22) and four screws (21) are envisaged for adjustment of the device in vertical position (Putans et al., 2005).

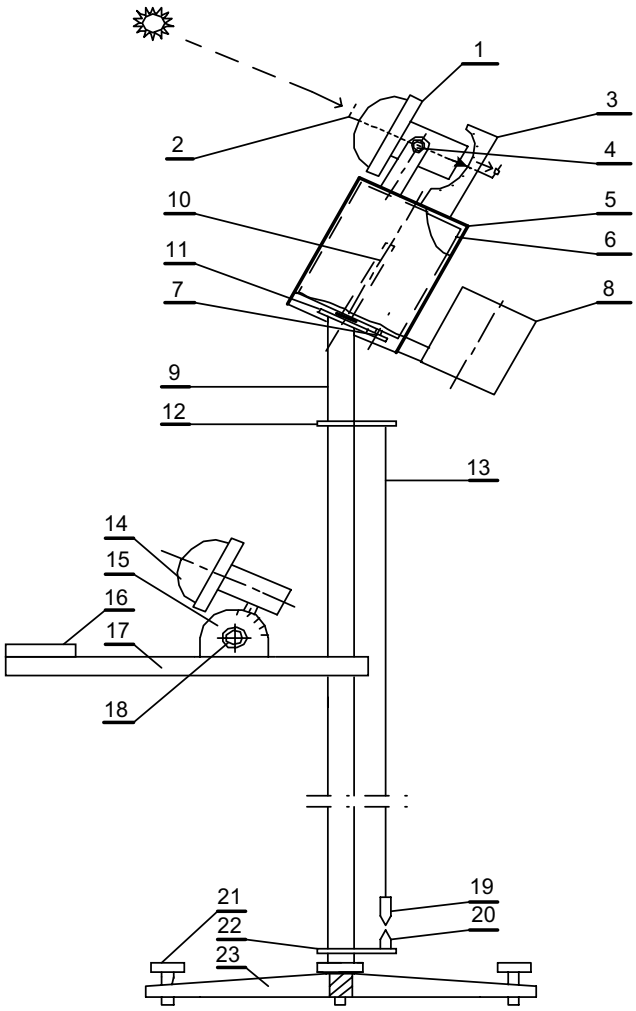

Figure 3. Construction of the device MD-4: 1 – thermo-battery tracing the sun; 2 – back-sight; 3 – orientation limb; 4 – fixation button; 5 – protecting cylinder; 6 – driving drum; 7 – cog-wheel; 8 – container for HOBO module; 9 – steel bar; 10 – slanting axle; 11 – immovable cog-wheel; 12 – holder of the thread plumb; 13 – thread plumb; 14 – stationary thermo-battery; 15 – limb of the stationary thermo-battery; 16 – compass; 17 – holder; 18 – fixation button of the stationary thermo-battery; 19 – plumb; 20 – cone of the plumb; 21 – screws; 22 – holder of the cone; 23 – base.

In 2005, from April 1 to November 26, using meteorological data acquisition device MD-4, the intensity of solar radiation on the surface tracking the sun and stationary placed one, air temperature, and relative humidity were measured. The obtained results were registered into the data saving device HOBO H08 module 007 and the 'BoxCar' computer program. For measuring of temperature and relative humidity, corresponding sensors were used, but for acquisition of the intensity of solar radiation – two thermo-batteries. One of the batteries followed the movement of the sun but the other was kept stationary in a position that sunbeams were striking it perpendicularly in the middle of the day.

Results and Discussion

The solar radiation on both planes, registered by thermo-batteries, was compared to the data given in the literature.

For every series of measuring by the use of 'Excel' program the mean temperature, relatives humidity and amount of energy registered by tracking the sun and stationary placed thermo-batteries is calculated. The energy obtained by thermo-batteries with values of global radiation given in literature is compared (Fig.4). Fig.5 illustrates the power of solar radiation, amount of energy registered by thermo-batteries, the air temperature, and relative humidity on 20 June, 2005.

The obtained results are generalized in Table 1. During the 227 days of measurement, thermal-battery tracking the sun registered 1387.1 kWh•m^{-2} of energy, but the stationary located battery – 994.19 kWh•m^{-2}. It means that tracking the sun thermobattery gathered 1.395 times more heat energy in comparison with the stationary placed one.

From the 'BoxCar' program the obtained information

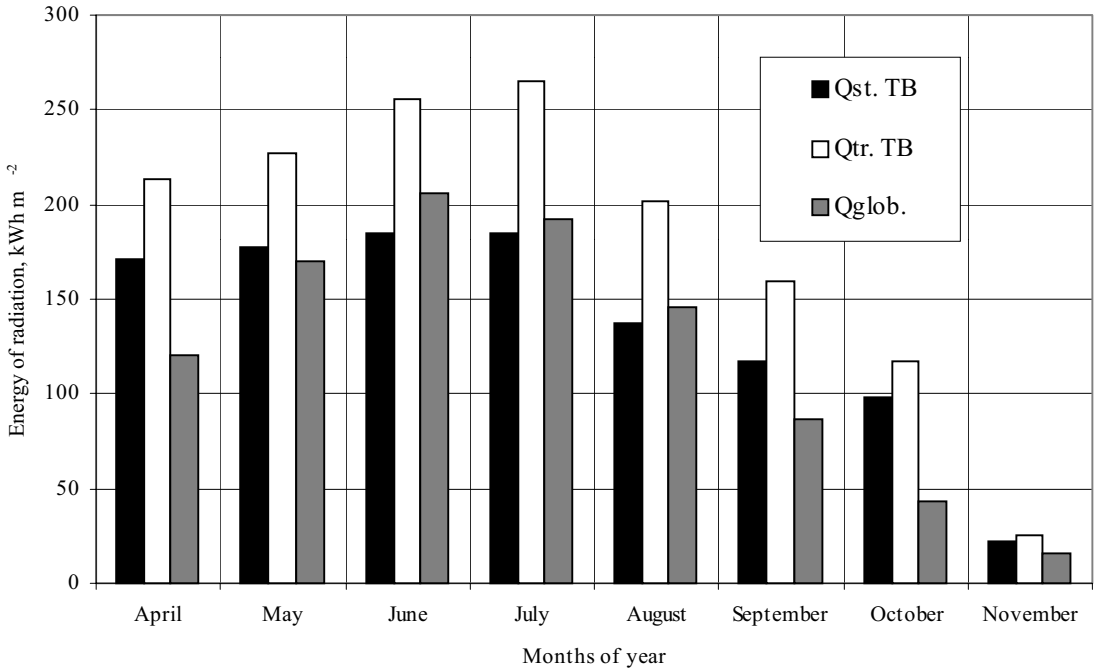

Figure 4. Energy of the sun radiation by months in 2005: $Q_{st.}$ – registered by a stationary placed thermo-battery; $Q_{tr.}$ – registered by tracking the sun thermo-battery; $Q_{glob.}$ – global radiation, given in literature (Kaškarova, 2003).

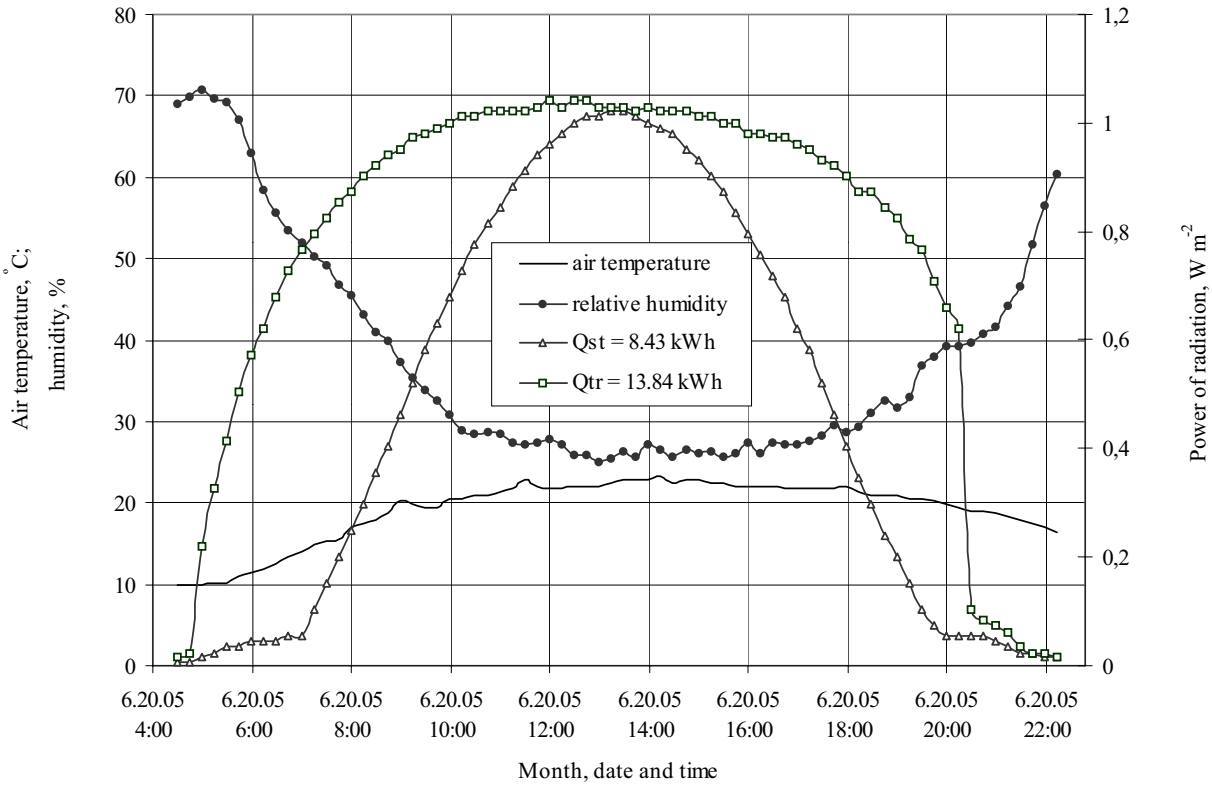

Figure 5. Power of solar radiation, amount of energy registered by thermo-batteries, air temperature, and relative humidity on 20 June, 2005.

Table 1

Distribution of days after maximal power values at Ulbroka, 2005

Period of time	Number of days	Number of days with solar radiation %		
		>75%	25-75%	< 25%
April 1 – 6	6	4	2	-
April 16 – May 5	20	6	9	5
May 6 – 15	8	2	2	4
May 16 – 24	9	5	3	1
May 26 – June 14	19	5	8	5
June 14 – July 7	21	6	13	2
July 5 – 25	21	6	14	1
July 26 – August 14	20	1	12	7
August 15 – September 3	20	11	6	3
September 4 – 24	21	4	9	8
September 25 – October 14	20	10	7	3
October 15 – November 4	21	6	7	8
November 6 – 26	21	0	3	18
Days total	227	66	96	65
In %	100	29	42	29

was brought into the 'Excel' program by means of which for every of series (number of days) the average values of the air temperature (T_{aver}), relative humidity (RH_{aver}) and intensity of solar radiation on the surface tracking the sun (Q_{tr}) and stationary placed (Q_{st}) were calculated (Table 2). From the table 2 it follows that during 227 summer days the sun tracking thermo-battery gathered 1387.1 kWh·m^{-2} of energy, but the stationary located – only 994.19 kWh·m^{-2} or 1.4 times less (Q_{track}/Q_{st}). Comparison of both amounts of the obtained energy shows that smaller difference was at the start and at the end of measurements (about 1.2 times), but bigger difference (13.84/8.43) – in the middle of the summer (1.64 times). It can be explained by the part that in spring and autumn the angle of incidence of solar rays is smaller and therefore the effect of tracking the sun is not so tangible. The bigger amount of energy was registered on 20 July (13.84 kWh) by the thermo-battery tracking the sun, but the smallest amount – on November 17 when both thermo-batteries registered only 0.3 kWh·m^{-2}. The intensity of solar radiation on that day was only 0.07 kW·m^{-2}. If the weather conditions are good and days are sunny, even in late autumn it is possible to obtain a rather big amount of heat energy. So on 1 November, the thermo-battery tracking the sun registered 5.7 kWh·m^{-2} by energy, but the stationary placed one – 4.7 kWh·m^{-2}. If the solar collector tracking the sun is working at 30% efficiency rate, then during a day about 2 kW h of heat energy will be obtained from each m^2 of the collector's area. In the second part of the measuring period, the energy amount obtained by tracking the sun thermo-battery diminished by 13.84/5.7 i.e. 2.43 times. Analysis of every-day energy curves demonstrated that the decrease of obtained energy was mainly due to the fact that days in autumn are becoming shorter. It means that under the weather conditions of Latvia, tracking the sun solar collectors should be used for heating of domestic water.

For processing of measuring data, the 'BoxCar' and 'Excel' programs were used. First of all, in the 'BoxCar' program the visual review of the obtained graphs was done. According to the power cost, all 227 days, graphs were parted into three groups as follows:

1) days with registered energy amount less than 25% of the possible obtained during a clear sunny day;

2) days with registered energy amount from 25 to 75 % of the possible obtained;

3) days with registered energy amount more than 75%

Table 2

Meteorological data obtained in Ulbroka from 1 April till 26 November, 2005

Period of time	Number of days	T_{aver}, °C	RH_{aver}, %	Q_{st}, kWh·m^{-2}	Q_{trac}, kWh·m^{-2}	Q_{track}/Q_{st}
April 1 – 6	6	5.49	60.04	35.49	45.90	1.393
April 16 – May 5	20	7.11	57.66	113.54	139.43	1.228
May 6 – 15	8	8.72	70.01	14.70*	47.55	–
May 16 – 24	9	14.32	58.46	57.00	86.90	1.624
May 26 – June 14	19	14.86	63.93	98.27	134.43	1.368
June 14 – July 7	21	18.17	59.50	146,20	204.25	1.397
July 5 – 25	21	19.87	64.38	127.40	194.45	1.526
July 26 – August 14	20	17.44	78.23	68.03	90.48	1.330
August 15 – September 3	20	16.40	69.10	116.70	172.18	1.475
September 4 – 24	21	13.80	74.50	77.56	1204.12	1.342
September 25 – October 14	20	11.10	77.97	78.83	97.19	1.232
October 15 – November 4	21	4.97	65.47	53.08	61.97	1.167
November 6 – 26	21	2.71	83.27	7.39	8.31	1.120
Total	227			994.19	1387.80	1.395

**In this period some improvement and adjustment of the device was needed.*

of the maximum energy possible to obtain in a clear sunny day.

As it is seen from Table 2 during the time of measuring 66 days with energetic value more then 75% of maximum possible were, but with energetic value less then 25% were 65 days. The rest 95 days were with the energetic value 26–74% of maximum possible at that time. In April, at the second half of August, at the end of September, and at the start of October there were several sunny days. Cloudy days were from 26 July till 14 August, when there was only one day with Q>75%, and from 6–26 November, when there were no days with Q>75%.

Conclusions

1. Meteorological information about solar radiation, air temperature and relative humidity was acquired during 227 days – from 1 April to 26 November has been carried out – in Ulbroka, Riga region.
2. Power of solar radiation was measured with two thermo-batteries, one of which followed the motion of the sun and its surface was constantly kept perpendicular to the direction of falling sunbeams, but the second was placed stationary and periodically turned only in a vertical plane.
3. During the period of investigation, the stationary thermo-battery registered 994.19 kWh·m^{-2} of energy but tracking the sun battery – 1387.1 kWh·m^{-2}, which is 1.395 times more.
4. The greatest amount of energy on a clear sunny day like 20 June registered by the thermo-battery tracking the sun was 13.84 kWh·m^{-2}, but amount of energy registered by a stationary placed thermo-battery – 8.4 kWh·m^{-2}.

References

1. Kaškarova G. (2003) Saules enerģijas izmantošanas iespējas Latvijā. (Using possibilities of solar energy in Latvia). Enerģētika un Automatizācija, 7, 42 pp. (in Latvian).
2. Putans H., Ziemelis I., Putans A., Ziemelis E. (2005) Removable device for measuring and registration of meteorological parameters. Starptautiska zinātniska konference 'Inženierproblēmas lauksaimniecībā'. Rakstu krājums. Jelgava, pp. 222-227.
3. Шукстерис В.С., Киверис Р.В. (1989) Возможности применения солнечной энергии для отопления и горячего водоснабжения малоэтажных домов. (Using possibilities of solar energy for heating and domestic water for houses). Энергосбережение и нетрадиционные источники энергии в сельской местности. Иркутск, 132 с. (in Russian).

FUEL USAGE IN AGRICULTURE

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Abstract

Fuel as the main energy resource in agriculture and forest production is surveyed in the work. Specific weight of fuel and lubricants in applicable expenses in country farms is analysed, average fuel and oil consumption in farms of different specialization, as well as changes in oil price in farms of different size and specialization are shown.
Key words: fuel, lubricants, expenses, consumption, agriculture.

Introduction

Fuel expenses constitute an important part in agriculture farm expenditures.

Fossil energy resources are diminishing every year in the world. New energy sources are required to substitute traditional resources. That is why now different technologies driven to foundation and discovering of renewable energy resources and usage are developed very intensively.

Academic and member of Latvian Bio-fuel Association Arnis Kalniņš (Kalniņš, 2005) has done feasibility study and research on the existent now situation and bio-fuel production possibilities in Latvia. Research material is made as the future economy strategy foreseeing development tendencies – agriculture plant possible practical usage as a renewable energy porter for fuel production.

Under guidance of Vilnis Gulbis, professor of the Institute of Power machinery of the Faculty of Engineering, Latvia University of Agriculture actual research on the influence of different type of bio-fuel and their mixtures was done and their influence on different power machinery investigated (Berjoza et al., 2003).

Aleksejs Daņiļevičs from the Institute of Microbiology and Bio-technology of the University of Latvia investigated possibilities of substituting oil origin fuels with bio-fuel as well as bio-fuel production economical aspects (Daņiļevičs, 1999).

Six production units have started production of bio-fuel in Latvia: 'Delta- Riga' Ltd in Valmiera, 'Lako' Ltd in Madona district, 'Mamas-D' Ltd in Daugavpils district, 'Iecavnieks' Ltd and 'Jaunpagasts Plus' Ltd in Bauska district, 'Mežrozīte' Ltd in Dobele district. Four more production units are planned to start production of bio-fuel in 2007.

So far investigation of many authors reveal many problems to be solved. Only results of researchers are included in this work. The author has done investigation on the consumption of fossil fuels and their expenses in the period from 2000 to 2004. Because of limited amount of research work there is no wide investigation on usage of bio fuel in agriculture.

The hypothesis of the research: fuel consumption and its expenses in country farms are growing.

The aim of the work: to investigate total fuel and lubricant consumption on agriculture and fuel and lubricant expenses in country farms.

Tasks nominated for reaching the goal:

1. To investigate dynamics of total fuel usage and their types in agriculture and forest production.
2. To show dynamics of registered tractors and agriculture automotive machines.
3. To analyse specific weight of fuels and lubricants in applicable expenses in country farms.
4. To show consumption expenses for fuels and lubricants in farms of different specialization.
5. To evaluate fuel and lubricant consumption expenses in agriculture farms of different sizes in all regions.

Materials and Methods

Calculation constructive method, comparison method and monographic method were used for data and research result processing.

Elaboration of the report is based on the author's theoretical and practical knowledge and is connected with theme of the promotion work.

Education and scientific literature, materials from State Statistics Committee, Internet materials, data from State Technical Inspection Agency were used in working out of the paper.

Results and Discussion

Fuel and lubricants are one of the main energy resources in agriculture, forest production and hunting business.

Data in Table 1 illustrate that during period of five years (2000 – 2005) consumption of oil products used while working on the field has increased by 13.2 %. Among oil products diesel fuel has the highest consumption percentage from 85.2 5 in 2000 up to 88.8 % in 2004. Tractors consume diesel fuel most – about 70 – 75 % of total consumption.

With entering European Union, support for Latvian agricultural farms has increased considerably. Agriculture farmers have has the possibility to apply for EU support – direct payments. Following the data in Table 1 it is seen oil product consumption in agriculture farms and forest production has increased considerably in 2003 which is

Table 1

Fuel consumption in agriculture and forest production (2000 – 2004)

Indicator	2000	%	2001	%	2002	%	2003	%	2004	%	2004, % compared to 2000
Oil products, thousand t	1945	100	2084	100	1665	100	2372	100	2201	100	113.2
Chain growth tempo, %	0		7.1		-20.1		42.5		-7.2		
Base growth tempo, %	0		7.1		-14.4		22.0		13.2		
Car benzine, thou. t	44	2.3	11	0.5	17	1.0	44	1.9	44	2.0	100.0
Chain growth tempo, %	0		-75.0		54.5		158.8		0		
Base growth tempo, %	0		-75.2		-61.4		0		0		
Diesel fuel, thou. t	1657	85.2	1870	89.7	1445	86.8	2125	89.6	1954	88.8	117.9
Chain growth tempo, %	0		12.9		-22.7		47.1		-8.0		
Base growth tempo, %	0		12.9		-12.8		28.2		17.9		
Mazut (heavy oil), thou. t	244	12.5	203	9.8	203	12.2	203	8.5	203	9.2	83.2
Chain growth tempo, %	0		-16.8		0		0		0		
Base growth tempo, %	0		-16.8		-16.8		-16.8		-16.8		

Source: Energy Balance of the Republic of Latvia Central Statistics Board Energy in 2004, 2005

connected with the EU support in 2004. It lets the farmers increase the number of tractors, crop harvesting combines and automotive machines for forest production.

Table 2 shows that number of tractors in 2005 has reached the level of year 2000 that is proportionally 100.5 %.

The biggest tractor number chain growth tempo is in 2005: 2.6%.

Most of the tractors are based on the former Soviet Union production tractors. In the period of time 2001 – 2003 State Technical Inspection Agency paid a lot of attention to arrangement of tractor, automotive machine and agriculture technique registration. In these years most intensive worn out technique was taken off State Technical Inspection Agency register and written off the balances of farms.

Table 2

The number of registered tractors and automotive agriculture and forest production machines in Latvia (2000 – 2005)

Indicator	2000	2001	2002	2003	2004	2005	2005/ 2000%
Tractors	76103	74673	74017	73605	74581	76495	100.5
Chain growth tempo, %	0	-1.9	-0.9	-0.6	1.3	2.6	
Base growth tempo, %	0	-1,9	-2.7	-3.3	-3.0	0.5	
Crop harvesting combines	4491	4546	4588	4632	4842	5200	115.8
Chain growth tempo, %	0	1.2	0.9	1.0	4.5	7.4	
Base growth tempo, %	0	1.2	2.2	3.1	7.8	1.2	
Automotive grass harvesting and chopping machines	1666	1566	1520	1504	1500	1533	92.0
Chain growth tempo, %	0	-6.0	-3.0	-1.1	-0.3	2.2	
Base growth tempo, %	0	-6.0	-8.8	-9.7	-10.0	-8.0	
Automotive technical culture harvesting and cleaning machines	127	98	81	42	68	72	56.7
Chain growth tempo, %	0	-22.9	-17.3	-48.1	61.9	5.9	
Base growth tempo, %	0	-22.9	-36.2	-66.9	-46.5	-43.3	
Forest machines	700	802	859	956	975	1059	151.3
Chain growth tempo, %	0	14.6	7.1	11.3	2.0	8.6	
Base growth tempo, %	0	14.6	22.7	36.6	39.3	51.3	

Source: Data from State Technical Inspection Agency

Table 3

Annual average applicable expenses in one farm per year, LVL (2000 – 2004)

Indicator	2000	%	2001	%	2002	%	2003	%	2004	%
Applicable expenses, total LVL	1464	100	1467	100	3491	100	3682	100	4811	100
Chain growth tempo, %	0		0.2		137.9		5.5		30.7	
Base growth tempo, %	0		0.2		138.5		151.5		228.6	
Including:										
Maintenance of buildings and technique	288	19.7	241	16.4	729	20.9	747	20.3	988	20.5
Fuel and lubricants, LVL	726	49.6	713	48.6	1463	41.9	1476	40.1	2046	42.5
Chain growth tempo, %	0		-0,1		105.2		3.3		38.6	
Base growth tempo, %	0		-0.1		101.5		103.3		181.8	
Electricity and heating, LVL	170	11.6	169	11.5	374	10.7	424	11.5	537	11.2
Services, machine rent, LVL	134	9.1	123	8.4	202	5.8	365	9.9	525	10.9
Other applicable expenses, LVL	146	10	221	15.1	723	20.7	670	18.2	715	14.9

Source: Data from (Bratka, 2005), (Bratka, 2004), (Bratka, 2003), (Bratka, 2002)

In these years we can notice diminishing of number of tractors. But increase in number of technique in 2005 is connected with possibilities to use EU support payments for purchasing of modern technique.

Number of crop harvesting combines has increased in these years because farms have the possibility to purchase such machines with the help of structural funds. The biggest chain growth tempo is in 2005 7.4%, base increase tempo 1.2 %.

Number of automotive grass harvesting and chopping machines has diminished. In 2005 base growth tempo was - 8.0 %. Number of automotive technical culture harvesting and cleaning machines has diminished in the years run. Base growth tempo was - 43.3 %.

Forest machine number has the tendency to grow stable. It is connected with intensive forest production. The highest base growth tempo is in 2001 4.6 %, base growth tempo in 2005 51.3 %.

Expenses for fuel and lubricants form the biggest part of applicable expense sum for a farm. It depends on the size of agriculture farm, its specialization.

As we can see from the data of table 3 specific weight of fuel and lubricant in applicable expenses differs in the range from 40.1 % till 49.6 %. Annual average expenses for fuel and lubricants in one farm has grown from 726 LVL in 2000 up to 2046 LVL in 2004 or by 281.8%. I assume it is connected with larger consumption of fuel and rapid growth of its price.

Applicable expenses for consumption of fuel and lubricants are not possible to directly link with a branch of industry because the technique is used in several productions, for instance gardening, cattle breeding, also in general management of the household.

Table 4 illustrates there is diminishing chain and base growth tempo in swine breeding in 2003 which is connected with crisis in the branch in respect of pork import (mainly from Poland and Estonia in the period from January, 2002 until July, 2003).

Analysing chain growth tempo and base growth tempo in different years in the farms with marked agriculture specialization we can see average expenses for consumed fuel and lubricants have a tendency to grow. In agriculture specialized farms there are the highest fuel and lubricant expenses compared to farms with different specialization.

To determine link between fuel and lubricant expenses and size of the farm the author analysed these expenses with different size agriculture specialization farms in the period 2001 – 2004.

In European Union economical size of the farms is determined with the help of European measure ELV – certain number of EURO changing depending on inflation level. To secure comparability of data it is necessary to determine economical size of the farms. After this the farms can be included in the common system.

Following EU economical size class 4-<8 ELV farms are small, 16-<40 ELV are middle size farms, 100-<250 ELV are very big farms. The author chooses group division because there are the most important agricultural differences in fuel and lubricant expenses.

Data in Table 5 show that expenditure consumption for fuels and lubricants against total agriculture production value in LVL in big agriculture farms is approximately 2 times smaller.

There is a common tendency noticed in the period of analyses: the bigger the farm the smaller amount of expenses for fuels and lubricants consumed on every Lat (LVL) of agriculture production value.

Table 4

General fuel and lubricant expenses in LVL in farms of different specialization (2001 - 2004)

Type of specialization	2001	2002	2003	2004	2004 comp. to 2001 + or – ; %
Agriculture	1297	2368	3143	4093	315.6
Chain growth tempo, %	0	82.6	32.7	30.2	
Base growth tempo, %	0	82.6	142.3	215.6	
Mixed plant-growing	486	878	705	954	196.3
Chain growth tempo, %	0	80.7	-19.7	35.3	
Base growth tempo, %	0	80.7	45.1	96.3	
Swine – breeding and poultry farming	8197	6878	1219	2659	- 67.6
Chain growth tempo, %	0	-16.1	-82.3	118.1	
Base growth tempo, %	0	-16.1	-85.1	-67.6	
Pasture domestic animal growing	1386	2106	1464	1781	128.5
Chain growth tempo, %	0	51.9	-30.5	21.7	
Base growth tempo, %	0	51.9	5.6	28.5	
Mixed cattle breeding	238	521	546	869	365.1
Chain growth tempo, %	0	118.9	4.8	59.2	
Base growth tempo, %	0	118.9	129.4	265.1	
Mixed	845	1166	1071	1209	143.1
Chain growth tempo %	0	38.0	-8.1	12.9	
Base growth tempo %	0	38.0	26.7	43.1	

Source: Data from (Bratka, 2005); (Bratka, 2004); (Bratka, 2003); (Bratka, 2002)

Table 5

Fuel and lubricant expenses and agriculture production in all regional agriculture specialization farms (2001 - 2004)

Years, magnitude groups	Total agriculture production, LVL	Consumption of fuels, lubricants, LVL	Fuel, lubricant expenses in LVL per 1 LVL of agriculture production value
2001			
4-<8	5 986	1 211	0.20
16-<40	33 348	4 927	0.15
100-<250	138 108	19 096	0.14
2002			
4-<8	7 553	1 481	0.20
16-<40	67 480	9 466	0.14
100-<250	837 512	77 955	0.09
2003			
4-<8	6 412	1 165	0.18
16-<40	94 188	12 104	0.13
100-<250	985 646	90 147	0.09
2004			
4-<8	5 897	1 442	0.24
16-<40	81 579	14 529	0.18
100-<250	1058 894	110 144	0.10

Source: Data from (Bratka, 2005), (Bratka, 2004), (Bratka, 2003), (Bratka, 2002)

Conclusions

1. In the last years fuel consumption in agriculture and forest production has stabilised.
2. Number of registered tractors in 2005 compared to 2000 has increased by 0.5 %, number of corn harvesting combines – by 15.8 %, number of forest production machines has increased by 51.3 %.
3. Specific weight of expenses for fuels and lubricants in country farm applicable expenses is in the borders from 40.1 % to 49.6 %.
4. In the farms with agriculture specialization there are higher average expenses for fuels and lubricants consumed.
5. The bigger agriculture specialization farm the smaller expenses for fuels and lubricants consumed on every Lat (LVL) of agriculture production value.

References

1. Berjoza D., Gulbis V., Birzietis G. (2003) Automobīla jaudas pētījumi, izmantojot dažāda sastāva biodegvielas (Research automobile power using biofuels of different compositions). Starptautiski zinātniskā konference. Spēkrati, loģistika un alternatīvās degvielas. Rakstu krājums. LLU, Jelgava, pp. 31 – 35. (in Latvian).
2. Bratka V., Filmanoviča E., Dambiņa L., Muceniece I. (2005) Lauku saimniecības darba ekonomiskās analīzes rezultāti 2004 (Results of economical analyses of country farm work 2004). Latvian Institute of State Agrarian Economy, 207 pp. (in Latvian).
3. Bratka V., Dambiņa L., Dāvida S., Filmanoviča R., Lazdiņa V., Lētiņa V. (2004) Lauku saimniecības darba ekonomiskās analīzes rezultāti 2003 (Results of economical analyses of country farm work 2003). Institute of State Agrarian Economy, 192 pp. (in Latvian).
4. Bratka V., Avotiņa B., Dambiņa L., Filmanovoča R., Lazdiņa V., Upeniece L. (2003) Lauku saimniecības darba ekonomiskās analīzes rezultāti 2002 (Results of economical analyses of country farm work 2002). Institute of State Agrarian Economy, 265 pp. (in Latvian).
5. Bratka V., Filmanoviča R., Lazdiņa V., Avotiņa B., Upeniece L. (2002) Lauku saimniecības darba ekonomiskās analīzes rezultāti 2001 (Results of economical analyses of country farm work 2001). Institute of State Agrarian Economy, 280 pp. (in Latvian).
6. Daņiļevičs A. (1999) Biodegvielas ražošanas ekonomiskie aspekti (Economics aspects of biodiesel production). Simpozija Alternatīvā enerģija Latvijā. Referātu krājums. LLU, Jelgava, pp. 30 – 34 (in Latvian).
7. Kalniņš A. (2005) Biodegvielas ražošanas un izmantošanas iespējas Latvijā (Possibilities of biofuel production and usage in Latvia). LR EM, Rīga, pp. 7-9. (in Latvian).
8. Latvian Republic Central Statistics Board (2005) Energy balance 2004. Latvian Republic Central Statistics Board, pp. 46 – 76.
9. Web site of State Technical Inspection Agency (2006). Statistika (Statistic). Available at: http://www.vtua.gov.lv/?id=82&sa=82, 09.02. 2006. (in Latvian).

STRESS MODELLING OF CHOPPED BIOMASS

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Abstract

Relevant resources for renewable biomass fuel production are wood, cereal straw residues, and emergent vegetation from wetlands. Peat is an important slowly renewable biomass fuel too. Using blended peat and woody or herbaceous biomass, sulphur content of the fuel is increased and, if the mixture is burned, sulphates are formed instead of chlorides, and the risk of high temperature corrosion is avoided. The loading, storage container discharging, mixing and automatic feeding process depends on internal stresses acting in the biomass volume. To estimate vertical stress in silos, a mathematical model was built. Vertical stress in the opening of the silo hopper reaches 1.4 kPa if the diameter of a silo is 0.4 m, but for the diameter of 2 m it is possible to obtain even 7.2 kPa. Increase of the coefficients λ and μ to the maximal values (λ=0.6; μ=0.5) decreases vertical stress for more than 70%.
Key words: biomass, model, silo, and peat.

Introduction

Ecological and economical situation in the world is increasing the demand for renewable energy sources with less impact on environment. Human activities (fossil fuel burning for energy supply etc.) have increased significantly the amount of greenhouse gases in the atmosphere (The Greenhouse…, 2003).

Biomass is a CO_2 emissions neutral source of energy. This is due to the fact that CO_2 is taken from the atmosphere and used by plants to grow. Although some CO_2 is emitted when manufacturing and burning biomass fuels, it is ultimately equal to the carbon dioxide absorbed by the plants used to produce this fuel (if the crops and trees are sustainably managed).

Peat briquettes, pellets and sod and milled peat are traded in the Baltic Sea area and are used mainly as a local energy source. Peat is an important natural source also for horticulture. Half of the global peat production (100 million m^3 in 2004) is carried out in the Baltic Sea area. Fuel peat is an important slowly renewable biomass fuel, which is usually co-fired with wood biomass in several power plants and district heating plants (Quality…, 2005).

Using peat with woody or herbaceous biomass has also other advantages. Use of peat in heat plants is crucially important, because the contents of metal alkaline and chlorides in woody biomass with bark or needles/leaves or herbaceous biomass are unusually high. Depending on the combustion conditions, the alkali metals can be oxidized or they can form sulphates or chlorides. If only wood chips or herbaceous biomass are burned, the sulphur content is low and chlorides are formed. The chlorides then tend to condense on heat transfer surfaces of the steam boiler, slowing down the heat transfer and causing the risk of high temperature corrosion. If the sulphur content of the fuel is increased, e.g. by blending peat with chips or herbaceous biomass, sulphates are formed instead of chlorides, and the risk of corrosion is avoided (Quality…, 2005).

In order to design silos, feeders, mixing and flow promoting devices for briquetting process, it is necessary to know flow properties of bulk solids. The loading, storage container discharging and automatic feeding process depend on internal stresses acting in the biomass volume. Knowledge of the stresses acting in chopped biomass is important for following applications:

- silo design for strength (e.g. DIN 1055 part 6);
- silo design for flow;
- loads on feeders and inserts;
- driving torque of feeders;
- design of silos in which the specific maximum stress is not exceeded (e.g. to avoid vibrations, particle attrition or extreme time consolidation) (Schulze, 2003).

For better understanding of the influence of different parameters on vertical stress σ_v in the silos, a mathematical model and a Simulink diagram were worked out in the Research Laboratory of Mechanics of the Latvia University of Agriculture. Values of the angle of wall friction and stress ratio λ have been experimentally established in the previous experiments.

Materials and Methods

Two different cases have to be taken into account when calculating stresses in silos at the filling state:

- stresses in the vertical part of a silo or container;
- stresses in the hopper (active state of stress, filling state).

The stresses in the vertical section of a silo (active state of stress) have been calculated by Janssen (Janssen, 1995) who used a so-called slice element method. He considered a slice-shaped volume element of infinitesimal height dz (Fig. 1), which has the same cross-sectional area A as the vertical section of the silo. Assuming constant vertical stress σ_v and constant bulk density ρ_b across the whole cross-section, the equilibrium of forces in z-direction yields (Dietmar, 2003):

$$A\sigma_v + g\rho_b A dz = A(\sigma_v + d\sigma_v) + \tau_w U dz, \quad 1)$$

where

A – area, m^2;
σ_v – vertical stress, Pa;
g – acceleration due to gravity, m s^{-2};
ρ_b – bulk density, kg m^{-3};
τ_w – wall shear stress, Pa;
U – perimeter, m.

After the introduction of the wall friction angle:

$$tan(\varphi_x) = \frac{\tau_w}{\sigma_w}, \quad (2)$$

where σ_w – wall normal stress, Pa,

and the stress ratio $\lambda = \frac{\sigma_h}{\sigma v}$, (3)

an ordinary differential equation for the vertical stress σ_v is obtained:

$$\frac{d\sigma_v}{dz} + \sigma_v \lambda \frac{U}{A} tan(\varphi_x) = g\rho_b. \quad (4)$$

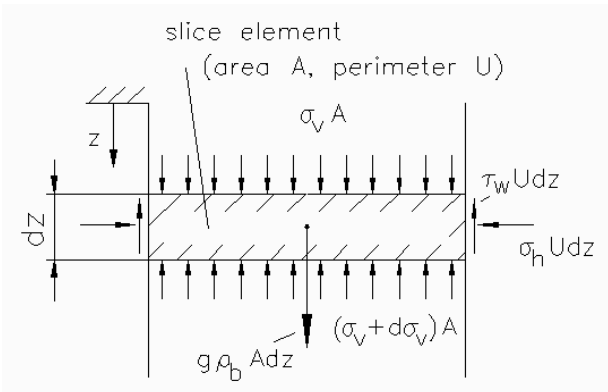

Figure 1. Slice element in vertical section (Schulze, 2003).

The influence of the wall friction angle φ_x is as follows: a rough wall (typical large wall friction angle) carries a larger part of the weight of the bulk solid than a smooth wall (typical small wall friction angle). Therefore, the maximum horizontal stress is greater in a silo with a smoother wall (if all other parameters and dimensions are identical) (Schulze, 2003). Wall friction angle is intrinsic property of the bulk material and the wall of the silo, therefore it has to be measured experimentally and individually for every different case.

Figure 2 shows an element of bulk solid in a cylinder, which is filled with bulk solid (assumed frictionless walls). The element of the bulk solid is affected by the vertical stress σ_v. As a result of the vertical stress, the horizontal stress σ_h acts in the horizontal direction. Stress ratio λ is calculated as a proportion of horizontal and vertical stresses (equation (3)). Every bulk solid has a specific stress ratio λ. For bulk solids stored at rest, the stress ratio is mostly in the

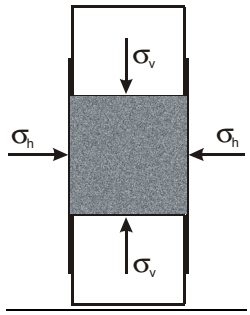

Figure 2. Element of bulk solid.

range from 0.3 to 0.6. For rough estimations of the stresses in the vertical section, λ = 0.4 can be used (Schulze, 2003).

The stresses in the hopper can be assessed also using a slice element method. Equilibrium of forces on a slice element in the hopper (Fig. 3) yields the following equation (Schulze, 2003):

$$d(A\sigma_v) + g\rho_b A dz = sin(\Theta)\sigma_w dA_M + cos(\Theta)\tau_w dA_M \quad (5)$$

If fully mobilized wall friction is assumed (see eq. (2)), it follows (Schulze, 2003) that:

$$\frac{d\sigma_v}{dz} - n\frac{\sigma_v}{z} = g\rho_b, \quad (6)$$

with:

$$n = 2[K(1 + \frac{tan(\varphi_x)}{tan(\Theta)}) - 1] \quad (7)$$

and:

$$K = \frac{\sigma_w}{\sigma_v}, \quad (8)$$

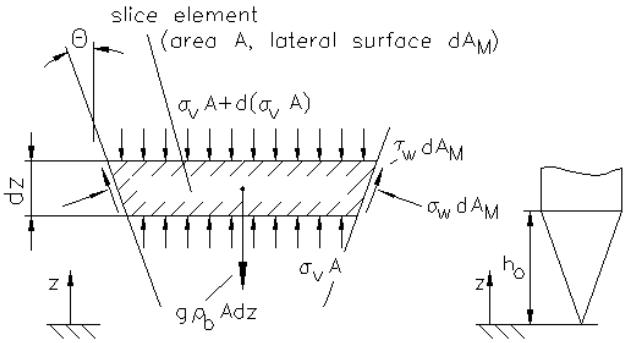

Figure 3. Slice element in hopper (Schulze, 2003).

where

Θ - inclination of hopper walls against the vertical, degrees;
σ_w – wall normal stress, Pa;
A_M – lateral area of slice element, m^2;
K – ratio of wall normal stress to mean vertical stress in the hopper;
z – coordinate in the vertical direction, m.

For calculation of σ_w equation (9) is used (Schulze, 2003):

$$\sigma_w = \frac{\sigma_v + \sigma_h}{2} + \frac{\sigma_v - \sigma_h}{2} cos(2(90 - \Theta)) \quad (9)$$

For better understanding of the influence of different parameters on vertical stress σ_v, a model was simulated using software 'Matlab-Simulink'. Both equations (4) and (6) for model design were used.

The model consists of four main blocks (Fig. 5). Block 1 is multiplication, which gives increment of vertical stress σ_v in conical part in dependence on bulk material density and the level of the silo (Fig. 5, eq. (6)). Block 2 calculates opposition of vertical stress from the conical part of the silo considering wall friction, and stress from sloping walls of the container (eq. (6)). Block 3 describes vertical stress σ_v in the cylindrical part of the silo in dependence on the bulk material density and the mass level in the silo. Block 4 calculates resistance for vertical stress in the vertical part of the container, which represents friction forces of cylindrical container walls (eq. (4)). In addition to friction forces, resistance of the conical part of the silo is included in this block. It is necessary for obtaining the increment of the vertical stress σ_v on the bottom of the conical part of the silo. Blocks 2 and 4 consider the influence of vertical stresses (see Fig. 5). After integration, vertical stresses from the conical and cylindrical part were summarized to obtain total vertical stress σ_v. Switches were used for holding constant stress from conical part of the silo when height of the bulk solid was extending above the conical part. The result of the model is the value of vertical stress in dependence on the bulk solid height in the silo.

For determination of the accuracy of this model, an experimental equipment was built. The model of the silo was filled with peat, and vertical stress on the copper bottom in dependence on the height was measured. Peat with moisture content ~15% and bulk density 140 kg m^{-3} was used for the experiments. Peat particles were less than 7 mm.

Results and Discussion

Theoretically (from modeling) and experimentally obtained curves of vertical stress in the silo opening in dependence on filling height of the bulk material are shown in Figure 4. Experimentally obtained coefficient of friction $tan\varphi_x$ = 0.2, bulk density of 140 kg m^{-3} and stress ratio λ = 0.3 are used for modeling.

The curves remain tight together, which means that the model can be used for determination of the vertical stress in the silo. The difference between the curves can be explained by the coefficient of friction which is changing in dependence on the stress, and those changes are not taken into account for this model.

Simulation shows that increasing of the stress ratio λ and coefficient of friction m results in higher wall loads in the upper area of the silo, i.e. wall normal stresses σ_w and shear stresses τ_w increase. Therefore, the load assumptions for the structural design are on the safe side with higher λ and $tan\varphi_x$. To be on the safe side for applications where the maximum vertical stress is important (e.g. for the calculation of the feeder load or the maximum vertical stress), the smaller λ and $tan\varphi_x$ should be used because it yields higher vertical stresses.

0rtical stress is influenced also by the angle of silo hopper, diameter of hopper opening, and bulk density.

Conclusions

1. The mathematical model, simulated using software 'Matlab-Simulink', can be used for calculation determination of vertical stress in silos.
2. Vertical stress σ_v remains constant when the level of mass reaches height equal ~ 4 diameters of silo.
3. Vertical stress in the opening of the silo hopper reaches 1.4 kPa if the diameter of the silo is 0.4 m, but for the diameter of silo 2 m it is possible obtain even 7.2 kPa.

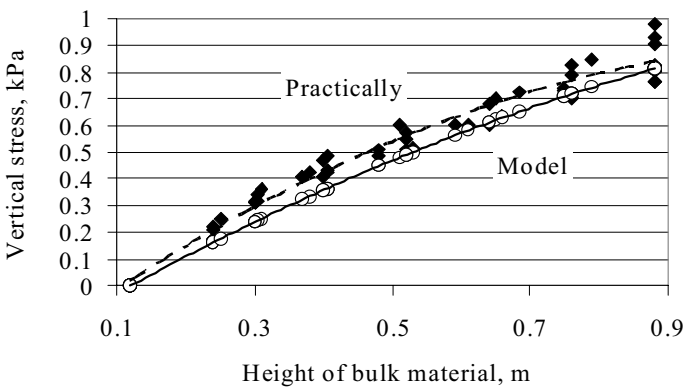

Figure 4. Vertical stress in silo (experimental and simulated).

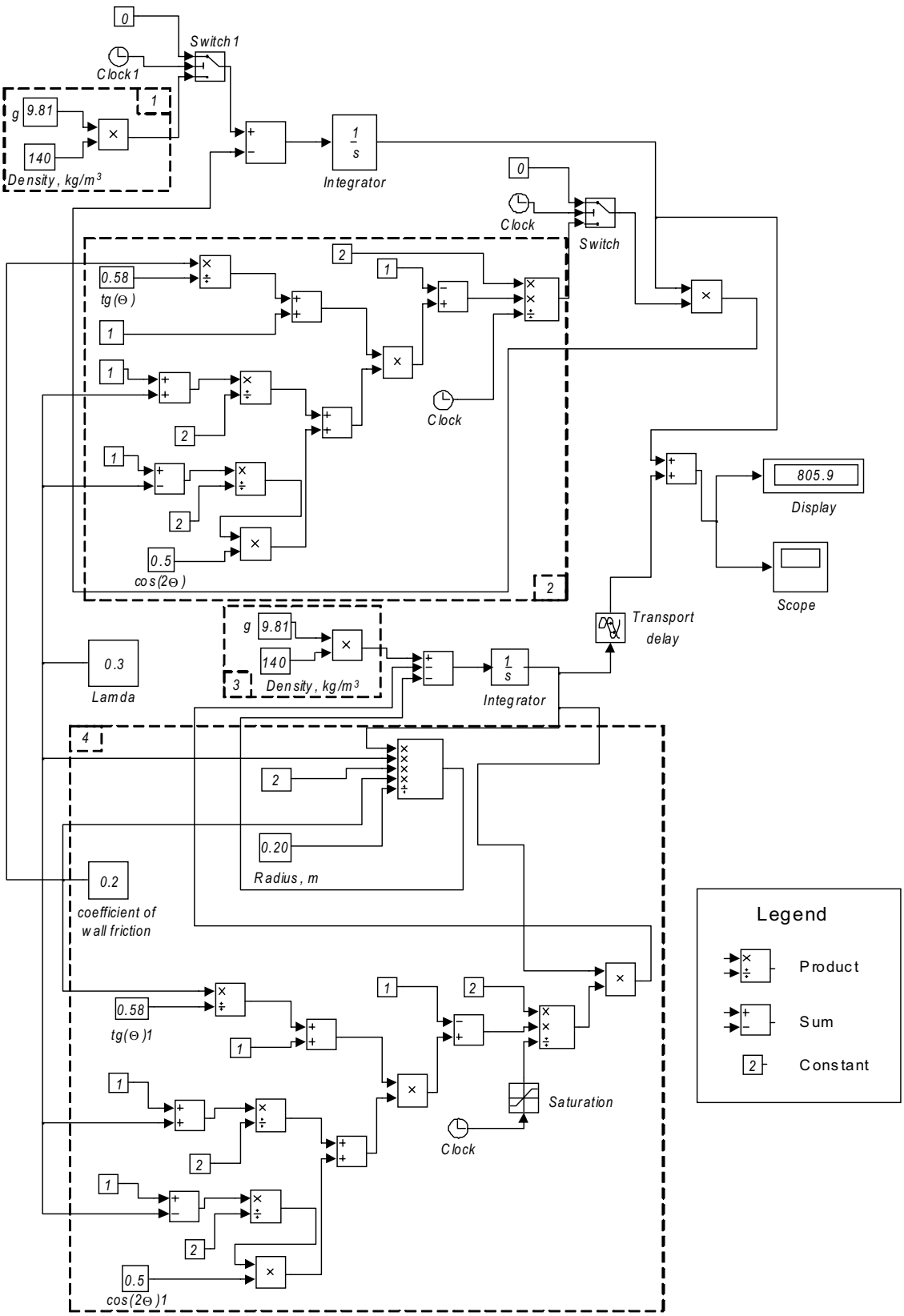

Figure 5. The mathematical model of bulk material silo in program 'Simulink'.

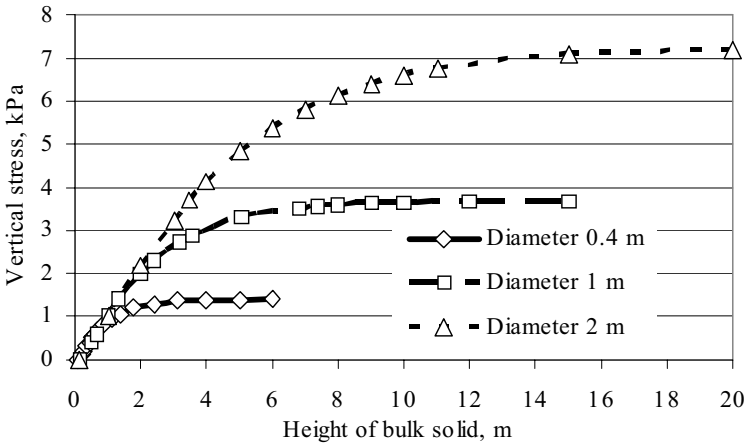

Figure 6. Simulated vertical stress.

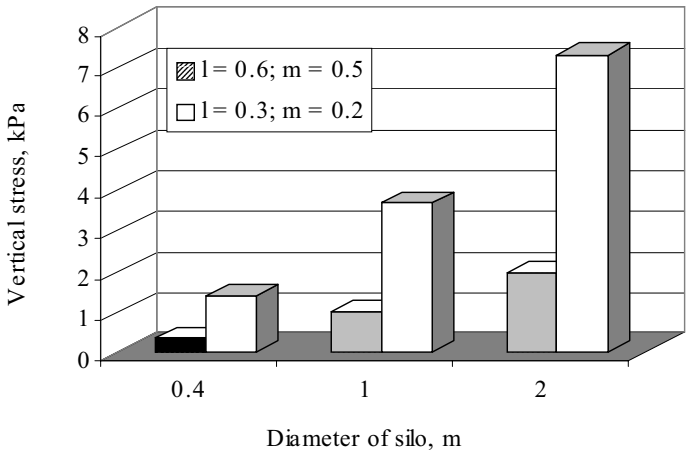

Figure 7. Maximal vertical stress at different diameter silos (simulated).

4. The increase of coefficients λ and μ up to the maximal values (λ=0.6; μ=0.5) decreases the vertical stress for more than 70%.

Acknowledgment

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References

1. Schulze D. (2003) Stresses in Silos. Available at: www.dietmar-schulze.de/spanne.html, 16.03.2006.
2. Janssen H.A. (1995) Getreidedruck in Silozellen, Z. Ver. Dt. Ing. 39, 1049 pp.
3. Quality guidelines for fuel peat – preparation started. (2005) Newsletter 2 on standards for bioenergy in the Baltic Sea Area. Available at: www.cbss.st/basrec/documents/bioenergy/ dbaFile8466.pdf., 06.02.2006.
4. The Greenhouse Effect. (2003) Available at: www.ucar.edu/learn/1_3_1.htm., 03.12.2005.

EXPERIMENTATAL RESEARCH OF OZONE USING IN GRAIN DRYING

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Abstract

Decrease of the consumption of energy resources is possible if grain is actively dry at low air temperatures, which also has a more favorable effect on a single grain. By using the new low-temperature technologies in grain drying, the same effect can be reached as by using grain dryers with high air heating temperatures. One of such technologies could be active drying of the grain layer at low air temperatures in ozone medium. Laboratory experiments show that the carried out moisture from grain is more efficient if active drying is performed using ozonized air. The presence of ozone in grain active drying process increases the amount of carried out moisture. Ozone when decaying to ordinary oxygen creates additional energy, which can be efficiently used in grain drying. As a result, grain drying is accelerated and energy consumption is decreased. Laboratory experiments prove the effectiveness of the presence of ozone in grain active drying process.

Key words: ozone, grain drying, grain active drying, ozonized air

Introduction

One of the main tasks is storage of the grain yield with possibly less wastage. Harvesting grain during dry summer the moisture of grain quite often is over 20%, but in wet weather it can exceed even 25% (Chegev, 2006). For drying of grain having such moisture high consumption of energy and time is necessary. The optimal term from harvesting of grain till drying would be from one to two days. Often for the purpose of economy grain is not dried to the condition moisture (or not dried at all) that very essentially influences the quality of grain afterwards.

As drying of grain till the optimal moisture is a very expensive process consuming much energy, it is possible to decrease the consumption of energy resources if wet grain is dried at low temperatures. Usually heated air is used in grain drying. For heating of air either solid or liquid fuel, electric or solar energy is used.

In grain drying applying the technology of low temperatures the same effect can be achieved as using high air heating temperature dryers or heat dryers. One of such technologies could be active ventilation of the grain layer at low air temperatures in ozone medium. In order to state the influence of ozone in grain drying, laboratory experiments were carried out. (Lauva et al., 2005a; Lauva et al., 2005b).

Materials and Methods

Experimental laboratory equipment was made up for simultaneous drying of grain using ozonized air and not using ozonized air (Figure 1). This equipment consists of ten grain cassettes; in each cassette a layer of wet grain of the density of approximately 20 mm is evenly refilled. The grain is weighed with electronic scales EW1500-2M with exactness (d = 0.01 g). The wet grain is dried using ozonized air (position 5) and without ozonized air (position 6). For drying of wet grain the air is fed by means of a fan (position 4), where the desired air filtration velocity that is controlled by an air flow velocity controller TESTO 400 (position 8) is set by a gradeless regulator. Ozone is produced by the ozone generator PRO 3,400 (position 2); in our experiments the amount of the produced ozone is 7.7 mg m^{-3} of air. As drying of grain is done using cold air, for regulation of the temperature of the in-flowing air before the fan a thermometer (position 1) is used and for regulation of the temperature before the grain cassettes thermometers (position 3) are used. The system is balanced by help of a throttle (position 7) in order to make the air filtration velocity through the wet grain with ozonized air equal to that without ozonized air. The moisture and temperature of the out- flowing air are regulated by help of the grain active ventilation regulation equipment GK-01 and air temperature sensors (position 9).

Artificially humidified grain was used as the object of the research. The initial moisture of grain was determined by the grain moisture meter Wille-55. At the end of the experiment for stating the amount of the carried away moisture the electronic scales EW1500-2M (d = 0.01 g) were used.

Results and Discussion

The experiments in grain drying were carried out at the air filtration velocity v = 0.2 m s^{-1} simultaneously with ozonized air and air without ozone. In the experiment grain with the initial moisture W1 = 21% and W1 = 27% was used. The duration of drying was two hours.

The experiments showed that the efficiency of ozone in grain drying appeared at the average grain initial moisture (W1 = 21%) as well as at wet grain (W1 = 27%) (Figure 2). During two hours of drying carrying away of moisture from grain is more intensive in the first cassette and it gradually decreases until the tenth. In all cases the amount of the carried away moisture from grain due to the influence of ozone is larger than that without using ozone. The presence of ozone in the grain active ventilation process

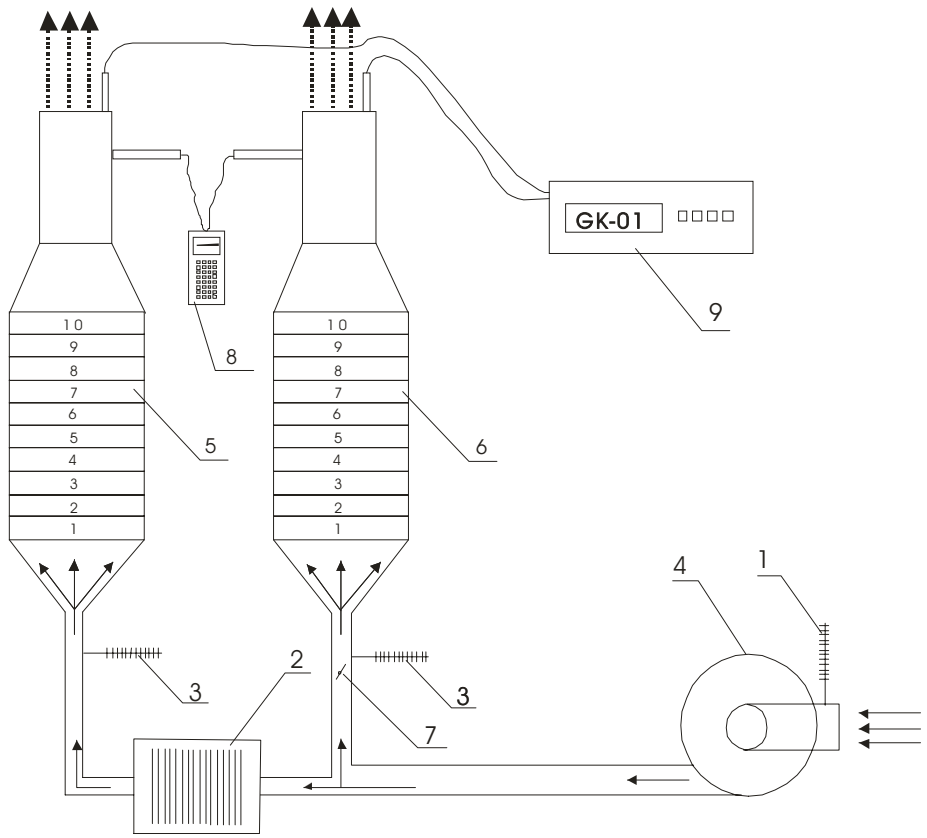

Figure 1. Experimental laboratory equipment for drying grain with ozonized air:
1 - thermometer for measuring the inflowing air temperature, 2 – ozone generator, 3 – thermometer for control of air temperature before the grain cassettes, 4 – fan, 5 – grain cassettes for drying of grain with ozonized air (10 pieces), 7 – throttle, 8 – air- flow velocity controller TESTO 400, 9 – grain active ventilation control devices GK-01 with air temperature – moisture sensors.

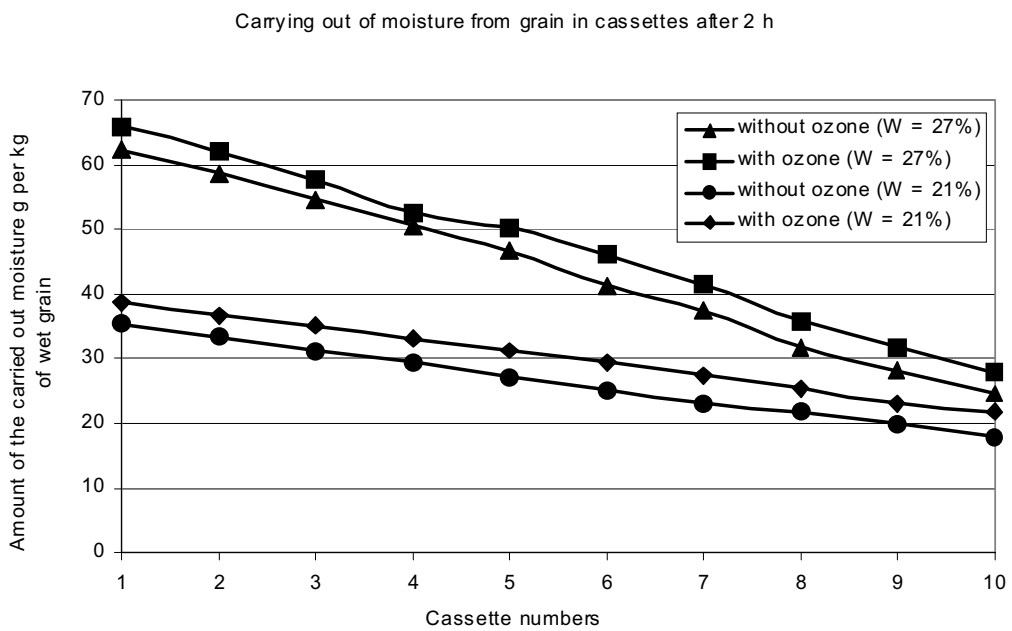

Figure 2. The amount of the carried out moisture (grams per kg of wet grain) after two hours drying grain with ozone and without ozone at the velocity v = 0.2 m s^{-1} and at grain moisture W = 21% and W = 27%.

increases the carried away amount of moisture (Figure 3). It shows that from the initial grain moisture the efficiency of using ozone does not change essentially. It can be seen from these experiments that ozone does not influence the initial process of grain drying essentially, as at the beginning of drying the moisture from the space in between the grains and the moisture from the surface of grains is carried away. It can be clearly seen in Figure 4, where drying grain during the first ten minutes from the first grain cassette approximately 20 g of moisture per kg of grain are carried away, but already within the next 20 minutes - only about 10 g of moisture per kg of wet grain.

Figure 3 demonstrates that after two hours of drying wet grain (W = 27%) the amount of the carried away moisture is larger due to which the moisture of grain in the first cassette is approximately 22%, but in grain of average moisture (W = 21%) - approximately 18%. At the beginning of drying the moisture amount carried away from grain with higher moisture content is larger. When grain becomes drier a longer period of time is necessary for drying as moisture is carried away from the grain itself.

It can be seen from these experiments that ozone does not influence the initial process of grain drying essentially, as at the beginning of drying the moisture from the space in between grains and the moisture from the surface of grains is carried out. It can be clearly seen in (Figure 4), where drying grain during the first ten minutes from the first grain cassette approximately 20 g of moisture per kg of grain are carried out, but already within the next 20 minutes only about 10 g of moisture per kg of wet grain.

Examining the moisture of the out-flowing air (Figure 5) it is seen that at equal initial out-flowing air temperature in the first 10 minutes of the process the moisture of air decreases because the moisture that is in the space between grains is carried away and only approximately after 20 minutes the process of drying starts inside the grain, then also ozone starts working as with decomposition of ozone energy is released that increases the temperature of the through-flowing air. A conclusion can be drawn that due to the influence of ozone, drying of grain occurs through the amount of the released energy, that is, with increasing of the drying agent temperature. Ozone does not essentially influence the initial process of grain drying while moisture that is in the space between grains is carried away, but its influence occurs after 20 minutes. The out-flowing air temperature starts to increase. With the air temperature increasing by 1 °C the moisture decreases by about 5%. The presence of ozone accelerates grain drying which results in the decrease of energy consumptuon. Laboratory experiments proved the efficiency of the presence of ozone in the process of active ventilation of grain.

Similar research has been carried out in Russia and Belarus (Trockaja, 1997, Golubkovich et al., 2005). Several hypotheses have been set out about the influence of ozone in the process of grain drying (Krivopishin, 1988). Using the active ventilation technology with ozonized air it is possible

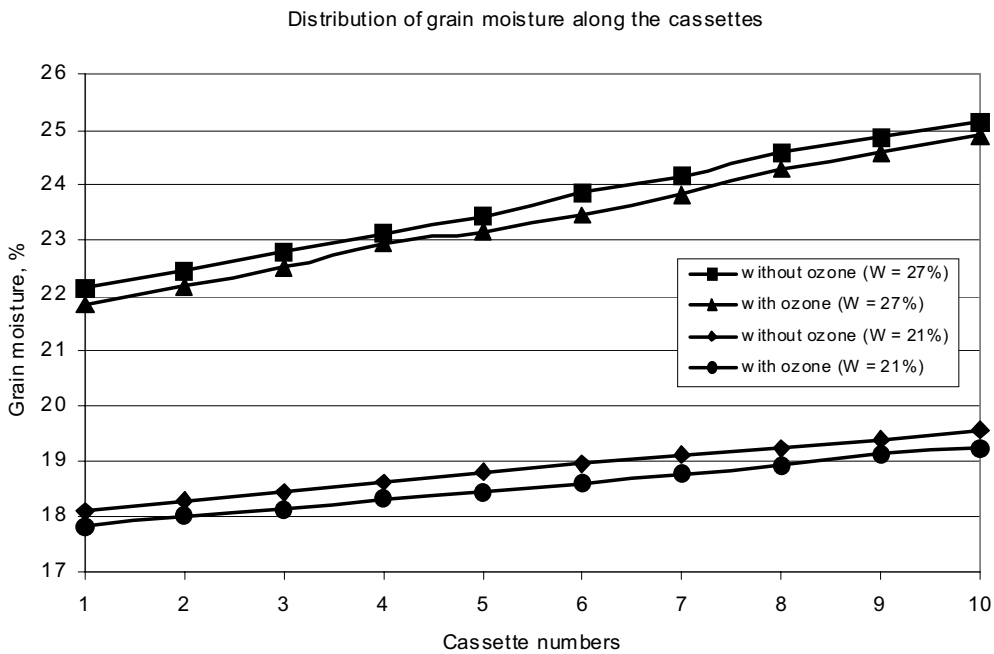

Figure 3. Distribution of grain moisture along the cassettes after two hours of drying with ozonized air and without ozonized air at different moistures of grain (W = 21% and W = 27%).

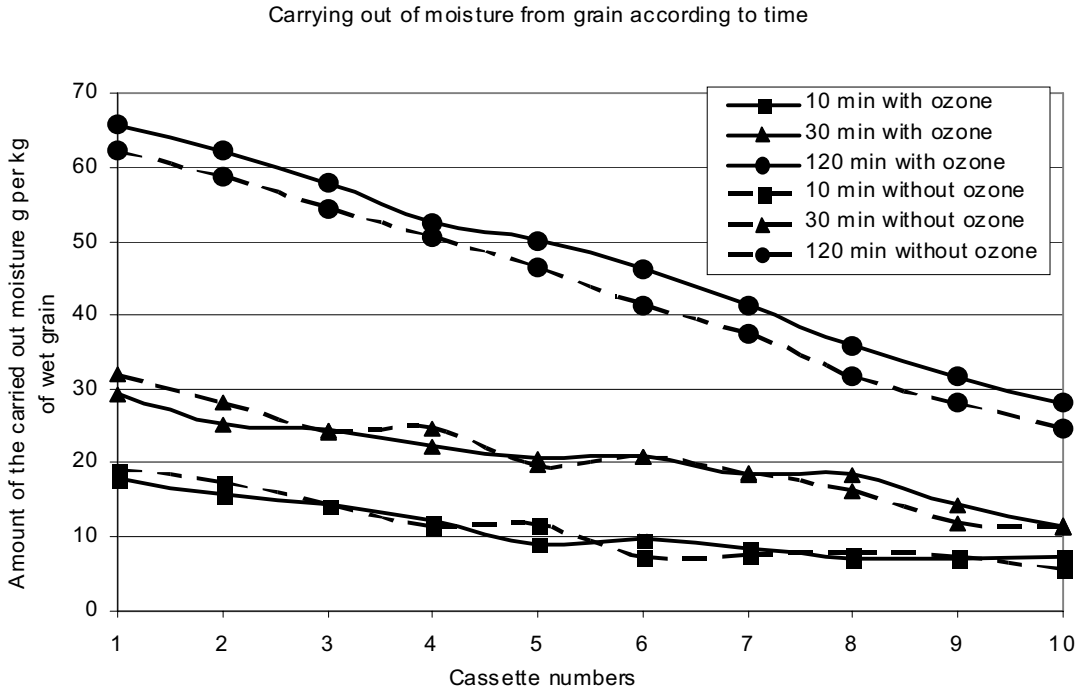

Figure 4.The amount of the carried out moisture g per kg of wet grain at different duration of drying (10 min., 30 min. and 120 min.) drying grain with ozone and without ozone, v = 0.2 m s^{-1}.

that for carrying away of 1 kg of moisture from grain 20% less energy is needed compared to drying without ozone use (Bogatova, 2005; Golubkovich et al., 2005).

Conclusions

In the experiments it was proved that the presence of ozone in the process of active grain drying increases the carried away amount of moisture. Ozone does not essentially influence the initial process of grain drying while the moisture in the space between the grains is carried away, but its influence occurs after approximately 20 minutes when the presence of ozone increases the grain drying in the result of what the consumption of energy decreases. With

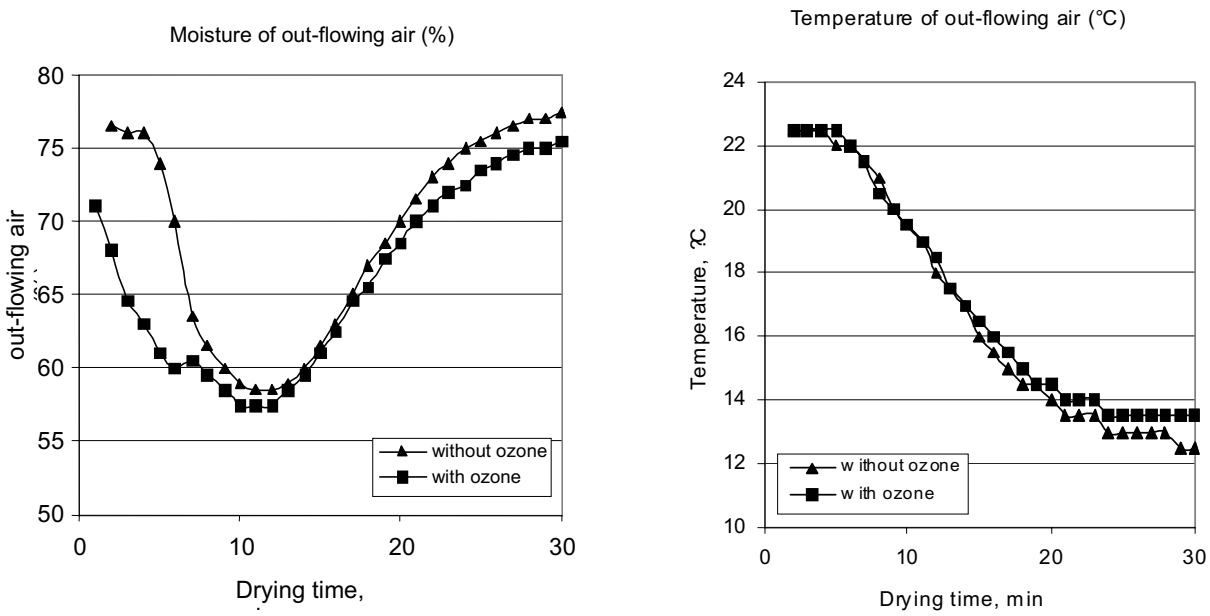

Figure 5. Moisture of the out-flowing air (%) and temperature °C ventilating grain with ozonized air and air without ozone at the velocity v = 0.22 m s^{-1}.

decomposition of ozone back to oxygen, additional energy is obtained that allows using this energy in drying of grain.

The presence of ozone in the process of grain drying increases carried away moisture amount, but it does not have essential influence on the efficiency of ozone usage from the initial grain moisture. Ozone does not influence the initial process of grain drying essentially as at the beginning of drying the moisture that is in the space between the grains and the moisture on the grain surface are carried away.

References

1. Trockaja T.P. (1997) Energy Saving Technology of Drying Agricultural Materials in Ozone – Air Medium. Predprint, Minsk, BelNIIMSH, 750 pp.
2. Golubkovich A.V., Vigodskij J.N., Bigodskaja N.J. et al. (2005) Efficiency of Using Ozone Air Mixtures in the Process of Drying Grain. Moscow, Available at: www.media-security.ru/, 04.2005
3. Krivopishin I.P. (1988) Ozone in Industrial Poultry Breeding. 2nd edition, revised and supplemented. - M., Rosagro-promizdat, 175 pp.
4. Chegev (2006) Ozonizing of Grain and other Sifting Products. Available at: http://www.media-security.ru/Chegev/OzonZerno.htm., 01.03.2006.
5. Bogatova Tatyana (2005) Ozone-oxidizer. Available at: http://www.ng.ru/science/2005-06-22/15_ozon.html., 22.06.2005.
6. Lauva A., Aboltins A., Palabinskis J. (2005a) Grain Active Drying Using Ozonized Air. / Proceedings of the international scientific conference 'Engineering Problems in Agriculture'. Jelgava. June 2-3, 2005, pp. 190-192.
7. Lauva A., Aboltins A., Palabinskis J. (2005b) Grain Active Drying Using Ozonized Air. Proceedings of the International Conference 'New technological processes and investigation methods for agricultural engeineering'. No.10. Raudondvaris 8 – 9 September 2005. – pp. 322 – 326.
8. Golubkovich A.V., Chizhikov A.G., Vigodskij J.N., Bigodskaja N.J. (2005) Intensification of the Processes of Temporary Grain Storage and Drying Using Ozonized Drying Agent. All Russian NII of Agricultural Mechanization. Available at: http://www.rus-ozone-assoc.ru/archives/1rus_conf_pr/Presentations/Golubkovich.pdf./,07.06.2005.

IMPACT OF THE SHARE INCLINATION ANGLE ON THE PLOUGH BODY RESISTANCE

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Abstract

The main parameters of the plough body that determine the ploughing efficiency are the initial and the final soil strip lifting angles on the share-mouldboard surface, the angles of its horizontal generatrix, the radius of this surface, and the working width of the body. By using analytical correlations derived as a result of theoretical research, a computer algorithm has been worked out for simulating the functions of the plough body and the forces exerted by soil upon the operating parts, as well as its draft resistance. These correlations allow to determinate the forces acting on the plough body and its draft resistance depending on the share inclination angle, as well as to evaluate its impact on the ploughing efficiency: energy, and the fuel consumption, and the quality of work. By increasing the initial lifting angle ε_1 (inclination angle of share toward furrow bottom) the draft resistance increases. For economical ploughing, the initial lifting angle of the soil strip must have a minimal value, its optimum may vary 28…32°. The use of bodies having optimal parameters allows obtaining good ploughing quality, reduce draft resistance by 12…20% and to raise correspondingly the efficiency, to save fuel and financial resources for ploughing.

Key words: plough body parameters, forces acting on the plough body, draft resistance, optimisation of parameters.

Introduction

Ploughing is one of the most power-consuming and expensive processes in agricultural production. It is known from our previous investigations (Vilde, 1999, 2004; Ruciņš et al., 2005) that the draft resistance of ploughs and energy requirement for ploughing depend on the plough body parameters and on such soil properties as its hardness, density, friction, and adhesion. However, there were no sufficient analytical correlations that would enable to determine the impact of the share inclination angle on the draft resistance of the share-mouldboard surface and the plough body, as a whole, as well as on the ploughing quality and expenses depending on the body parameters.

The purpose of the investigations is to study the factors that determine the quality and energy requirement of ploughing, the impact of body, parameters on it and to find technical solutions for its improvement.

Materials and Methods

The objects of the research are the forces acting on the plough body and its draft resistance depending on the body design parameters, as well as the physical and mechanical properties of soil and the mode of operation. On the basis of the previous investigations (Vilde, 1999), a computer algorithm has been worked out (Ruciņš et al., 2005) for the simulation of the forces exerted by soil upon the operating (lifting and supporting) surfaces of the plough body, and the draft resistance caused by these forces (Fig. 1).

Results and Discussion

Mathematical methods and computer algorithms worked out for the simulation of soil tillage processes allow calculating the forces acting upon the machine operating parts and their optimal design (including the plough body) for qualitative soil tillage with minimum energy consumption (Vilde, 1999, 2004; Ruciņš et al., 2004, 2005). According to this investigation, the draft resistance R_x of the plough body is determined by the share cutting resistance R_{Px}, the resistance caused by weight R_{Gx} of the strip lifted, by the inertia forces R_{Jx}, by soil adhesion R_{Ax}, and by weight R_{Qx} of the plough body itself (including a part of the weight of the plough). However, the latter is not dependent on the plough parameters:

$$R_x = \sum R_{ix} = R_{Px} + R_{Gx} + R_{Jx} + R_{Ax} + R_{Qx} \ . \qquad (1)$$

The vertical reaction R_z and the lateral reaction R_y of the operating part are defined by the sum of corresponding partial reactions:

$$R_z = \sum R_{iz} \qquad R_y = \sum R_{iy} \ . \qquad (2;\ 3)$$

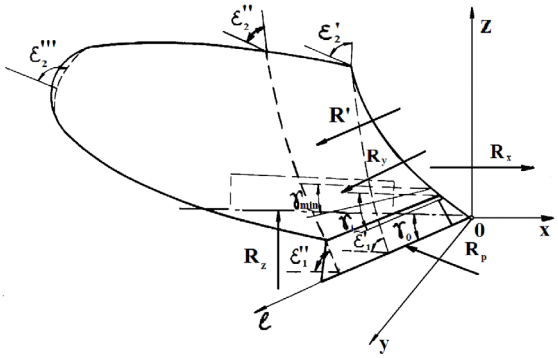

Figure 1. Scheme of the plough body, its parameters and acting forces.

The total draft resistance R_x of the operating part is composed of the resistance of the working surface R'_x and the resistance of the supporting (lower and lateral) surfaces R''_x:

$$R_x = R'_x + R''_x = \sum R'_{ix} + f_0 \left(\sum R_{iz} + \sum R_{iy} + p_{Axy} S_{xy} + p_{Axz} S_{xz} \right), \quad (4)$$

where

f_0 – the coefficient of soil friction along the working and supporting surfaces of the operating part;

p_{Axy} and p_{Axz} – specific adhesion force, respectively, to the lower and the lateral supporting surfaces of the plough body;

S_{xy} and S_{xz} – the surface area of the lower and lateral supporting surface of the plough body.

Cutting resistance R'_{Px} is proportional to soil hardness ρ_0 and the share edge surface area w:

$$R'_{Px} = k_p \rho_0 ib \ , \quad (5)$$

where

k_p – the coefficient involving the impact of the shape of the frontal surface of the ploughshare edge;

i and b – the thickness and width of the edge.

It is evident from formula (5) that the friction of soil along the edge does not influence the cutting resistance of the edge.

At a sharp ploughshare (the rear bevel is absent):

$$R_{Pz} = 0 \ . \quad (6)$$

At a blunt (threadbare) ploughshare having rear bevel, the vertical reaction R_{Pz} on the hard soils can reach the summary value of vertical reactions, this summary value arising from other forces acting on the share-mouldboard surface (soil gravity and inertia) and the weight of the body Q.

At an inclined ploughshare, a lateral reaction R_{Py} arises, its value being affected by the friction reaction:

$$R_{Py} = k_p \rho_0 ibctg(\gamma_0 + \varphi_0), \quad (7)$$

where

γ_0 – the inclination angle of the edge towards the direction of movement (the wall of the furrow);

φ_0 – the angle of friction.

Friction of soil along the ploughshare edge reduces the lateral pressure of the ploughshare (the pressure of the plough body against the wall of the furrow).

The resistance of the supporting surface

$$R''_{Px} = k_p \rho_0 ibf_0 ctg(\gamma_0 + \varphi_0) = F''_{Px} \ . \quad (8)$$

The total cutting resistance

$$R_{Px} = k_p \rho_0 ib[1 + f_0 ctg(\gamma_0 + \varphi_0)] \ . \quad (9)$$

The lateral cutting resistance of the knife is determined by formulae, similar to those for the cutting resistance from below. Consequently, similar to the above formulae will also be the formulae defining the impact of friction on the total resistance of the knife.

Forces caused by the weight of the lifting soil strip:

$$R'_{Gx} \approx q\delta g k_y r \sin^{-1}\gamma \{ [(\sin\gamma \cos\varepsilon_1 + \cos^2\gamma \sin^{-1}\gamma) e^{f_0 \sin\gamma (\varepsilon_1 - \varepsilon_2)} - (\sin\gamma \cos\varepsilon_2 + \cos^2\gamma \sin^{-1}\gamma)] \cos\varepsilon_1 (\cos\varepsilon_1 e^{f_0 \sin\gamma (\varepsilon_2 - \varepsilon_1)} - \cos\varepsilon_2) * (\cos\varepsilon_1 - f_0 \sin\varepsilon_1 \sin\gamma)^{-1} \sin\varepsilon_1 \left[\sin\varepsilon_1 \sin\gamma + f_0 (\sin^2\gamma \cos\varepsilon_1 + \cos^2\gamma) \right] \}, \quad (10)$$

$$R_{Gz} \approx q\delta g r \sin^{-1}\gamma \ (\varepsilon_2 - \varepsilon_1), \quad (11)$$

$$R_{Gy} \approx q\delta g r \sin^{-1}\gamma \ (\varepsilon_2 - \varepsilon_1)(\varepsilon_1 + 0.52) \ ctg \ \gamma, \quad (12)$$

$$R''_{Gx} = f_0 (R_{Gz} + R_{Gy}) = F''_{Gx}. \quad (13)$$

Forces caused by the soil inertia:

$$R'_{Jx} = q \ \delta \ v^2 k_y^{-1} \sin\gamma \ \{ (\sin\gamma \ \cos\varepsilon_1 + \cos^2\gamma \sin^{-1}\gamma) e^{f_0 \sin\gamma (\varepsilon_1 - \varepsilon_2)} - (\sin\gamma \cos\varepsilon_2 + \cos^2\gamma \sin^{-1}\gamma) + (\cos\varepsilon_1 - f_0 \sin\varepsilon_1 \sin\gamma)^{-1} e^{f_0 \sin\gamma (\varepsilon_2 - \varepsilon_1)} \sin\varepsilon_1 \left[\sin\varepsilon_1 \sin\gamma + f_0 (\sin^2\gamma \ \cos\varepsilon_1 + \cos^2\gamma) \right] \}, \quad (14)$$

$$R_{Jz} = q \ \delta \ v^2 k_y^{-1} \sin\gamma \ \sin\varepsilon_2 \ e^{f_0 \sin\gamma \ (\varepsilon_2 - \varepsilon_1)}, \quad (15)$$

$$R_{Jy} \approx q \ \delta \ v^2 k_y^{-1} \sin\gamma \ \cos\gamma \ (1 - \cos\varepsilon_2), \quad (17)$$

$$R''_{Jz} = f_0 (R_{Jz} + R_{Jy}) = F''_{Jx}. \quad (18)$$

Forces caused by soil adhesion:

$$R'_{Ax} = p_A b r \sin^{-1}\gamma \ (e^{f_0 \sin\gamma (\varepsilon_2 - \varepsilon_1)} - 1) * \{ \sin\gamma \cos\varepsilon_1 + \cos^2\gamma \sin^{-1}\gamma + (\cos\varepsilon_1 - f_0 \sin\varepsilon_1 \sin\gamma)^{-1} * \sin\varepsilon_1 \left[\sin\varepsilon_1 \sin\gamma + f_0 (\sin^2\gamma \cos\varepsilon_1 + \cos^2\gamma) \right] \}, \quad (19)$$

$$R_{Az} = 0, \quad (20)$$

$$R_{Ay} \approx 0, \quad (21)$$

$$R''_{Ax} = f_0 (p_{Axy} + p_{Axz} S_{xz}) = F''_{Ax}. \quad (22)$$

where:

q – the cross section area of the strip to be lifted;

δ – the density of soil;

k_y – the soil compaction coefficient in front of the operating part;

f_0 – the soil friction coefficient against the surface of the operating element;

v – the speed of the movement of the plough body;

p_A – the specific force of soil adhesion to the operating surface;

b – the surface width of the soil strip;

ε_1 and ε_2 are correspondingly the initial and the final angles of the lifting (share – mouldboard) surface;

γ – the inclination angle of the horizontal generatrix towards the direction of movement (the wall of the furrow);

g – acceleration caused by gravity (g = 9.81).

The soil friction coefficient and the specific force of soil adhesion are not constant values. Their values decrease with the increase in speed (Vilde et al., 2004). This is considered in calculations.

The obtained correlations (10) – (19) show how the initial lifting angle ε_1 of the soil strip (the inclination angle of the share) impacts the draft resistance of the share-mouldboard surface, the resistance of the supporting surfaces, and of the plough body in totality. The following graphs (Figs. 2 –12) show those changes of the draft resistances depending on the initial lifting angle ε_1 at the angle between the horizontal generatrix of the operating surface and the vertical longitudinal plane γ=40° and at the different speed v.

From the above graphs it follows that increasing of the

share inclination angle ε_1 leads to increasing of partial resistances caused by soil strip gravity, inertia forces and adhesion and, as a result – increasing the draft resistance R'_x of the share mouldboard surface (lifting surface) of the plough body from 6% to 13% (Figs. 2 – 5). The increase of the resistance is more remarkable at high speeds.

The resistance of the supporting surfaces of the plough body depends on the values of the reacting forces. Yet their value is dependent, in many respects, on the manner of unification and perfection of the hydraulically mounted implements of the tractor. The vertical reaction of the plough with modern tractors having power regulation is transferred to the body of the tractor, and it affects the plough resistance to a considerably lesser degree (Vilde et al., 2004).

Increasing of the share inclination angle leads to decreasing of the vertical reaction R_x (reaction of the lower

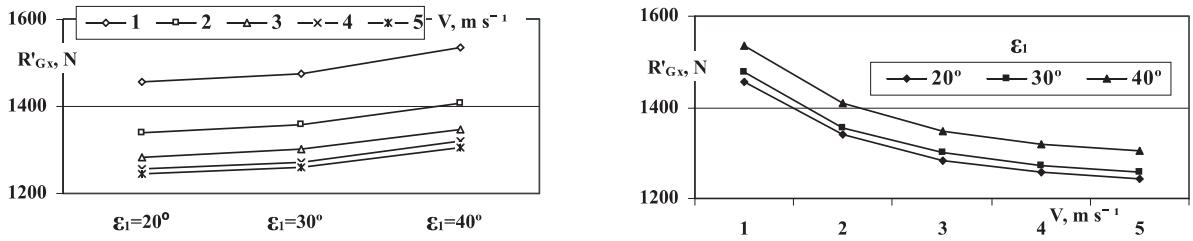

Figure 2. Draft resistance of the lifting surface caused by the gravity of the soil strip depending on the initial lifting angle ε_1 and speed v.

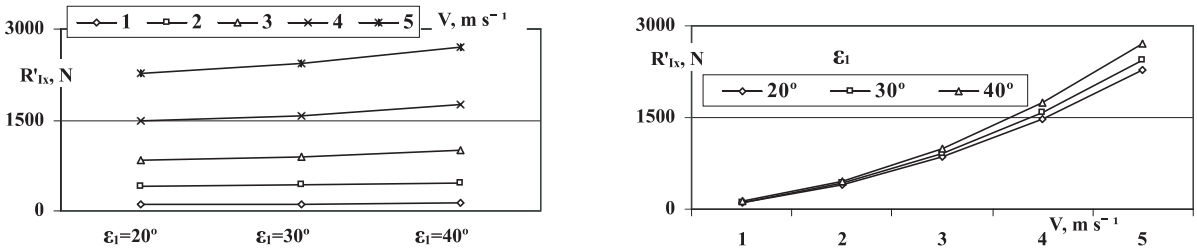

Figure 3. Draft resistance of the lifting surface caused by the soil inertia forces of the soil strip depending on the initial lifting angle ε_1 and speed v.

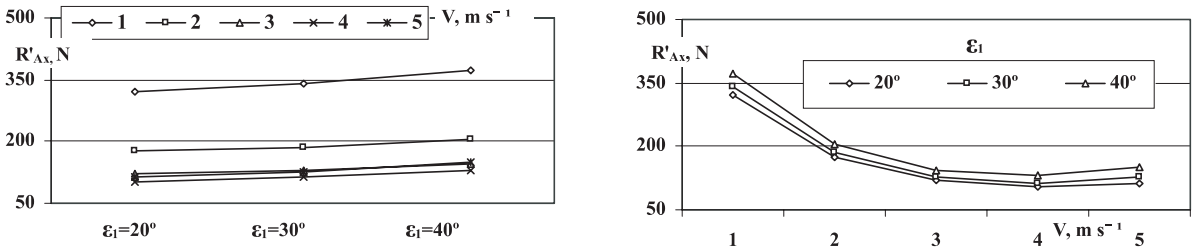

Figure 4. Draft resistance of the lifting surface caused by soil adhesion depending on the initial lifting angle ε_1 and speed v.

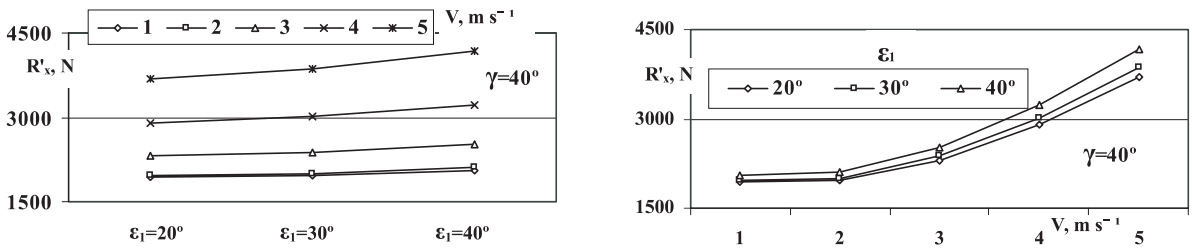

Figure 5. Total draft resistance of the lifting surface caused by soil gravity, inertia forces and adhesion depending on the initial lifting angle ε_1 and speed v.

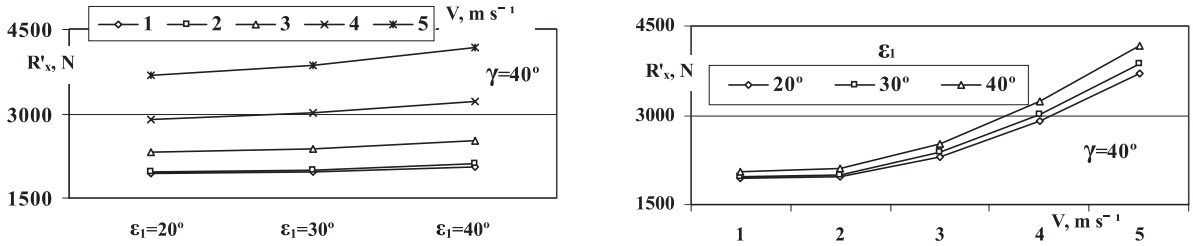

Figure 5. Total draft resistance of the lifting surface caused by soil gravity, inertia forces and adhesion depending on the initial lifting angle ε_1 and speed v.

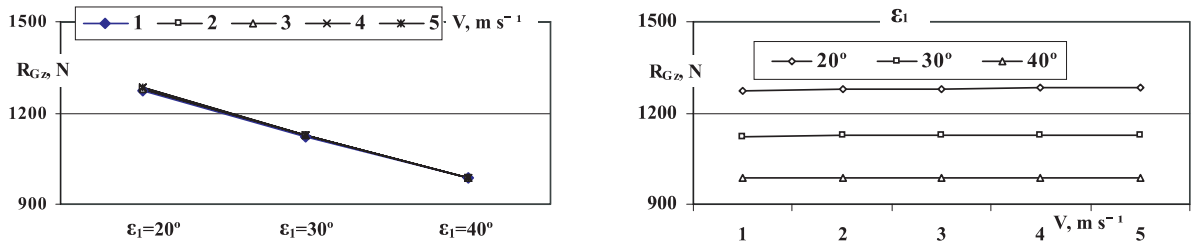

Figure 6. Reaction of the lower supporting surface caused by the gravity of the soil slice depending on the initial lifting angle ε_1 and speed v.

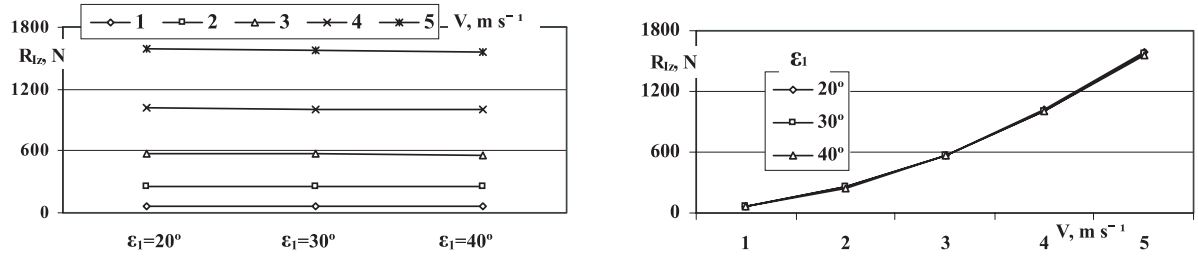

Figure 7. Reaction of the lower supporting surface caused by soil inertia forces depending on the initial lifting angle ε_1 and speed v.

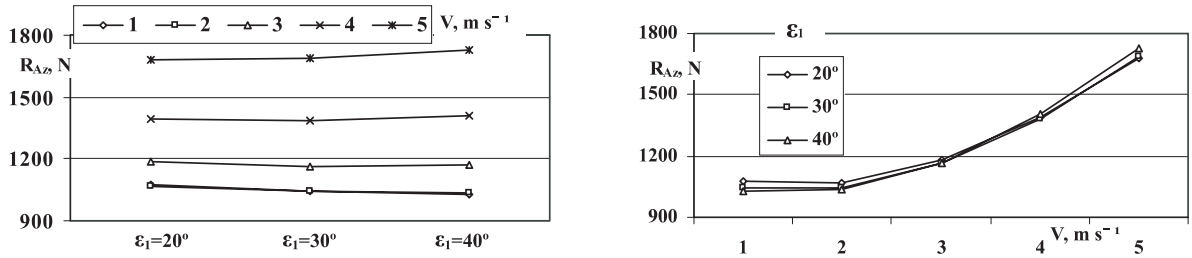

Figure 8. Reaction of the lower supporting surface caused by soil adhesion depending on the initial lifting angle ε_1 and speed v.

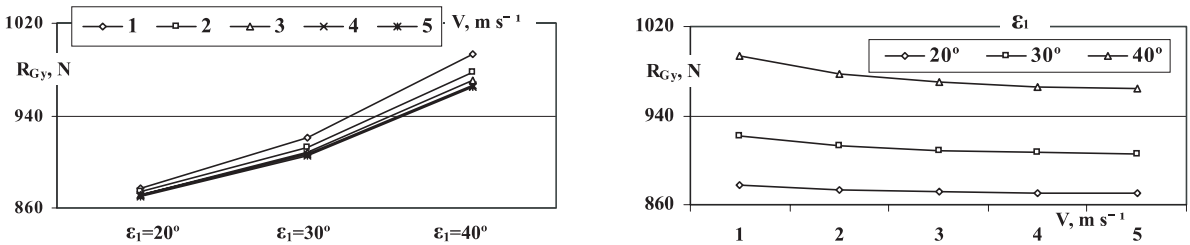

Figure 9. Reaction of the lateral supporting surface caused by the gravity of the soil strip depending on the initial lifting angle ε_1 and speed v.

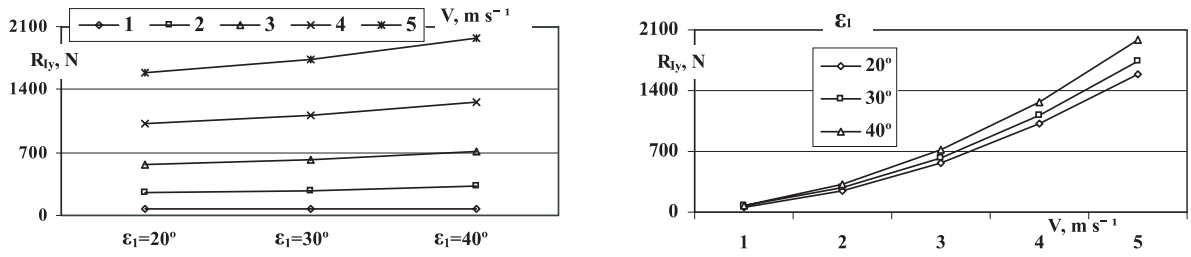

Figure 10. Reaction of the lateral supporting surface caused by soil inertia forces depending on the initial lifting angle ε_1 and speed v.

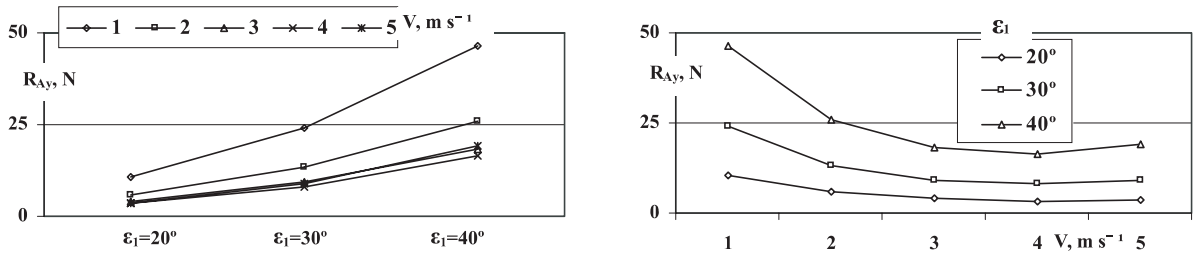

Figure 11. Reaction of the lateral supporting surface caused by soil adhesion depending on the initial lifting angle ε_1 and speed v.

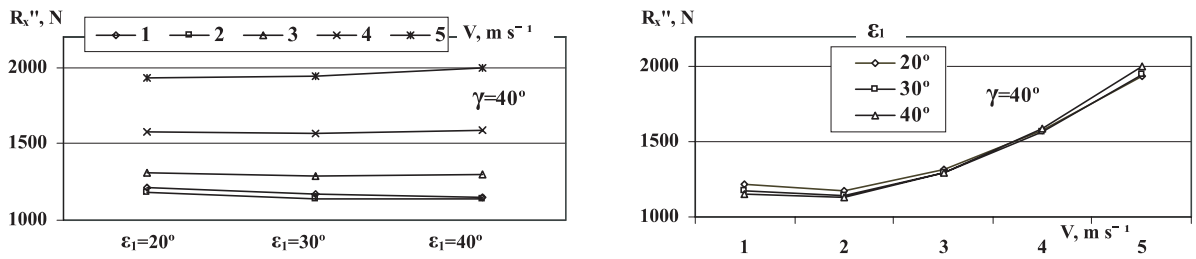

Figure 12. Summary draft resistance of the plough body supporting surfaces depending on the initial lifting angle ε_1 of the soil strip and speed v.

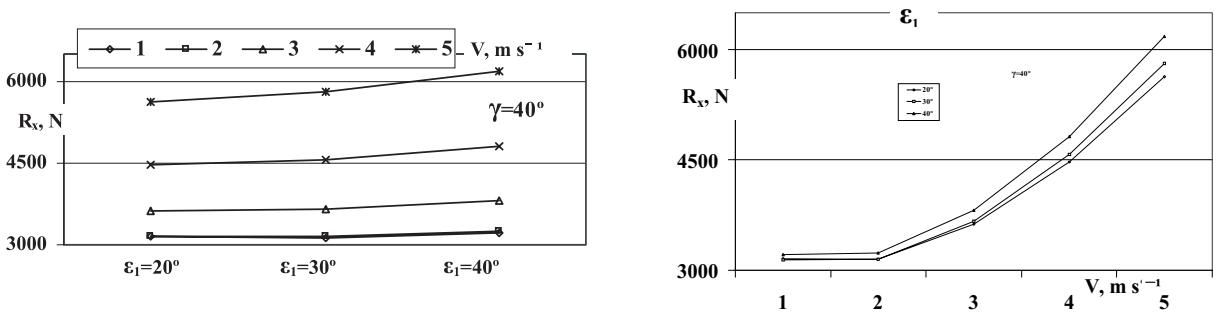

Figure 13. Total draft resistance of the plough body depending on the initial lifting angle ε_1 of the soil strip and speed v.

supporting surface) caused by soil strip gravity, has less influence on it of the forces caused by inertia and adhesion (Figs. 6 - 8) and leads to increasing of the lateral reactions caused by all theses forces (Figs. 9 – 11). In connection with that the change of the share inclination angle has insignificant influence on the draft resistance $R^{//}_{x}$ of the supporting surfaces (Fig. 12).

Changes in of the total draft resistance of the plough body depend on the mode of operation. If the plough is working in a floating mode, then increasing of the share inclination angle increases the draft resistance R_x of the plough bodies from 2% to 10% (Fig. 13), but if the plough is working with a power regulation means, the changes in the total draft resistance may be followed by the draft resistance changes in the share-mouldboard surface (at lower values of the total resistance the floating mode of operation).

The resistance component R_{px} to the cutting of a soil strip is not included into total resistance of the plough body, which is not dependent on the ploughshare inclination but on its sharpness (thickness of the cutting edge).

The materials of the calculations which were carried out using the correlations given above present the values and regularity of the changes in the forces acting on the share-mouldboard and the supporting surfaces, the draft resistance of the share-mouldboard and the supporting surfaces, as well as the total resistance of the plough body and its components under working conditions depending on the body parameters and the working speed. Possibilities to reduce the tillage energy requirement have been clarified.

The obtained materials show that by increasing the initial lifting angle ε_1 (inclination angle of share toward furrow bottom) the draft resistance increases. For economical ploughing, the initial lifting angle of the soil strip (the angle between the share and the furrow bottom) must have a minimal value – 24…30°. A smaller inclination angle is not desirable because of the wear of the share there is a possibility at the blunt (threadbare) ploughshare to obtain a rear bevel which can hinder the plough body from going into soil. This phenomenon is observed with the Kverneland plough bodies No. 8 having a 20° inclination angle of their outer part. For safer work in hard loamy soils its optimal value may be approximately 30° (28…32°).

In such a way, the deduced analytical correlations and the developed computer algorithm enable simulation of the soil coercion forces upon the share-mouldboard surface of the plough body, taking into consideration its draft resistance, as well as determination of the optimum parameters at minimum resistance.

The use of bodies having optimal parameters allows obtaining good ploughing quality, reduce draft resistance by 12…20% and to raise correspondingly the efficiency, to save fuel and financial resources for ploughing (Ruciņš et al., 2004).

Conclusions

1. The deduced analytical correlations and the developed computer algorithm enable simulation of the soil coercion forces upon the operating surfaces of the plough body, determination of its specific draft resistance depending on the body design, the working parameters and soil properties and motivation of the optimal values of parameters.

2. Presentation of the draft resistance of the plough body as the sum of its components – the cutting resistance of the strip, the resistance caused by its weight, the soil inertia forces and adhesion – allows analysis of the forces acting upon the share-mouldboard surface, finding out the character of their changes depending on speed and the parameters of the surface, and assessment of their ratio in the total resistance.

3. The main parameters affecting the ploughing efficiency are: the initial and the final angles of the lifting (share-mouldboard) surface; the inclination angle of the horizontal generatrix towards the direction of the movement and the regularity of its variation; the thickness of the share edge; the radius of the lifting surface and the area of the lifting and supporting surfaces.

4. By increasing the initial lifting angle ε_1 (inclination angle of the share toward furrow bottom), the draft resistance increases. For safer work in hard loamy soils its optimal value may be approximately 30° (28…32°).

5. The use of bodies having optimal parameters allows obtaining a good ploughing quality, reduction of the draft resistance by 12…20% and a corresponding rise in the efficiency, saving fuel and financial resources for ploughing.

References

1. Vilde A. (1999) Dynamics of the soil tillage machine operating parts and their elements. In: Proceedings of the Latvia University of Agriculture, Vol.1 (295). Jelgava, Latvia. pp. 36-44.
2. Vilde A. (2004) Mechanical and mathematical foundations for modelling the dynamics of soil tillage machine operating parts. In: TEKA Commission of Motorization and Power Industry in Agriculture, Volume IV. Polish Academy of Sciences Branch in Lublin. – Lublin, Poland, pp. 228–236.
3. Rucins A., Vilde A. (2004) Mathematical modelling of the operation of plough bodies to determine their draft resistance and optimum parameters. In: TEKA Commission of Motorization and Power Industry in Agriculture, Volume IV. Polish Academy of Sciences Branch in Lublin. Lublin, Poland, pp. 177–184.
4. Vilde A., Rucins A. (2004) The impact of soil physical and mechanical properties on draft resistance of ploughs. In: TEKA Commission of Motorization and Power Industry in Agriculture, Volume IV. Polish Academy of Sciences Branch in Lublin. Lublin, Poland, pp. 243–248.
5. Vilde A., Cesnieks S., Rucins A. (2004) Minimisation of soil tillage. In: TEKA Commission of Motorization and Power Industry in Agriculture, Volume IV. Polish Academy of Sciences Branch in Lublin. Lublin, Poland, pp. 237 – 242.
6. Rucins A., Vilde A. (2005) Modelling forces acting on the plough body. Simulation in Wider Europe. 19th European Conference on modelling and Simulation ECMS 2005 June 1-4, 2005 Riga, Latvia. Riga, pp. 414-419.
7. Rucins A., Vilde A. (2005) Impact of the working width of the plough body on the tillage efficiency. In: Research for rural development 2005. International scientific conference proceedings. Jelgava, 19-22 May, 2005. Jelgava, pp. 36-42.

WATER MANAGEMENT

INVESTMENT INTO WATER MANAGEMENT IN LITHUANIA

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Abstract

The development of the water management economy must satisfy the demands of the society and create the assumptions for a balanced development of the Lithuanian economy. Therefore it is essential to develop a politically independent, innovative and effective water management economy, which shall ensure the supply of the continuous, long-term and accessible services of water supply and wastewater management, socially necessary to all users, the quality of which shall meet the provided requirements.
Lithuanian economy has been evolving towards the market economy for the entire decade after the restoration of the independence in 1991. The situation in water supply and maintenance economy was complicated: water management economy in most localities was worn and economically ineffective, wastewater treatment equipment was physically and morally outdated.
After joining the European Union, it was required to harmonize the national requirements with the legislation of the European Union: the core attention in the water management sector had been given to the implementation of the Directive of the Common Water Policy. The implementation of the European Union requirements in the water management sector required big financial investment. The objective of this article is to evaluate the investment into the water management sector in Lithuania.
The European Union, the International financing institution and national sources are the main resources for the financing of the development of the water sector. In 2000–2003, the subsidies and grants from the aforementioned organizations amounted to 1,169.921 thousand LTL. In order to improve the assimilation of the investment, it is essential to increase the pay-back of the water management sector, modify the current management, administration and control structure of the companies in the water management sector.
Key words: water management, investment, European Union

Introduction

Lithuania has been transforming its rural development sector during the past decade. This has included transformation of water management. The maintenance of large-scale drainage systems installed during the former period needs a lot of organizational and financial support. The study presents a critical analysis of the present state of water management infrastructure in Lithuania. The existing opportunities are highlighted, with the emphasis on actions to be taken to explore the challenges arising.

After joining the European Union, it was required to harmonize the national requirements with the legislation of the European Union: the core attention in the water management sector had been given to the implementation of the Directive of the Common Water Policy. The implementation of the European Union requirements in the water management sector required big financial investment. The objective of this article is to evaluate the investment into the water management sector in Lithuania.

Materials and Methods

Methods: the analysis of the scientific literature and documents; the analysis of the statistical data; the SWOT analysis.

Results and Discussion

The drinking water for the consumers in the Republic of Lithuania is supplied solely from the underground water sources, which in most cases is of good quality. In 2004, the consumption of the drinking water amounted to 17 million cubic meters per annum, which was 26 percent less than consumed in the year 1997. However, the general tendency shows the growth in the consuming of drinking water (see Fig.1).

Approximately 66% of all population in Lithuania is provided with the water supplied centrally (90–95 percent of the population of the biggest cities and approximately 20–30 percent of the village population). Approximately 1 million of the population uses ground water from the dug wells, which is often polluted and does not meet the requirements, applied for the drinking water.

From 1996 till 2000, the general consumption of water decreased by 37 percent, and starting from the year 2001, it started to grow and, compared to the data of the year 2004, has increased by 53 percent (see Fig.2).

Referring to the statistical data of 2004, the total length of the water supply networks in the cities, towns and villages of the state was 10.947 km. Approximately 80 percent of these networks are made of cast iron, and approximately 17 percent are made of steel. According to the calculations of the specialists, the condition of 77 percent of these networks is satisfactory, and the remaining networks must be repaired or reconstructed. The total output of the water supply network is 1704 thousand cubic meters every 24 hours.

In 1990, in accordance with the requirements applicable at that time in Lithuania, 25% of the collected

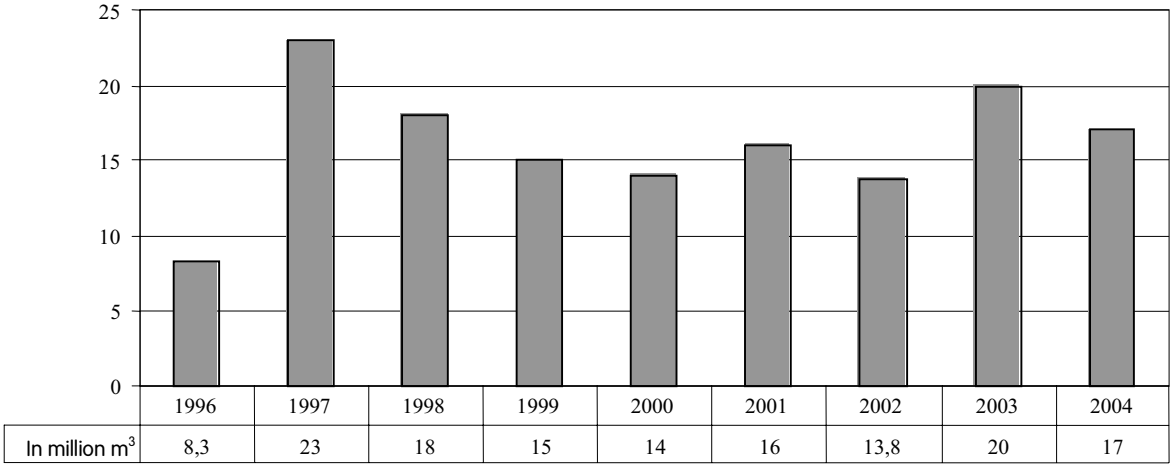

Figure 1. The consumption of the drinking water in Lithuania in 1996-2004, million cubic meters (Department of Statistics to the Government of the Republic of Lithuania, 2005).

wastewater was treated. After the restoration of the independence, the main attention of the state in the area of the environment protection was paid to the treatment of the city wastewater. Within the last 14 years, according to the data of the Department of Statistics to the Government of the Republic of Lithuania, approximately 1, 2 billion litas has been invested into the construction of sewage systems for the biggest cities, therefore currently there is 69% of waste-water, collected through the centralized systems, treated according to the requirements in force (see Table 1). The waste-water from the small towns and villages is not treated at all or treated insufficiently and, though the waste-water amount in the total amount of the collected waste-water is not very large, the number of objects is great, therefore the conditional price of the problem solving is much higher than for the analogical implementation in the biggest cities. Approximately 600 of the waste-water treatment facilities in small towns and countryside townships are worn, therefore it is necessary to update them or build new ones. The service for the centralized collection and management of waste-water is accessible only to 58% of all population in Lithuania, though this indicator is much smaller in the countryside.

There are quite big mismatches, comparing the main indicators of the water management economy in Lithuania with the average indicator of the countries of the European Union. The centrally supplied drinking water of good quality is delivered to approximately 63 percent of the consumers

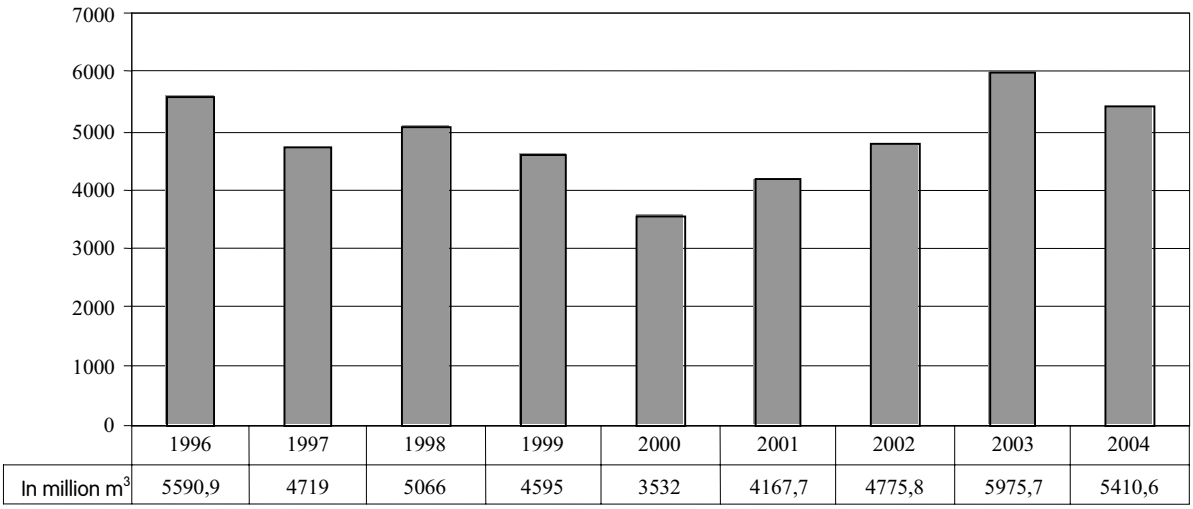

Figure 2. The total water consumption in Lithuania in 1996-2004, million cubic meters (Department of Statistics to the Government of the Republic of Lithuania, 2005).

Table 1

Of the main indicators of the water management economy in Lithuania in 2004 (Ministry of the Environment, 2005)

The analyzed indicator (by priority)	The dimension of the indicator	The value of the indicator in Lithuania	The average value of the indicator in the countries of the European Union
The treatment of the waste-water to the established requirements	The share of the wastewater, treated to the established requirements, in percent	69%	92%
Everyday water consumption	The amount of the consumed water, in liters for one resident per day	74l	150l
The quality of the centrally supplied drinking water	The share of centrally supplied drinking water, which meets the requirements for such water, in percent	63%	90%
The centralized water supply in the village settlements	The number of the consumers of the centrally supplied water in the village settlements (up to 2000 residents), in percent from the total number of the residents of such settlements	34%	80%

in Lithuania and 90 percent of the consumers for the EU countries. The visionary amount of the consumed water, that is likely to decrease, is 74 l on average, and one resident of the EU countries consumes 150 l on average every twenty four hours. In the village settlements (up to 2000 residents), only 34 percent of the population uses the centralized water supply, and this number in the EU countries is 80 percent. In Lithuania, 69 percent of the household waste-water is completely treated, and this number in the EU countries is 92 percent (see Table 1).

The state of the water management sector is summarized by the analysis of strengths, weaknesses, opportuni-

Table 2

The SWOT analysis of the water management sector (Lithuanian water suppliers association, 2005)

Strengths	Weaknesses
1. Sufficient resource of good quality underground water in the most of Lithuania 2. Favourable conditions for the development of the legal regulations for the water supply and waste-water management economy 3. Established preconditions to obtain the financial support from the funds of the European Union 4. There is a large share of the infrastructure for the centralized water supply and waste-water management developed 5. Long years of practice in public water supply and wastewater management 6. High qualification of the operation personnel in the city companies 7. The territory planning principles are advantageous to the development of the infrastructure for water supply and waste-water management 8. Established legal preconditions for the price determination, based on the economic principles	1. Insufficient and inconsistent legal framework, which regulates activities of the water supply and wastewater management 2 The rate of increase in the cost of water supply and waste-water management in populated localities is greater than the increase in the earnings of the population 3. Most water companies (especially smaller ones) work at a loss, they are unable to invest (borrow) by themselves and do not meet the requirements, necessary to receive assistance from the EU 4. The development of the centralized water supply and waste-water management infrastructure and constructions is unbalanced 5. The regional development of the services in the water supply and waste-water management sector is not implemented 6. The largest share of the developed water supply and waste-water management infrastructure does not meet the demands, is uneconomic, or worn

9. The developed system for the accounting of the amount of water consumed	7. The principle of „expenditure return" is not universally applied, therefore water suppliers do not have sufficient finances for the development and maintenance of the infrastructure, which would meet the demands 8. The water economy is segmented into companies of various sizes and of various output capacities, where most of them are unable to ensure the quality of the services and administer development
Opportunities	Threats
1. To improve the legal framework, which regulates activities of the water supply and wastewater management 2. To rearrange management of the water sector by concentrating the assets and the providing of the services 3. To effectively use the financial support from the EU funds 4. To establish the preconditions for participation of the private sector in the development and management of the water supply and waste-water management economy 5. To create more favorable work conditions for the companies, which provide public water supply and wastewater management services	1. Growth of the prices of drinking water and wastewater-management due to the implementation of the EU requirements 2. Growth of disproportion in the conditions of provision of the services of the drinking water supply and wastewater management in the cities and country side regions 3. Incompetence in using financial support of the EU funds for implementation of the requirements for the water supply and waste-water management in small conurbations 4. Activities of the water supply and waste-water management may remain economically unpaid-back and shall require assistance from the state 5. Without ensuring the provision of high quality services for an acceptable price, utilization of the infrastructure may decrease, the provided services may become prohibitive and inaccessible to the consumers, which have small income

ties, and threats (hereinafter referred to as SWOT analysis) (see Table 2).

According to expert opinion, 2230 million litas will be required for the implementation of the directives of the European Union in the sector of water management, and they will be allocated till the year 2010. More than one half of this amount shall be allocated for the implementation of the directive for the Urban waste-water treatment, and less than one third of it shall be allocated for the implementation of the Nitrate directive. The remaining amount is constituted of the costs for implementation of the directive for the Integrated pollution prevention and control and the Drinking water directive. The implementation costs of other water sector directives are comparatively small. While calculating the investments it was presumed that the expenditure for the maintenance and supervision amount to 7%. The annual investment till the year 2010, which shall be needed for the implementation of the most important directives are demonstrated in Figure 3.

Domestic and foreign finance resources play an important role in financing the water management sector. The main economic means are subsidies, charges for the pol-

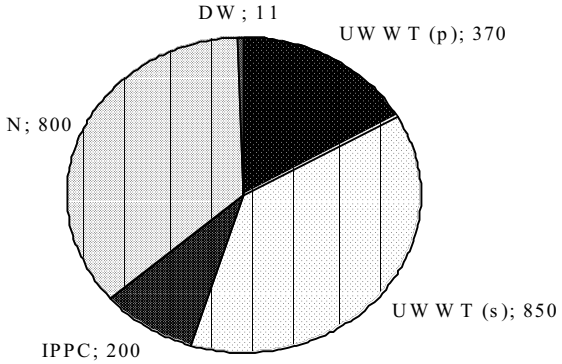

Figure 3. The annual investment into the water management economy for the implementation of the requirements of the European Union, in million LTL. (Ministry of Finance, 2005).

Note:

UWWT (p) – investment for the implementation of the directive of the Urban waste-water treatment – treatment equipment;
UWWT (s) - investment for the implementation of the directive of the Urban waste-water treatment - networks;
IPPC - investment for the implementation of the directive for the Integrated pollution prevention and control;
N - investment for the implementation of the Nitrate directive;
DW - investment for the implementation of the Drinking water directive.

lution, and user fees. The following domestic resources are used for financing in Lithuania:

- the total revenue of the state and municipalities;
- charges for the pollution and penalties;
- the user fees for the services received from the municipalities;
- the internal resources of the facilities;
- the commercial capital (credits and stock).

It is expected that in the future the private sector will invest into water economy from the current remnants, profit, or stock. The existence and use of these private finances greatly depend on the general economic state and effectiveness of the environment protection. There are the following foreign financing resources:

- the financing from the international financing institutions;
- the assistance of various foreign countries for the the environment protection.

The European Union, the International financing institutions and national resources are the main financing sources for the development of the water sector. In 2000–2003 the subsidies and grants from the aforementioned organizations comprised 1,169.921 thousand LTL (see Fig.4).

ISPA – is one of the main financing sources for the environment protection, the finances of this resource have been and are still used in Lithuania for financing of the projects of the water and waste sector. In 2002-2004 there were 14 investment projects for ISPA financing, and which were allocated 345 million litas for their implementation. After joining the European Union, ISPA transformed into the Cohesion fund. The Cohesion fund of the European Union is another potential sources of financing, from which Lithuania should receive 80-100 million litas on average.

Furthermore, Lithuania can use the structural funds. According to the calculations of the Ministry of the Environment, Lithuania annually receives 30 million litas from the EU Regional development fund. If the project, related to the agriculture, improves the quality of water, the implementation of such project may receive the assistance from the EU SAPARD program.

The International financing institutions: The World Bank, ERPB, and EIB allocate subsidies and soft loans for the environment protection. According to the regulations and cooperation agreements with the international financing organizations, applicable in Lithuania, every year at least 50 million litas are allocated for the environment protection means.

The national financing sources, compared to the foreign sources, are relatively small. Every year 40 million litas are allocated from the State budget for the financing of the water management projects. Contribution of the Environment protection funds is rather small, compared to other sources of financing. The opportunities for the financing of the water management projects from the budgets of municipalities or the environment protection funds of the municipalities are also very limited. It is expected that the private capital should commit such amount of the investment which is needed for the development of the municipal infrastructure.

In most cases the decisions regarding the investments, made by the municipal institutions, irrespective of the development of the water management economy, actual prices and the decrease in consumption and the possibilities of the repayment of the credits, have been not optimal, since there have been the facilities built, which have from 2 to 5 times bigger capacity than the actual capacity needed. The water management companies have not yet started returning these loans, and some of the loans have been

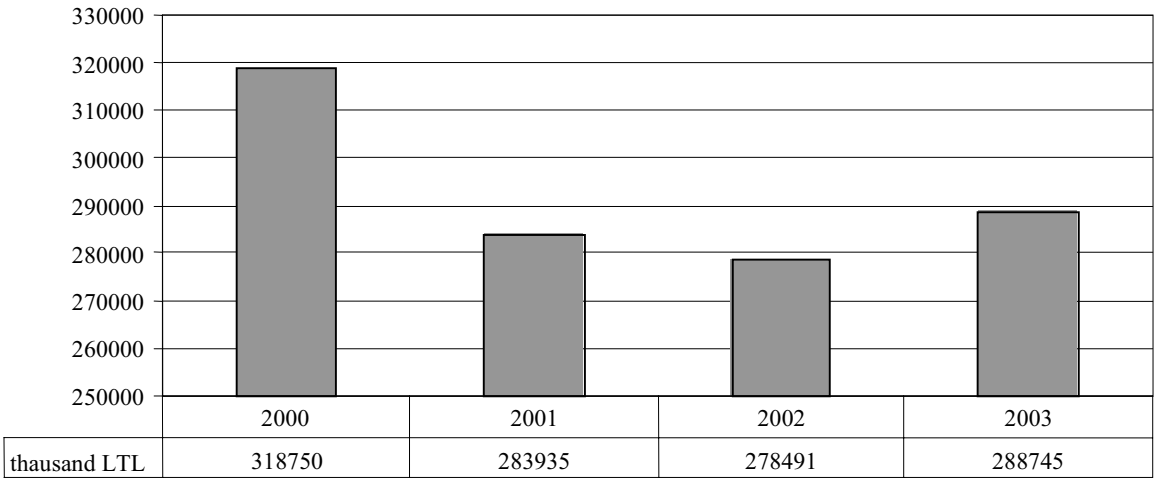

Figure 4. The subsidies and grants, allocated for the water management economy in Lithuania, thousand LTL. (Department of Statistics to the Government of the Republic of Lithuania, 2005).

started to be repaid from the State budget due to the insolvency of the companies. The proportion of loans and income is far from showing that these loans can be repaid given the current effectiveness of the water management economy. One of the main reasons for such situation is politicized system for price determination. According to the laws currently in force, the consumer prices are approved by the municipality councils, which do not always take the necessary investment or the actual cost of water into consideration. Though the price projects must be coordinated with the National Control Commission for Prices and Energy before the approval, this institution only has limited opportunities to determine the processes for the price determination and investment planning. The main limitations in assimilating the investments in the water management economy are: the increase in financial incapacity of the water management economy, big subscribers, disconnecting because of the increasing costs, inability to co-finance the ISPA/ Cohesion funds projects, inability to update and expand, environmental and social problems, and non-application of one's undertakings and termination of the operation of many small water management objects due technical wear and financial position. In order to alter the emerging situation, it is necessary to increase the pay-back of the water management sector. The rates for the users must be of such value so they could maintain the water management business and the investments could be made into the improvement of the quality of services and the maintenance of the technical condition. Since the water management sector is the economical activity, which may be economically payable back, there is a probability that by proper legal regulations, by eliminating the politicized management of the sector and by optimizing the management of the companies and having created an opportunity for the companies to receive a necessary amount of investment and know-how, the water management companies will have opportunities to operate effectively, invest the loan funds and repay the loans by the means of the funds, which shall be obtained from the economical activity. In light of the fact that the investment needs partial financing from the state and by assessing the necessity to ensure the rational use of the funds based on effective management, it is essential to modify the current management, administration and control structure of the companies in the water management sector.

Conclusions

1. The development of water management economy must satisfy the demands of the society and establish the preconditions for balanced development of the Lithuanian economy. Therefore it is important to develop a politically independent, innovative and effective water management economy ensuring the supply of continuous, long-term and accessible services of water supply and wastewater management necessary to all users, the quality of which would meet the provided requirements.

2. Lithuanian economy has been developing towards the market economy for the entire decade after the restoration of the independence in 1991. The situation in water supply and maintenance economy was complicated: water management economy in most localities was worn out and economically ineffective, wastewater treatment equipment physically and morally outdated

3. European Union, International financing institution and national sources are the main resources for the financing of the development of water sector In order to improve the assimilation of the investment it is essential to increase the pay-back of water management sector, also to modify the current management, administration and control structure of the companies.

References

1. Department of Statistics to the Government of the Republic of Lithuania Available at: http://www.std.lt, 10.12.2005.
2. Ministry of the Environment of the Republic of Lithuania Available at: http://www.am.lt, 10.12.2005.
3. Ministry of Finance of the Republic of Lithuania. (2004) The projection of the economical indicators in Lithuania 2005 – 2008. Available at: http://www.finmin.lt, 04.27.2005.
4. Lithuanian water suppliers association. (1997) Directions for the use of the water management economy. Vilnius, pp. 1-5.
5. Sakalauskas A., Stankevičius V., Petrulis B., Šulga V. (1982) Water supply. V.: Mokslas, pp. 123-134.
6. The improvement of the water sector management, implementing the requirements of the EU in the area of environmental protection. (2001) Research / Prepared by FMĮ UAB 'Suprema', UAB 'EkoRivi', the law office 'Jurevičius, Balčiūnas ir partneriai', 254 pp.
7. Water management. The information publication of the Lithuanian water suppliers association, pp. 23-56.

THE POLLUTANT SPREAD AND STREAM SELF-PURIFICATION MODELLING WITH DIFFERENTIAL EQUATIONS

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Abstract

The paper analyses possibilities to model the concentration of DIN – a harmful pollutant from the eutrophication point of view – contained in the stream and self-purification processes of the stream. During the studies the data of a small right affluent of the river Mūša (administrative district of Biržai) was used. The data comprised results of natural observations about the changes in DIN concentrations during the vegetation period and cold period of the year.

The model of pollution dispersion through the stream is a parabolic differential equation with partial derivatives, initial as well as boundary conditions. Constant DIN pollution in a stream stretch containing constant hydrological parameters and adequate environment conditions is proportional to the concentration of pollutants inflow. Further from the pollution source the constant pollution is exponentially decreasing. At the distance expressed by x(m) from the initial pollution concentration c_0 measuring place, DIN concentration is expressed by $C(x) = c_0 e^{-0.00017x}$ in the cold season of the year and by in $C(x) = c_0 e^{-0.00031x}$ during the vegetation period. The stream polluted in the result of agricultural activity, further flowing through forest-covered area is significantly purified already at a 1.5 km stretch. Relatively, DIN concentration decreases about 3.8 times a day during the vegetation period and about 2.7 times a day during the cold season of the year.

Key words: stream, pollution, modelling, self-purification.

Introduction

Climatic conditions have determined that the most profitable and suitable for agricultural activity soils in Lithuania are waterlogged and naturally do not contain much nutrients. Drainage creates the basic conditions for the development of agriculture here. One of the principal conditions to obtain rich yield in drained land plots is the annual fertilization of the soil. Drainage drains the soil and thus discharges a rather large amount of plant-unavailable fertilizer salts. Water of channels discharges those nutrients into streams and rivers and in such way pollutes them.

According to the Law of Environment Monitoring, in Lithuania water quality of nearly 50 rivers is under observation. Water in most rivers, particularly in the Mūša, the Kulpė, the Obelis, the Lėvuo, the Tatula, the Sidabra (the Mūša basin), the Nemunėlis, and the Laukupė (the Nemunėlis basin) is polluted (sometimes even heavily polluted) with nitrogen and phosphate substances (Ministry of Environment of the Republic of Lithuania, 2002). Despite the self-purification processes, water in the lower reaches of the river often contains twice as much mineral salts than water in the upper reaches. Such increased pollution of river water is often explained by two pollution sources – pollution from agriculture and industrial wastewater.

To describe the processes of river water quality, different mathematical models have been used for many years. Those models contribute to the investigations of water pollution problems, prognosis of water quality, and estimation of the state of the aquatic ecosystem. Possibilities for natural self-purification processes are different in every individual river, because each river has different hydrological and basin characteristics, as well as type and loading of pollution.

During the process of land reclamation, a large number of water flows was made into channels in Lithuania, which resulted in the changes in natural environment and hydrological network. Effluents of regulated streams often entered drained lands, the peculiarities of pollution and purification of which have not been analyzed in scientific literature so far. Seeking to manage the pollution of river water from the ecological point of view, it is important to know how agricultural pollution is spreading from river effluents via different streams, as well as how small streams are capable of self-purification.

The objective of the study was on the basis of a mathematical model to describe the flow of fertilizer salts from agricultural land plots via the stream as well as the self-purification process of the stream from similar pollutants. The first task of our study was on the basis of a differential equation to model the concentration of nitrate nitrogen, a dangerous pollutant from eutrophicational point of view, contained in the stream, and self-purification abilities of the stream.

Materials and Methods

Characteristics of the studied stream

The stream under investigation - the Bėrė (13 km long) - is a right tributary on the river Mūša. The sources of the stream are located in drained lands of Kirdonys village (in administrative district of Biržai). Runoff fluctuations of the drainage that gives the source to the stream affect the runoff of the stream by about 85%. The basin area until the stream effluent (the stream effluent is considered to be the

last outlet of the drainage system) covers 1.23 km^2, from which 68 km^2 is drained land. Forest density of the territory is 23.2%. The length of drainage channels to the effluent makes up 2.54 km. Soils and landscape are plain land with the average surface slope of 0.2-0.3% (between the watershed and stream bed). Soils prevailing in the territory are glacial-lacustrine clay soils. Considering the grain-size composition, physical clay particles (>0.01mm) are prevailing; they make up 58-83% of total soil mass (Šukys et al., 2005).

Further from the effluent the stream is flowing through the forest via the regulated channel-type bed, 0.6 m wide. Water of the stream is capable of self-purification, particularly during the vegetation period. The average slope of the stream in the investigated 1500 m long stretch is 1.1 promile. Discharge of the stream in the outlet is fluctuating from 4 to 60 l s^{-1} during the vegetation period and from 12 to 140 l s^{-1} during the cold melting period in winter-spring season.

To model self-purification processes of the stream, the data about DIN (DIN = NO_3-N + NH_4-N) concentration contained in the stream water below the effluent at the distance of 10, 500 and 1500 m during the vegetation and cold periods was used for the studies.

To model self-purification processes of the stream, the data collected by Water Management Institute of Lithuanian University of Agriculture about DIN (DIN = NO_3-N + NH_4-N) concentration contained in the stream water below the effluent at the distance of 10, 500 and 1500 m during the vegetation and cold periods of 2004-2005 years was used for the studies.

Theoretical background of the modeling

Assumptions:

- at a certain place (at the point *A*, for example) the stream is constantly receiving pollutants of exceeding concentration;
- below the pollution place (i.e. from point *A* to point *B*) the stream is flowing via the vicinity that contains no other pollution sources; flow velocity and discharge of the stream water is relatively stable within the stretch *AB*; environmental conditions of the stream (vegetation of the bed, air temperature, etc.) are similar.

As it is known (Allan, 1995; Vincevičienė, 1998; Lamsodis et al., 2005; Vaikasas 2002; Vaikasas et al., 2004), pollutants concentration $C(x,t)$ in point x at the time moment t satisfies the homogenous parabolic (transport) equation with partial derivatives:

$$\frac{\partial C(x,t)}{\partial t} = d\frac{\partial^2 C(x,t)}{\partial x^2} - v\frac{\partial C(x,t)}{\partial x} + kC(x,t), \qquad (1)$$

where

d>0 – coefficient of pollutants diffusion in water;

v=0 – water flow velocity;

k=0 – coefficient estimating the decrease in pollutants concentration due to self-purification processes.

Supposing that any two of those coefficients equal to zero, a one-factor is obtained model from the equation (1). For example, when d=0 and v=0, $\frac{\partial C(x,t)}{\partial t} = kC(x,t)$ is obtained, which means that the velocity of concentration $\frac{\partial C(x,t)}{\partial t}$ decreases due to purification. The velocity is proportional to the coefficient k and to the concentration value $C(x,t)$. If the velocity of concentration decrease is constant, i.e. $\frac{\partial C(x,t)}{\partial t} = f \equiv const < 0$, the model of pollution will be expressed by a non-homogenous differential equation:

$$\frac{\partial C(x,t)}{\partial t} = d\frac{\partial^2 C(x,t)}{\partial x^2} - v\frac{\partial C(x,t)}{\partial x} + f. \qquad (2)$$

To ensure the uniqueness of the solution, boundary and initial conditions should be joined to the equation (1) (Paulauskas, 1974; Фарлоу, 1985). The mentioned conditions are formed on the basis of the following assumptions:

- in the initial cross-section of the stream at the point x=0, the pollutant influent maintains constant concentration c_0:

$$C(0,t) = c_0; \qquad (3)$$

- far from the pollution source, where the pollutants disappear due to self-purification processes of the stream:

$$\lim_{x\to\infty} C(x,t) = 0; \qquad (4)$$

- no pollution detected in the initial moment of stream observation:

$$C(x,0) = 0. \qquad (5)$$

The latter assumption might reduce the generality of the problem. In order to avoid this, the initial condition (5) may be replaced by non-zero initial condition $C(x,0)$.

Thus, the equation (1), boundary conditions (3), (4) and initial condition (5) make up the whole model of pollution flow through the stream and self-purification of the stream water:

$$\frac{\partial C(x,t)}{\partial t} = d\frac{\partial^2 C(x,t)}{\partial x^2} - v\frac{\partial C(x,t)}{\partial x} + kC(x,t),\ d>0,\ v\ge 0,\ k\le 0,$$
$$C(0,t) = c_0,$$
$$\lim_{x\to\infty} C(x,t) = 0,$$
$$C(x,0) = 0$$

If the concentration of inflowing pollutants is not changing over the time, this means that after a certain period of time stable concentration $C(x,t)$ with respect to variable t will be observed in the stream, i.e.:

$$\lim_{t\to\infty} \frac{\partial C(x,t)}{\partial t} = 0. \qquad (6)$$

Taking into account this equality (6), the equation (1) becomes an ordinary differential equation:

$$d\,C''(x) - v\,C'(x) + k\,C(x) = 0 \qquad (7)$$

Table 1

DIN concentrations in the stream Bėrė

Distance x between two study places, m	DIN concentration during the vegetation period, mg l^{-1}		DIN concentration during cold period, mg l^{-1}	
	c_0	C	c_0	C
490	12.1	14.2	6.6	6.0
490	10.4	9.8	6.0	6.2
490	6.4	5.9	4.5	5.2
1000	14.2	9.6	6.0	5.4
1000	9.8	7.7	6.2	4.8
1000	5.9	3.0	5.2	3.4
1490	12.1	9.6	6.6	5.4
1490	10.4	7.7	6.0	4.8
1490	6.4	3.0	4.5	3.4

*c_0, C – DIN concentration in the initial and final points of the studied stream stretch

with the boundary conditions

$$C(0) = c_0, \tag{8}$$

$$\lim_{x \to \infty} C(x) = 0. \tag{9}$$

The general solution of the equation (7) comprises two functions, i.e. two fundamental solutions. However, only one solution satisfies the boundary value condition (9), therefore the solution of the boundary value problem (7), (8), and (9) of self-purification process of the stream from the pollution is

$$C(x) = c_0 e^{\lambda x}, \tag{10}$$

where the parameter λ depends on the equation (7) coefficients

$$\lambda = \frac{v - \sqrt{v^2 - 4\,d\,k}}{2d} \le 0 \ . \tag{11}$$

Further task of the research is to evaluate the coefficients of the model of pollution dispersion in the stream as well as self-purification processes of the stream considering the natural data obtained during the observations under the changing environmental conditions.

Results and Discussion

To find the values of parameters λ and k, the data of natural investigations performed on the determination of DIN concentrations contained in the stream Bėrė during the vegetation and cold periods was used (the data mentioned is presented in the Table 1).

For the calculations, average stream flow velocities were used for the case of vegetation and cold periods (v=0.14 m s^{-1} and v=0.18 m s^{-1} respectively). Value of diffusion coefficient d was taken as 10^{-4} per day (Dobkevičius, 2001). As the results show, slight changes in the coefficient have no effect on parameter λ.

To find the self-purification coefficient k, the least squares method was used, i.e. the following minimization problem was solved:

$$\sum (C(x,k) - C_{actual})^2 \to \min, \tag{12}$$

where $C(x,k)$ are concentration values computed from the expression (10) and the sum is taken over all actual data given in the table.

As it was obtained, during the vegetation period k= - 4.344 10^{-5}, which corresponds to the decrease in concentration by 3.8 times a day, and the value of parameter λ= -0.00031. In the cold period of the year, k= 3.113 10^{-5}, which corresponds to the decrease in concentration by 2.7 times a day and the value of parameter λ = -0.00017.

Thus, at the distance of x (m) from the place of the determination of initial concentration c_0, the solution of equation (7) is expressed as $C(x) = c_0 e^{-0.00017\,x}$ in the cold period of the year and $C(x) = c_0 e^{-0.00031\,x}$ during the vegetation period.

Under the conditions of 3 different values of initial pollution, graphs of those solutions are presented in the Figure 1.

Conclusions

1. The model of pollution dispersion through the stream is a partial parabolic differential equation with initial and boundary conditions.

2. Stable over time self-purification processes of the stream from constant pollution source may be modeled by a boundary value problem for an ordinary second order differential equation.

3. DIN pollution in a stream stretch containing constant hydrological parameters and adequate environment conditions is proportional to the concentration of pollutants inflow. Further from the pollution source the constant pollution is exponentially decreasing along the stream.

4. The stream polluted in the result of agricultural

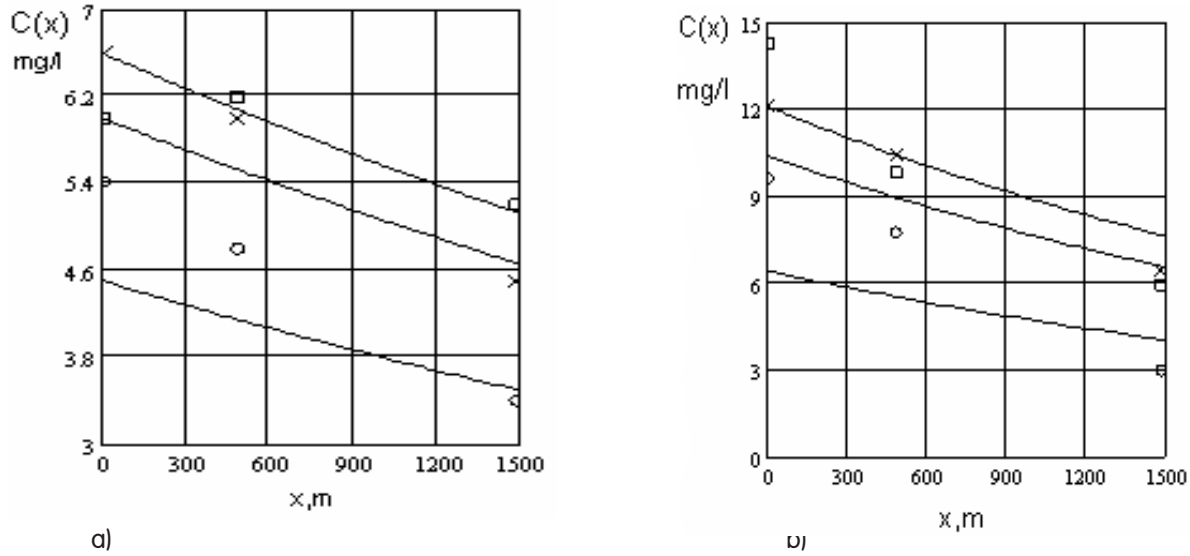

Figure 1. Decrease in DIN concentration *C* in the stream, in respect of the distance *x* to the pollution source in cold (a) and warm (b) periods.

activity, is further flowing through a 1.5 km long forest-covered area. During this flow the stream is self-purified significantly: DIN concentration is relatively reduced 3.8 times a day during the vegetation period and 2.7 times a day during the cold period. The total decrease of the concentration depends on the self-purification and the stream velocity.

References

1. Allan J.D. (1995) Stream ecology: Structure and function of running Waters. London a.c.-Chapman and Hill, 388 pp.
2. Dobkevičius M. (2001) Hidrogeodinamika (Hydrogeodynamics).Vilnius, 358 pp. (in Lithuanian).
3. Lamsodis R., Vaikasas S. (2005) The potencial to retain nitrogen in beaver ponds and delta floodplains of the River Nemunas. Large Rivers. Vol. 15, No. 1-4, pp. 225-241.
4 LR Aplinkos ministerija (2002) Lietuvos upių vandens kokybės metraštis (The yearbook of Lithuanian river water quality), Vilnius, 38 pp. (in Lithuanian).
5. Paulauskas V. (1974) Matematinės fizikos lygtys (Mathematical physics equations). Vilnius, Mintis, 456 pp. (in Lithuanian).
6. Šukys P., Šauliene A. (2005) Peculiarities of water runoff and pollution in streams of the karst region. Water Management Engineering. Transactions, Vol.2 (5), pp. 93-99.
7. Vaikasas S. (2002) Sedimentation and self-purification processes in the Nemunas floodplain. Research for rural development 2002. International scientific conference proceedings, Jelgava, Latvia, pp. 121-125.
8. Vaikasas S., Rimkus A. (2004) Modelling of nitrogen retention processes in the Nemunas floodplain. Water Management Engineering. Transactions, Vol.1 (4), pp. 5-11.
9. Vincevičienė V. (1998) Atvirų telkinių vandens kokybės modeliavimas (Surface water quality modelling). Kaunas, Technologija, 298 pp. (in Lithuanian).
10. Фарлоу С. (1985) Уравнения с частными производными. Для научных работников и инженеров (Partial differential equations for scientists and engineers). Москва, Мир, 384 с. (in Russian).

POLLUTION OF WATER AND SLUDGE WITH HEAVY METALS AND OIL PRODUCTS IN PARK POND OF KĖDAINIAI TOWN

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Abstract

The paper presents the analysis of the pollution of water and sludge of the pond situated in the park of Kėdainiai town. The analysis of pollutants such as heavy metals and oil-products has been carried out with the aim to evaluate the possibilities of arranging a sanitary safe bathing, place in the park and use the accumulated sludge.
It was determined that the content of heavy metals in sludge exceeds the maximum permissible limit for sludge pollution in Lithuania. According to cadmium amount, the pollution also exceeds maximum allowable soil pollution level. However, the sludge in the pond contains a rather large amount of oil-products. After carrying out stirring-up tests of botoom sludge, it was determined that turbid water is polluted with oil-products that exceed the maximum permissible limit.
Key words: pond sludge, heavy metals, oil-products, pollution.

Introduction

The pond of Kėdainiai town park was arranged in 1972 having constructed a ferroconcrete spillway dam on the stream Dotnuvėlė for the maintenance of a stable water level and lowering of surplus water. The height of affluent is 4 m, and pond area is 5.1 ha. During the last 30-year period, a large amount of naturally formed sludge accumulated on the bottom of the pond. Those sludge sediments were supplemented with industrial and domestic wastewater from the town as well as with untreated wastewater from a former soviet military airport. There is no exact data about all harmful mineral and chemical substances accumulated in sludge of the pond (Martin, 2004; Heinrich et al, 2002; Vaikasas et al., 2004).

In other countries, to decompose or remove oil pollutants from the soil, different biological, chemical and physical methods are used. More than 40 companies are engaged in this activity. However, such work is rather costly. In Lithuania, theoretical issues of oil products removal are still under the analysis, and ground treatment technologies are being investigated (Šatkauskas, 2002).

To use the pond as a recreational territory (i.e., a resting-place for town dwellers, or a swimming and sports place for children and young people), it was necessary to find out conditions and requirements from the point of view for the arrangement of swimming areas in ponds (HN92:1999…, 1999). In order to use better the pond as a recreational territory (for the relaxation of town people, for swimming activities and water sports of children and young people), it was necessary to find out the conditions for the arrangement of clean and safe swimming areas in respect to the hygienic norms and requirements of Lithuania (HN92:1999 …, 1999). The work was financed by Kėdainiai Municipality, limited company 'Hidroveda', the studies were supported from National Science and Study Fund of Lithuania.

The objective of the work was to investigate the pollution of sludge and water of the pond in Kėdainiai park, and to evaluate possibilities for the arrangement of a sanitary safe swimming place and usage of sludge.

Materials and Methods

The studies of pollution of sludge and water in the pond were carried out during vegetation period (July-September). Sludge samples were taken in the vicinity of the future swimming place, on the left slope of the pond at the distance of 20 m and 40 m from the dam (A-A profile), as well as in other places determined by the customer (Fig.1). Three silt samples were taken for the studies from each place determined in the scheme; time period between sample taking was one month. A special boat and a sludge-sucking device were used during the investigations. Water samples for laboratory analysis were taken with the help of a batometer from surface layer (0.2 m deep) and bed layer (0.5 m deep above the bottom) of the pond. During the investigation of water pollution with heavy metals and oil products, an experiment of sludge stirring was made.

Amounts of oil products and heavy metals contained in sludge and water of the pond were detected in the laboratory of Agrochemical Study Center of the Lithuanian Agricultural Institute (in Kaunas). Amounts of heavy metals were determined in the laboratory in the following way: for Cadmium, Nickel, Lead, Copper and Zinc determination soils extract with 2M HNO_3; for Arsenic AAS method with electrothermal atomizer SVP D- was used; Hydrargyrum – spectrometric cold steam method of atomic absorption SVP D-3. Amounts of oil products were determined applying spectrometric method of infrared rays. Data of laboratory investigations was summarized having calculated the average values of three analyties that were used for the discussion of the results.

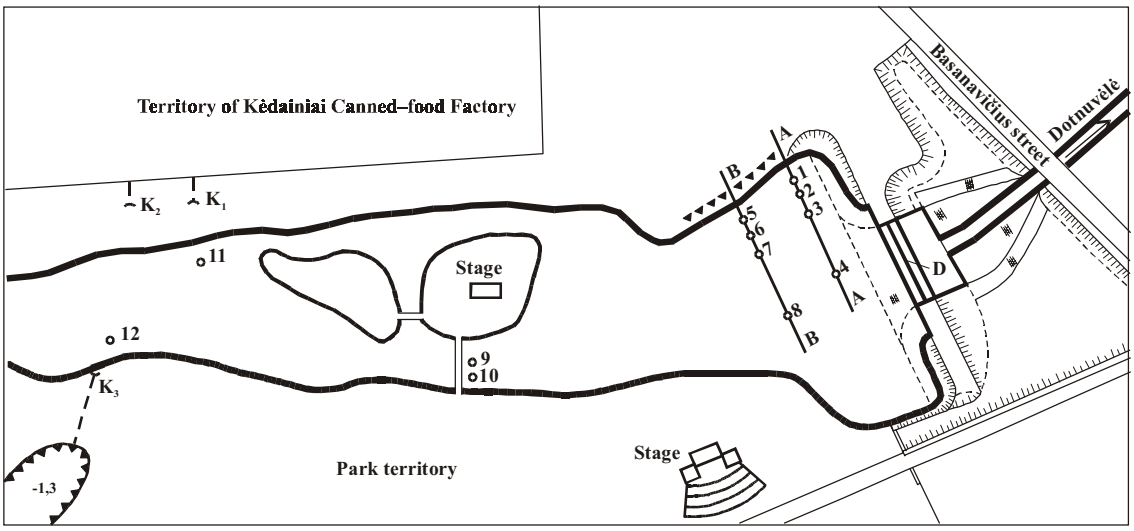

Figure 1. Scheme of Kėdainiai spillway dam on the Dotnuvėlė stream: D – spillway dam; ° – sludge sampling place; K – wastewater outlet device; A-A, B-B – sludge sampling profiles ▼▼▼▼ – bank of the swimming-place.

Results and Discussion

Pollution of pond sludge with oil products

Further from the main pollution source – sewerage drainpipe of a former military airport – pollution of pond sludge with oil products is most intensive (Table 1). At the distance of 20 m below the drainpipe, the amount of oil products was on the average 656 mg kg^{-1}; at the distance of 230 m below the drainpipe (in a thicker sludge layer below the bridge to the island) their amount was 800 mg kg^{-1}. At 360 m below the drainpipe (B-B profile), the amount of oil products was 800-2300 mg kg^{-1}, while at the distance of 380 m (A-A profile) their amount in sludge reached even 1300-2900 mg kg^{-1}. This is explained by the fact that more intensive sedimentation of oil products along with fine suspended sediments occurred in still, less mobile water that is usually found nearby the dam.

As the fatest studies have shown, the ground polluted with oil products may be purified with the help of oil-oxidating microorganisms. Recently, the ground purification with plants and worms is becoming more and more popular (Jankevičius et al., 2003).

Thus it may be stated that sludge of Kėdainiai park

Table 1

Pollution of pond sludge with oil products in study places

Sludge sampling places	Distance below the drainpipe, m	Distance from the bank, m	Water depth, m	Thickness of sediment, m	Amount of oil products, mg kg^{-1}
Below wastewater outlet of former airport	20	10	1.6	0.8	656
Below wastewater outlet of canned-food factory	70	10	1.6	0.7	310
At the bridge to the island:	230	10 *	2.4	0.5	400
		10 **	2.4	0.3	800
Profile B	360	4	1.4	0.2	800
		8	2.4	0.4	2300
		15	3.1	0.6	800
		50	3.7	1.1	250
Profile A	380	4	1.7	0.6	330
		8	2.1	0.6	2900
		15	2.5	0.8	1300
		50	3.0	1.2	220

** Distance from the bank of the park; ** Distance from the bank of the island*

Table 2

Concentrations of heavy metals detected in sludge samples

Heavy metal	Concentration in sludge samples, mg kg^{-1}		Concentration in sandy loam soils, mg kg^{-1}	
	Profile A-A	Profile B-B	Background	Maximum allowable
Cadmium	1.2	1.2	0.5	1.0
Chromium	20.6	20.0	45	52
Nickel	21.8	19.6	18	46
Lead	32.8	43.6	20	52
Copper	21.7	22.6	13	52
Zinc	100	114	41	156
Arsenic	1.29	1.21	not given	2.0
Hydrargyrum	0.017	0.014	0.2	0.6

pond (particularly sludge found in the territory of the future swimming-place) contains extremely high concentrations of oil products (2300-2900 mg kg^{-1}). Sludge with such high pollutants concentrations cannot be used for purposes.

Pollution of pond sludge with heavy metals

Amounts of heavy metals detected in sludge samples were calculated by milligrams for one kilogram of dry sludge matter. The calculation results are presented in Table 2. Here also the background amounts and maximum allowable rates of the studied metals contained in sandy loam soils (in nearby farms of Kėdainiai, (i.e., most acceptable for fertilization with sludge) according to (Land 20…, 2001).

Considering the study results, according to the pollution with heavy metals, the sludge may be attributed to category I. However, the amounts of mentioned heavy metals (except for chromium) significantly exceed the background amounts of those metals contained in soils of Lithuania (Table 2): cadmium amount is 2.4 times higher, nickel amount is 1.2 times higher, and amounts of lead, copper and zinc are 2.2, 1.8 and 2.4 times higher, respectively. Having compared with maximum allowable soil pollution level (Land 20-2001 000 …, 2001), only cadmium concentration is too high in the sludge (i.e., exceeds MAC 1.2 times). Unfortunately, such cadmium concentration is found at the pond bank most suitable for the arrangement of a swimming-place. Compared to other places, here the sludge samples contained higher concentrations of other harmful elements, too, including chromium, nickel, lead, copper, and zinc. Such sludge is not allowed to be used as ground for planting greenhouse vegetables or pot plants, because plants uptake the mentioned elements (particularly cadmium and zinc) very easily (HN60 …, 1996; Lietuvos žemdirbystės …, 2001).

Table 3

Concentrations of heavy metals and oil products in the water of the pond

Name of pollutant	Concentration in samples (mg l^{-1})			Maximum allowable concentration level*
	Before stirring of water	Having stirred the sludge on the bottom	0.5 hours after stirring	
Cadmium	0.001	0.001	0.001	0.005
Chromium	0.002	0.003	0.001	0.005
Nickel	0.007	0.007	0.004	0.01
Lead	0.010	0.015	0.017	0.10
Copper	0.010	0.011	0.004	0.01
Zinc	0.049	0.060	0.064	0.01
Arsenic	0.001	0.002	0.001	0.05
Hydrargyrum	<0.0001	0.0002	<0.0001	0.002
Oil products	0.05	1.8	<0.05	0.05

** According to maximum allowable concentration level for fishery determined by (LR Aplinkos…, 2000).*

Water pollution with heavy metals and oil products

It was determined that having stirred the sludge, the amounts of suspended sediment in water increased from 10 mg l^{-1} (in natural state) to 400 mg l^{-1} (in turbid water). Small amounts of heavy metals changed insignificantly (Table 3).

Having disturbed water with sludge, amounts of oil products and suspended sediments increased about 30–40 times. This shows that if turbid water is discharged from the pond, large amounts of oil products would enter the river Nevėžis. However, no oil cover was observed on the surface of turbid water. After half an hour from the disturbance moment, the feculence with adsorbed oil products drifted away and settled on the pond bottom.

Conclusions

1.Sludge of Kėdainiai park pond has accumulated a large amount of organic matter. However, the sludge pollution with heavy metals 1.2–2 times exceeds the background pollution rates of Lithuanian soils.

2. According to cadmium, the pollution is 1.2 times higher than the maximum allowable soil pollution rate. Before using such polluted sludge as a
fertilizer, it is necessary to investigate the amounts of those metals contained in the soils. Considering those facts, a proper rate of spread sludge is to be determined.

3. According to the amounts of oil products, sludge is contaminated in all studied places. In the place of the future swimming-pool, the sludge is particularly heavily polluted with oil products (2300-2900 mg kg^{-1}). Such kind of sludge (without necessary processing) cannot be used for soil fertilization, quarry re-cultivation, or any other farming activity.

4. Pond sludge studies show that turbid water contains high amounts of oil products (1.8 mg kg^{-1}). Their amount exceeds the highest rate for fishery about 30 times. To remove the sludge of pond, necessary measures should be taken not to allow so that turbid water to enter the stream Dotnuvėlė

References

1. Jankevičius K. and Liužinas R. (2003) Aplinkos biologinis valymas (Biological purification of the environment), Vilnius, 201 pp. (in Lithuanian).
2. Heinrich D. and Hergt M. (2002) Atlas Ökologi (Ecology Atlas). DTV, München, 288 pp. (in German).
3. Land 20-2001 000. (2001) Nuotekų dumblo naudojimo tręšimui reikalavimai. Lietuvos normatyvinis dokumentas (Lithuanian normative document. Requirements for wastewater sludge used for the fertilization) (in Lithuanian).
4. HN60 (1996) Cheminių medžiagų didžiausios leistinos koncentracijos dirvožemiuose. Lietuvos higienos norma (Lithuanian hygienic norm. Maximum allowable concentrations of chemical substances in soils) (in Lithuanian).
5. HN92 (1999) Paplūdimiai ir jų maudyklos. Lietuvos higienos norma. (Lithuanian hygienic norm. Beaches and swimming places) (in Lithuanian).
6. LR Aplinkos ministerija (2000) Lietuvos upių vandens kokybės metraštis (Annals of water quality of Lithuanian rivers). Vilnius , 89 pp. (in Lithuanian).
6. Lietuvos žemdirbystės instituto agrocheminių tyrimų centras (2001) Sunkieji metalai Lietuvos dirvožemiuose ir augaluose (Heavy metals contained in Lithuanian soils and plants). Kaunas, 343 pp. (in Lithuanian).
7. Martin C.W. (2004) Heavy metal storage in near channel sediments of the lahn river, Germany. Geomorphology, 61, Issues 3-4, pp. 275–285.
8. Šatkauskas G. (2002) Pervežto grunto, užteršto naftos produktais, mėginių paėmimo metodika (Methodology of sampling of ground polluted with oil products). Aplinkos inžinerija, pp. 48–53 (in Lithuanian).
9. Vaikasas S. and Poškus V. (2004) Dotnuvėlės ir Smilgos vagų Kėdainiuose nuosėdų užterštumo tyrimai. (Investigations on sediment polltion in the streams Dotnuvėlė and Smilga in Kėdainiai). Vandens ūkio inžinerija. 26(46), pp. 31–39 (in Lithuanian).

EFFICIENCY OF WASTEWATER TREATMENT IN SLAUGHTERHOUSE IN TWO-STAGE CONSTRUCTED WETLANDS

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Abstract

The paper presents the investigations performed by Water Management Institute of Lithuanian University of Agriculture on the pollution and treatment efficiency of wastewater formed in an up-to-date slaughterhouse built in 2003.
Wastewater is canalized from the slaughterhouse by red and green sewerage systems. Initially the wastewater is pre-treated in a fat separator, further treatment process is performed in physical-chemical treatment facilities and settling ponds.
After primary treatment, the wastewater is directed into two-stage constructed wetlands of horizontal flow.
The wastewater in slaughterhouse is about 4-5 times more polluted than domestic wastewater containing even 20 times higher fat concentration.
During the primary treatment process (fat separator + physical-chemical treatment device + settling pond), from 73.1 to 98.9% of pollutants are removed. After primary treatment, indices of wastewater are similar to those of domestic wastewater: pH – 8.5, biochemical oxygen demand (BOD_5) – 98 mg l^{-1} of O_2, N_{total} and P_{total} – 46 and 8.9 mg l^{-1} respectively.
After biological treatment in two-stage constructed wetlands of horizontal flow, the wastewater satisfies the environment protection requirements according to organic (BOD_5) and biogenic (N_{total} and P_{total}) pollutants concentrations and thus may be released into the environment.
Regression dependencies of medium and strong relation (R^2=0.503-0.893) of pollutants BOD_5, SS (suspended sediments), N_{total} and P_{total} in treated wastewater on the load of constructed wetlands have been determined.
Key words: pollutants, wastewater, pollution load, treatment efficiency.

Introduction

With the support of the EU structural fund SAPARD, four up-to-date cattle slaughterhouses were built in Lithuania until 2000-2005. Limited company (Ltd) 'Agaras' (Biržai district) started operating a new cattle slaughterhouse in October 2003.

Since the year 1992, wastewater of 5 cattle slaughterhouses and meat processing companies has been investigated. As the study results have shown, wastewater pollution with organic matter (according to BOD_5) was 1200-3000 mg l^{-1} of O_2 in companies butchering cattle and processing meat; however, in slaughterhouses the index was even higher – up to 6000 mg l^{-1} of O_2 (Strusevičius, Strusevičienė, 2001).

As such wastewater is heavily polluted with fat, its treatment is rather complicated. Fresh wastewater contains 600-1200 mg l^{-1} of fat. The main source of organic pollution load of wastewater is blood, content of entrails and stomach, and fat, the pollution of which according to BOD_5 (biochemical oxygen demand) is 150000, 60000, and 1000000 mg l^{-1} of O_2 respectively. Therefore those pollutants are to be collected in manufactories.

Generally, wastewater is treated in industrial aeration biological treatment facilities. There is a wide supply of such up-to-date equipment controlled with the help of processors (Šeškevičius, 1977; Henze et al., 1995). Principle stages of wastewater treatment process are primary treatment and deep biological (secondary) treatment. During the primary treatment, wastewater pollution according to BOD_5 is reduced to 400-600 mg l^{-1} of O_2 - here also fat is secreted from wastewater. During the second stage of treatment process, wastewater is usually treated in aerotanks (Menčinskas, 2000).

Suggested equipment and technologies are of high technical level; however, they are rather expensive from the point of investments and operation. No cheaper or simple technologies are suggested to meat processing companies therefore biological wastewater treatment is not popular.

Having evaluated wastewater chemical and biological characteristics as well as pollutants transformation processes occurring during the treatment of wastewater, a primary wastewater treatment technology based on physicochemical wastewater treatment ways was created. The first such experimental technology was implemented in agricultural company 'Nematekas' in 2000.

'Agaras' Ltd was suggested to use our technology for primary wastewater treatment. For biological wastewater treatment, aerotanks were replaced by constructed wetlands where no electrical energy is needed for biological treatment process of pollutants (Gasiūnas et al., 2003).

The objective of the work was to determine the pollution degree of wastewater from cattle slaughtering as well as to investigate pollutants removal efficiency in different treatment stages.

Materials and Methods

The paper presents investigations of changes in wastewater formation and pollution indices when

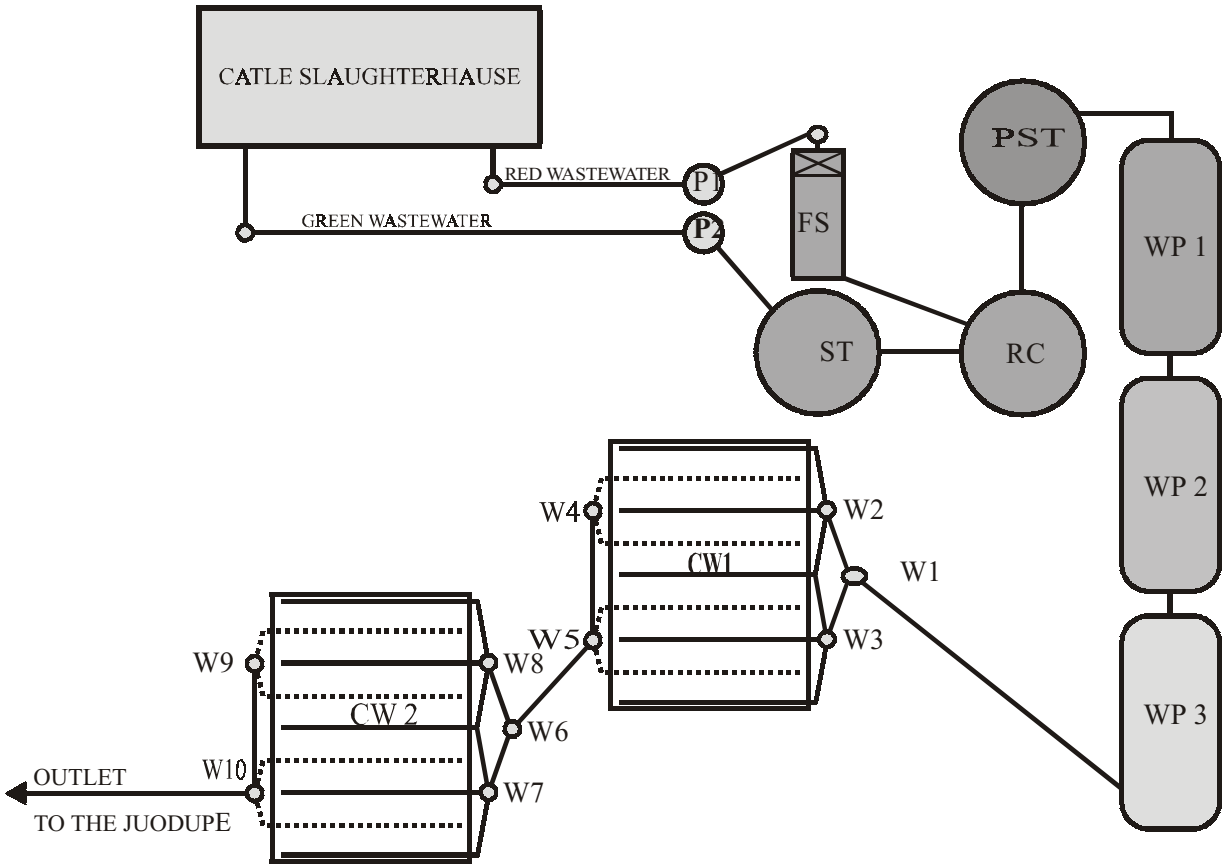

Figure 1. Technological scheme of wastewater treatment facilities of 'Agaras' Ltd:
P1 – pump-house of red wastewater; P2 – pump-house of green wastewater; FS – fat separator; ST – settling tank; RC – chemical reaction chamber; PST – primary settling tank; WP1-WP3 – wastewater ponds; CW1-CW2 – constructed wetlands; W1-W10 – wastewater wells.

wastewater flows via different treatment stages in the experimental treatment facilities arranged in 'Agaras' Ltd.

Wastewater treatment technological scheme is given in Figure 1. Two wastewater sewerage networks are arranged in the slaughterhouse – red wastewater canalization system and green wastewater canalization system.

Red wastewater canalization system collects wastewater from cattle butchering and washing of slaughtering equipment and premises.

Green wastewater canalization system receives domestic wastewater, and also wastewater from washing of animals and their transportation trucks.

Pumps of red wastewater pump-house P1 supply wastewater into the fat separator FS. After fat removal, wastewater is supplied into the chemical reaction chamber RC. Pumps of green wastewater pump-house P2 supply wastewater into the vertical settling tank ST where coarse organic pollutants are separated from wastewater. Pretreated green wastewater and red wastewater after fat removal are further supplied into the reaction chamber RC.

Reaction chamber RC contains an ejector wastewater mixing device arranged that is made of submersible engine, pump and 'Venturi' muzzle (manufactured by 'Flygt', Sweden). Here wastewater is mixed in a hydraulic way, creating wastewater-air mixture. The selected model of 3.1 kW capacity guarantees no less than 0.3 m s^{-1} turbulent velocity of wastewater in the whole reservoir. Moreover, 4 kg of oxygen (about 96 kg a day) is supplied into wastewater along with the air. According to our calculations, such amount of oxygen is nearly 10 times less than that needed for the maintenance of aerobic environment.

A dosage device of coagulants is mounted above the mixing chamber. Quicklime (CaO) is supplied into reaction chambers for the coagulation of pollutants (1 kg of quicklime for 1 m^3 of wastewater).

Reaction chamber (RC) and primary settling tank (PST) are connected by an open aperture (communicating vessels). In the settling tank, wastewater is in a calm state therefore floccules flowing along with wastewater from a mixing chamber settle on the bottom here.

From the settling tank wastewater is supplied into a three-chamber leveling and settling ponds WP1, WP2, and WP3. In this stage of treatment, wastewater flow is leveled (the company works 5 days a week) and settled additionally. The pond is able to contain wastewater of 60 days. The pond is designed so that wastewater would flow via the pond by the longest way (ratio of length and width is 10) (Matuzevičius, 1999).

After additional treatment in the settling pond, wastewater flows into constructed wetlands CW1. After treatment in this filter, wastewater is directed into the second constructed wetlands CW2. Here wastewater biological treatment is finished. Both filters cover the area of 1600 m^2. Filter contains coarse sand from local quarry (K_{filtr}=16.8-25.5 m d^{-1}). Thickness of the filter is 0.8 m.

After biological treatment of wastewater in constructed wetlands, it is released into the stream Juodupė through a control well W10.

The designed capacity of the largest slaughterhouse is 40 mature animal units or 120 bacons per hour. When the slaughterhouse is functioning at full capacity, calculated wastewater amount is 100 m^3 d^{-1}. Blood is pumped from a slaughtered animal with the help of a special pump, therefore only little amount of it gets into red canalization system.

Having started operating the slaughterhouse, much attention was paid to the quality of slaughtering works seeking that as little as possible blood, contents of entrails and stomach, and manure would get into sewerage networks.

Wastewater samples for chemical analysis were taken twice a month from those places:

- before treatment – from pump-houses P1 and P2;
- after fat separation and mechanical treatment – from FS and ST;
- after treatment in physical-chemical device – from PST;
- after treatment in a settling pond – from the well W1;
- after treatment in the first stage of constructed wetlands CW1 – from the well W5;
- before release into the environment from CW2 – from the well W10.

Wastewater discharges were measured every day at 10.00 o'clock a.m.

Laboratory analyses of wastewater were made in the certified Chemical Analysis Laboratory of the Lithuanian Water Management Institute applying unified methods for wastewater laboratory analysis (Unifikuoti nuotekų …, 1994).The following indices were determined by the analysis: pH, BOD_5, $COD_{Cr,}$ SS, N_{total}, N-$NH_{4,}$ P_{total}, and fat.

Wastewater treatment efficiency was calculated according to the following equation (Kadlec and Knight, 1996):

$$E=100(Q_{it} \cdot C_{it} - Q_{ist} \cdot C_{ist}) / Q_{it} \cdot C_{it}, \quad (1)$$

where

Q_{it} and Q_{ist} – amount of wastewater inflow and outflow, m^3 d^{-1};

C_{it} and C_{ist} – pollutant concentration in wastewater, mg l^{-1}

Pollutants load of constructed wetlands A_n g m^{-2} d^{-1} was calculated according to the following formula:

$$A_n = \frac{C_{it} \cdot Q_{it}}{F}, \quad (2)$$

where

C_{it} – pollutant concentration contained in wastewater inflow, mg l^{-1} (g m^{-3});

Q_{it} – amount of wastewater inflow, m^3 d^{-1};

F – surface area of constructed wetlands, m^2.

Matematical and statiscical analysis of test results was performed using a binary correlation method.

Results and Discussion

Wastewater formation and pollution analysis

During the study period (October 2003 – September 2004), the capacity of cattle butchering was different as it depended on the market of meat production. At that period the main consumers of the company's production were meat processing companies and trade companies of the country. The greatest demand for fresh meat production in the home market was observed on the second part of the week and before holidays. Now about 60-150 cattle units and 150-240 bacons are butchered in the company. During the process, 55-76 m^3 of water is used. On other days up to 40-60 cattle units and 100-150 bacons are butchered; water demand is from 35 to 55 m^3 d^{-1}. Wastewater formation is as follows: from 8.00 to 10.00 a.m. – 15-20% of total wastewater amount of the day, from 10.00 to 15.00 p.m. – 30-40%, and from 15.00 to 17.00 p.m. – 40-55% of total wastewater amount of the day.

Amount of green wastewater (including domestic wastewater of 55 inhabitants, also wastewater from washing premises of animals, transportation truck of animals and other transport means) make up 15-20% of total wastewater amount formed in the company.

Summarized study data of wastewater pollution is presented in Table 1. Table 1 also contains comparative data of foreign researchers (Kutera, 1994) and our data obtained in 1994 during the investigation of wastewater pollution on up-to-date slaughterhouse 'Krekenavos mėsa' Ltd.

As it can be seen, pollution of wastewater from meat processing in 'Agaras' Ltd and 'Krekenavos mėsa' Ltd is similar, because the type of production of both companies is similar (butchering of animals and cutting of fresh meat).

Analysis of pollution of wastewater suggests that wastewater is particularly heavily polluted (concentration

Table 1

Pollution indices of wastewater (mg l^{-1}) from meat processing companies

Index	'Agaras' Ltd	'Krekenavos mėsa' Ltd	Data from foreign countries	
			Poland	USA
pH	6.7-7.5 6.8	6.9-7.6 7.1	7.2	6.8
BOD_5	1110.0-2880.0 1320.0	820.0-1950.0 1450.0	1600.0	910.0
COD_{Cr}	1510.0-4070.0 2210.0	1885.0-4077.0 2315.0	-	-
SS	860.0-3650.0 2240.0	-	1500.0	650.0
N_{total}	170.0-298.0 210.0	74.0-168.0 138.0	213.0	137.0
$N\text{-}NH_4$	81.0-184.0 115.0	-	-	-
P_{total}	24.0-38.0 33.0	-	27.0	18.0
Fat	417.0-2070.0 1140.0	-	330.0	210.0

Note: Numerator-minimum values, denominator-mean values.

of organic pollutants according to BOD_5 is 4-5 times higher than that in domestic wastewater).

Wastewater also contains high amounts of biogenic pollutants and high concentrations of N and P (2-3 times higher than that of domestic wastewater) (Strusevičius, 1996).

Fat concentration is also very high (417-2070 mg l^{-1}), therefore fat is to be separated first in order it would not settle on pipelines and partition of reservoirs.

On the basis of the experience of researchers from different countries (Strusevičius, 1996; Kutera, 1994), it can be stated that when biological wastewater treatment is applied, fat concentration should not exceed 50 mg l^{-1} in wastewater.

Primary wastewater treatment efficiency

In primary wastewater treatment facilities, fat is separated from wastewater and colloids heavier than water are settled. Further in the chemical reaction chamber, aeration-mixing process of wastewater is performed, during which coagulants are added and floccules are formed that are retained in the initial settling tank and sedimentation ponds. Table 2 presents summarized indices of pollutants removal from wastewater and treatment efficiency when wastewater is flowing via primary treatment facilities.

As it is seen from Table 2, the greatest amounts of fat (98.9%) and organic matter (BOD_5 = 96.6%) are removed from wastewater in the line of primary treatment facilities. Removal of biogenic matter is a little bit less intensive

Table 2

Primary wastewater treatment efficiency

Index	Before treatment	After treatment in a physical-chemical treatment device	After treatment in a sedimentation pond	Average treatment efficiency, %		
				in a chemical treatment device	in a sedimentation pond	in primary treatment facility
pH	6.8±0.33	8.6±0.51	8.5±0.43	+1.8	+1.7	+1.7
BOD_5 mg l^{-1} of O_2	1320.0±415.0	221.0±67.0	98.0±38.0	83.3	55.6	96.6
COD_{Cr} mg l^{-1} of O_2	2210.0±618.0	514.0±141.0	206.0±58.0	76.7	60.0	90.7
SS mg l^{-1}	2240.0±645.0	230.0±49.0	114.0±23.0	89.7	50.6	94.9
N_{total} mg l^{-1}	210.0±36.0	118.0±33.0	46.0±11.0	43.8	61.1	78.1
P_{total} mg l^{-1}	33.0±4.6	13.3±2.5	8.9±1.7	59.7	33.1	73.1
Fat mg l^{-1}	1140.0±368	46.0±11.8	13.0±6.3	96.0	71.8	98.9

Table 3

Efficiency of wastewater treatment in constructed wetlands

Index	Wastewater composition before treatment	Wastewater composition after treatment in CW1	Wastewater composition after treatment in CW2	Average treatment efficiency, %		
				CW1	CW2	biological treatment
pH	8.5±0.43	7.8±0.09	7.7±0.14	-0.7	-0.1	-0.8
BOD_5 mg l^{-1} of O_2	98.0±3.0	34.0.±19.6	14.3±9.6	65.3	58.0	85.8
COD_{Cr} mg l^{-1} of O_2	206.0±58.0	106.0±37.0	58.4±24.1	48.5	45.3	71.9
SS mg l^{-1}	114.0±23.0	43.5±16.8	2.01±11.9	62.3	51.2	81.6
N_{total} mg l^{-1}	46.0±11.0	23.6±9.4	16.4±7.2	47.9	30.5	64.4
P_{total} mg l^{-1}	8.9±1.7	3.6±1.6	0.96±0.19	59.6	73.4	89.2

(N_{total} and P_{total} – 78.1 and 73.1% respectively). Indices of pretreated wastewater are close to those of domestic wastewater, and according to BOD_5 they are even lower.

Wastewater treatment efficiency in constructed wetlands

After primary treatment wastewater flows into the first-stage constructed wetlands CW1. Area of the constructed wetlands is 1600 m^2. The constructed wetlands contain four sections of 400 m^2 each. With the help of shuttles arranged in the well W1, wastewater is supplied into the well W2 during a week, where it distributes in one side of the constructed wetlands (in 2 sections). Another week wastewater flows into the well W3 and distributes in the other side of the constructed wetlands. Changing wastewater load of the sections of constructed wetlands periodically, maximum mechanical aeration of the filter is achieved: sand pores are filled with wastewater, air is expelled from sand, then after supply is interrupted the wastewater flows out of sand pores and is replaced by air. One square meter of the filter (34% porosity) receives 11.6 g of oxygen per day on the average.

Apart from mechanical aeration, oxygen is supplied into the constructed wetlands by reed (*Phragmites australis*), too. Those marsh plants exude on the average 5-6 g of oxygen for one m^2 of filter area per day (Höppner et al., 1997). Reed roots and rhizomes maintain the reproduction of aerobic microorganisms enhancing pollutants decomposition as well as hydraulic permeability of sand media (Conley et al., 1991; Reed, 1995).

Functioning regime of the second-stage constructed wetlands is the same as that of the first-stage constructed wetlands. Table 3 presents the summarized data of pollutants removal in both stages of constructed wetlands.

Table 3 shows that first-stage constructed wetlands CW1 receive wastewater with much higher pollution concentration than second-stage CW2 therefore CW1 naturally retains more pollutants than CW2. On the other hand, after treatment in CW1, wastewater does not correspond to maximum allowable concentration (MAC) according to BOD_5, SS, N_{total} and P_{total} that are 25, 25, 20, and 2 mg l^{-1} respectively. After treatment in CW2, wastewater satisfies the environment protection requirements according to all pollution rates. The collected data about pollutants removal in both stages of constructed wetlands allowed us to determine the influence of pollution load of constructed wetlands on pollution concentration in treated wastewater.

Data of mathematical analysis is presented in Figures 2, 3, 4, and 5. Regression equations contain determination

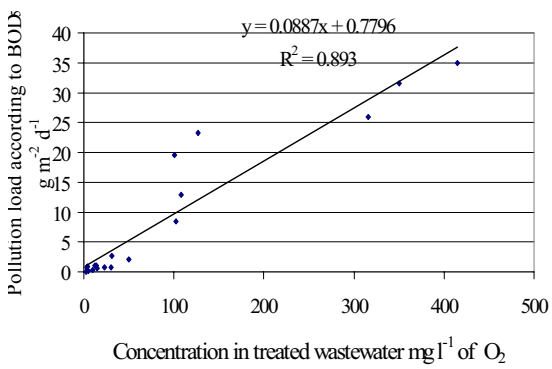

Figure 2. Dependence of pollution load of treated wastewater according to BOD_5 on the load of constructed wetlands.

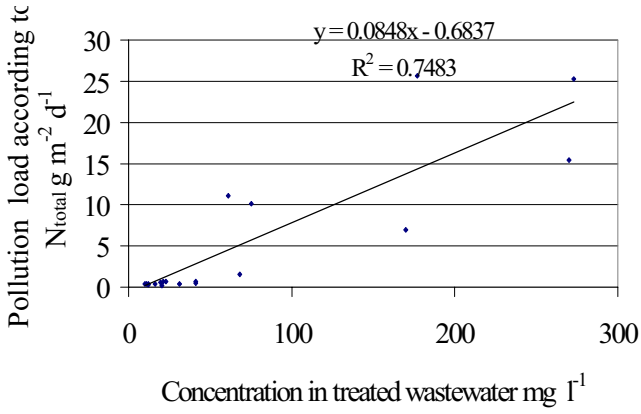

Figure 3. Dependence of pollution load of treated wastewater according to N_{total} on the load of constructed wetlands.

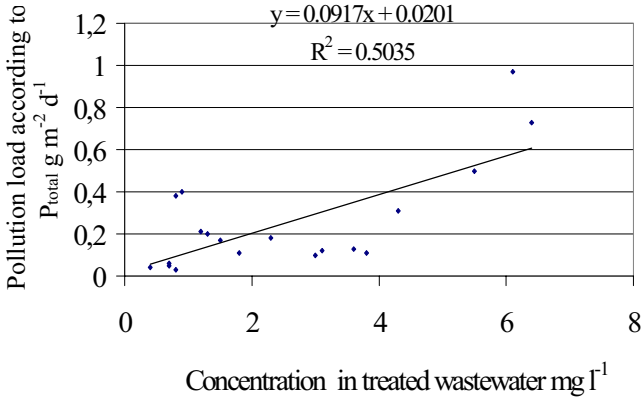

Figure 4. Dependence of pollution load of treated wastewater according to P_{total} on the load of constructed wetlands.

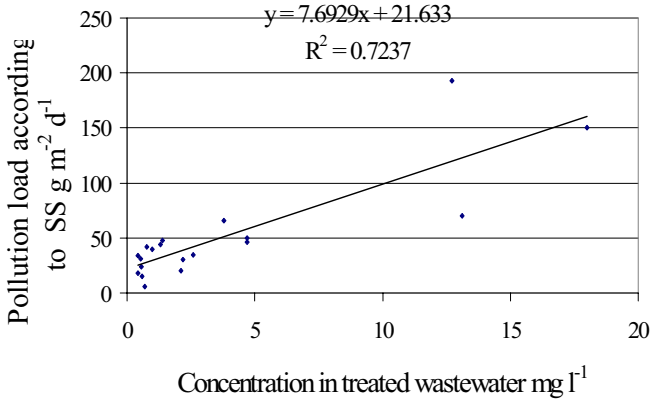

Figure 5. Dependence of pollution load of treated wastewater according to SS on the load of constructed wetlands.

coefficients of medium and strong relation (R^2 – 0.503-0.893). In respect of those dependencies, can be predicted pollutants concentrations in treated wastewater under different pollution loads of constructed wetlands.

Table 3 shows that first-stage constructed wetlands CW1 receive wastewater with much higher pollution concentration than second-stage CW2 therefore CW1 naturally retains more pollutants than CW2. On the other hand, after treatment in CW1, wastewater does not correspond to maximum allowable concentration (MAC) according to BOD_5, SS, N_{total} and P_{total} that are 25, 25, 20, and 2 mg l^{-1} respectively. After treatment in CW2, wastewater satisfies the environment protection requirements according to all pollution rates. The collected data about pollutants removal in both stages of constructed wetlands allowed us to determine the influence of pollution load of constructed wetlands

on pollution concentration in treated wastewater.

Data of mathematical analysis is presented in Figures 2, 3, 4, and 5. Regression equations contain determination coefficients of medium and strong relation (R^2 – 0.503-0.893). In respect of those dependencies, can be predicted pollutants concentrations in treated wastewater under different pollution loads of constructed wetlands.

Conclusions

1. Pollution of wastewater formed in cattle slaughterhouse is even 4-5 times higher than that of domestic wastewater, and fat concentration is even 20 times higher compared to that of domestic wastewater.

2. After treatment of wastewater in the first-stage of treatment facilities (fat separator + physical-chemical treatment facilities + settling pond), from 73.1 to 98.9% of pollutants are removed. Pollution indices of such wastewater are close to that of domestic wastewater: pH – 8.5, BOD_5 – 98 mg l^{-1} of O_2, N_{total} and P_{total} - 46 and 8.9 mg l^{-1} respectively.

3. After biological treatment in two-stage constructed wetlands of horizontal flow, the wastewater fully meets the environment protection requirements according to organic (BOD_5) and biogenic (N_{total} and P_{total}) pollutants concentrations and thus may be released into the environment.

4. Medium and strong regressive (R^2=0.503-0.893) dependencies of pollutants BOD_5, SS, N_{total} and P_{total} concentrations in treated wastewater on load of constructed wetlands have been determined during the investigations.

References

1. Conley M. Lucy, Dick I Richard, Lion W. Leonard (1991) An assessment of the root zone method of wastewater treatment. Research journal of the Water Pollution Control Federation. Vol.63 (3), pp. 239-247.
2. Gasiunas V., Strusevičius Z. (2003) The experience of wastewater treatment using constructed wertlands with horizontal subsurface flow in Lithuania. In: Mander U., Voble Ch., Poom A (eds): Constructed and Riverine Wetlands for Optimal Control of Wastewater at Catchment Scale. Conference FP RTD PRIMROSE. Tartu, pp. 242-249.
3. Henze M., Harremoes P., Jansen J., Arvin E. (1995) Wastewater treatment. Biological and Chemical Processes. Springer-Verlag Berlin Heidelberg, Berlin, 160 pp.
4. Höppner H., Günther T., Fritsche W. (1997) Biologische Prinzipien der Eliminierung von organischen Umweltchemikalien in Pflanzenkläranlagen. Wesser & Boden. Nr.12, 20 pp.
5. Kadlec R.H., Knight R.L. (1996) Treatment Wetlands. CRC Press/Lewis Publishers, Boca Raton.
6. Kutera J. (1994) Gospodarka gnojowicą. Wydawnictwo Akademii Rolniczej We Wroclawiu, Wroclaw, 370 pp. (in Poland).
7. Matuzevičius A.B. (1999) Rekomendacijos biologinio valymo renginiams projektuoti. (Recommendations for the design of biological treatment facilities).VGTU. Vilnius, 18 pp. (in Lithuanian).
8. Menčinskas R. (2000) Nuotėkų valymo technologijos ir įrengimai. (Wastewater treatment technologies and equipment). GEA PT Baltic, 13 pp. (in Lithuanian).
9. Reed S.C. (1995) Natural Systems for Waste Management and Treatment. New York, McGraw-Hill, New York, 40 pp.
10. Strusevičius Z. (1996) Nuotėkų, atliekų ir mėšlo tvarkymas žemės ūkyje. (Treatment of wastewater wastes and manure in agriculture). Vilnius, 156 pp. (in Lithuanian).
11. Strusevičius Z., Strusevičienė S.M. (2001) Pirminio nuotėkų valymo mėsos perdirbimo įmonėje tyrimai. (Investigations of primary wastewater treatment in meat processing company). Vandens ūkio inžinerija. Mokslo darbai. 16(38), pp. 76-84 (in Lithuanian).
12. Šeškevičius V. (1977) Mėsos ir pieno pramonės nutekamojo vandens valymas. (Treatment of wastewater in meat and milk industry). Vilnius, LIMTI, 53 pp. (in Lithuanian).
13. Unifikuoti nuotekų ir paviršinio vandens kokybės tyrimų metodai. (Unitied methods of the quality of wastewater surface water). I dalis. Cheminiai analizės metodai (1994) Vilnius, AAM Leidybos biuras, 174 pp. (in Lithuanian).

INVESTIGATIONS ON P-REMOVAL PROCESSES FROM WASTEWATER APPLYING MINERAL FILTERS

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Abstract

In the process of biological wastewater treatment, P-removal is efficient enough when the concentration of organic pollutants according to BOD_5 (biochemical oxygen demand) is no higher than 190 mg l^{-1} of O_2 and its relationship with phosphorus does not exceed 20.
Having studied the composition of wastewater from dairy farms it was determined that wastewater pollution according to BOD_5 is from 800 to 900 mg l^{-1} of O_2 and the ratio of BOD_5/P_{total} is 30-36.
The paper gives the results of the tests on P-removal from wastewater carried out in a laboratory model.
During the investigations wastewater was flowing via mineral filters (filtralite P (FLP), zeolite (CE), and shulgite (SG)). Total amount of Ca, Fe and Al oxides contained in those filters were 23.0, 16.1 and 7.9% respectively. The rates of P-removal from wastewater in the filters were as follows: 88.5% (FLP), 45.5% (CE), and 96.3% (SG).
Considering different hydraulic load, P-mass balance was calculated. The calculation results showed the following P absorption amounts: FLP – 5.08 g d^{-1}, CE – 1.76 g d^{-1}, and SG – 3.91 g d^{-1} (calculated for 1 m^3 of each filter).
Wastewater filtration through mineral media resulted in the removal of other pollutants, too: organic pollutants removal (according to BOD_5) was 30.8 to 72.5%, and the removal of nitrogen compounds (more than 90% of which were in the form of ammonium salts) was even 93.2% in CE filter.
Key words: phosphorus, wastewater, adsorption, filters.

Introduction

Phosphorus is often the main nutrient influencing etrophication processes of water bodies. As the biochemical cycle contains no any important gas elements, in natural systems phosphorus tends to turn into sediment and thus is rarely found in the ecosystem (EPA, 2000).

In the environment protection regulations of Lithuania, the rate of phosphorus is limited in wastewater outflow into the environment only from large wastewater treatment facilities nearby agglomerations larger than 10000 PE (population equivalents). Wastewater outflow from smaller treatment facilities has limited rates of pollutants BOD_5 and SS (suspended solids) (Aplinkosaugos reikalavimai…, 2001).

In the future, those rates will be checked and phosphorus concentration will be limited in wastewater outlet from smaller treatment facilities as well.

As the results of studies carried out by the year 2000 show, depending on wastewater forming conditions, P concentrations contained in wastewater differ significantly: wastewater inflow into treatment facilities from farmers' cattle-sheds contains 10 to 50 mg l^{-1} of P, and domestic wastewater usually contains 10-15 mg l^{-1} of P (Strusevičius, 1996).

During the biological wastewater treatment process, P removal is rather efficient when organic pollutants concentration (according to BOD_5) is no higher than 190 mg l^{-1} of O_2 and the ratio with phosphorus does not exceed 20 (Dauknys et al., 2000).

Having studied the composition of wastewater on diary farms it was determined that wastewater pollution according to BOD_5 is from 800 to 900 mg l^{-1} of O_2, and the ratio BOD_5/P_{total} is 30-36. After the biological treatment of wastewater from diary farms with high initial pollution concentration and insufficient relationship of BOD_5/P_{total}, phosphorus concentration contained in pre-treated wastewater reaches 12.6 mg l^{-1} (Strusevičius, Strusevičienė, 2003).

Currently, researchers have been developing different techniques and ways for P removal from biologically treated wastewater before its outlet into the environment. P-adsorption methods are most common.

Some authors (Drizo et al., 1997; Johansson, 1998; Cheung, 2000; Arias, 2001; Drizo et al., 2002) have made tests with substances of different porosity trying to discover the media ensuring long-term P removal. The researchers were using different methods to calculate operation longevity of those filters. Meanwhile, other scientists (Lookman et al., 1996; Monterroso Martinez et al., 1996) were trying to determine the ratio between peculiarities of those mineral substance sand P removal processes. Special containers were constructed for the studies: P removal processes and kinetics were modeled in a small part of filters of horizontal flow.

In 2002, we made the laboratory tests using calcite (CA) macadam found in Akmenė district (Lithuania) and containing no less than 54% of Ca, Al and Fe compounds able to adsorb phosphorus. The task of the studies was to determine transformation peculiarities of P compounds during wastewater treatment processes (2002). As the study results have shown, during wastewater filtration via CA macadam filter, P adsorption is rather slow. About 90% of phosphorus is removed from wastewater during a 5-day filtration period. Such long wastewater retention in CA filter

Table 1

Chemical composition of filtralite-P (FLP), zeolite (CE) and shulgite (SG)

Chemical components	Measure unit	Filtralite-P (FLP)	Zeolite (CE)	Shulgite (SG)
1	2	3	4	5
CaO	%	30.0	2.1	1.2
SiO_2	″	62.0	71.5	56.0
Al_2O_3	″	18.0	13.1	4.2
FeO	″	7.0	0.9	2.5
MgO	″	3.0	1.07	1.5
K_2O	″	4.0	2.5	1.5
Na_2O	″	2.0	2.5	0.2
P_2O_5	″	-	0.033	0.01
C	″	0.02	-	28.0
As	mg kg^{-1}	0.75	15.0	-
Cd	″	<0.4	-	-
Cr	″	8.9	-	-
Cu	″	5890.0	200.0	-
Hg	″	<0.015	-	-
Ni	″	9.3	-	-
Pb	″	<4.0	20.0	-

is not acceptable from the technological point of view.

Recently, a large variety of natural and artificial powdery mineral substances that might be used as P-adsorption filters are imported into Lithuania.

The objective of the studies was to compare P removal efficiency under laboratory conditions during wastewater filtration processes via different mineral filters, and to estimate treatment efficiency of the filters.

Materials and Methods

Three minerals were selected for the studies: filtralite P (FLP), zeolite (CE) and shulgite (SG).

FLP filtralite P is the product of coarse (swollen) clay particles created for P adsorption. Clay particles were burnt in a special long rotary oven at the temperature of 1200 °C (Zhu et al., 1998). Under such temperatures, the density of burning clay increases significantly. Volume mass is 600-800 kg m^{-3}; filtralite comprises crushed 0-4-mm particles. Thus, the same amount of filtralite-P is spread on the whole surface, which ensures quite efficient pollutants removal.

This mineral is made and used for wastewater treatment mostly in Norway. Recently, the company "Optiroc" has developed its activity in other European countries as well (Sweden, Estonia, Spain).

CE zeolite is natural mineral from Sokirnica mine (Ukraine). This mineral is attributed to aluminum silicates containing 70-75% of limestone optolite (empirical formula - $Me\cdot[(AlO_2)\cdot(SiO_2)\ y]z\ H_2O$). Aluminum and silicon oxides make up about 85% of the mineral, other microelements (calcium, sodium, magnesium, iron) make up 15%. Due to high-rate ion changes (1.5 mg-ekv g^{-1}), this mineral is often used as an adsorbent for the filtration processes of gas and water. This mineral may also be used as forage additive.

Chemical composition of all mentioned minerals is presented in Table 1.

SG is a natural mineral found in Karelia. Previously, this mineral was used for medicine and filtration of potable water. Apart from silicates, this mineral also contains about 30% of carbon that actively contributes to the adsorption processes.

Principle physical characteristics of the minerals are given in Table 2.

The laboratory test was conducted within a 2-month

Table 2

Physical characteristics of minerals FLP, CE and SG

Mineral	Particle size, mm (d_{10})	Particle size, mm (d_{60})	CU	Porosity, P%	Volume mass, kg m^{-3}	Specific area, m^{-1}
FLP	0.3	2.13	7.1	65.0	580.0	51000.0
CE	2.89	4.33	1.49	43.6	1232.0	770.0
SG	4.31	7.94	1.96	45.7	1242.0	460.0

period of the year 2003. The laboratory model contains three plastic reservoirs (H = 14 cm, B = 12.0 cm, L = 76.5 cm) filled with different minerals (Fig. 1). Wastewater flows from the dosing device into the beginning of each reservoir. In the reservoir, filtration of horizontal flow occurs.

In each reservoir, stable level of wastewater is maintained (12 cm). Further from the dosage device, the wastewater is provided to each filter by different discharge that was calculated so that wastewater residence time in each filter was 24 hours. The discharge was calculated by the following formula:

$$Q_d = \frac{W \cdot P}{100}, \quad (1)$$

where

W – filter capacity, dm ^{3} (W = 11.02 dm ^{3});

P – mineral porosity, %.

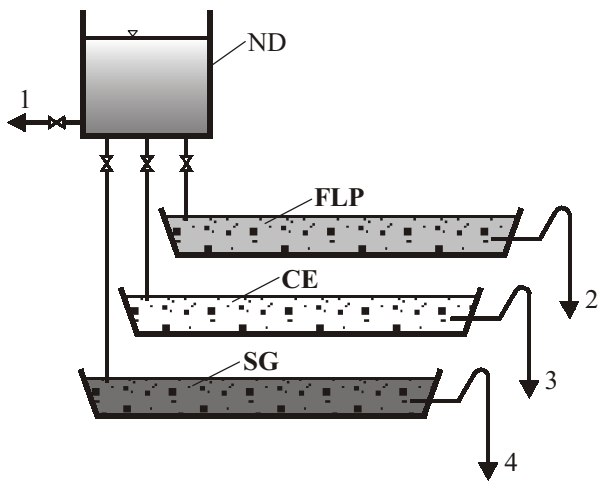

Figure 1. Laboratory model of P-removal filters with mineral media:
ND – wastewater dosage device; FLP, CE, SG – filters with mineral media; 1-4 – wastewater sampling spots.

Wastewater discharges into each filter were as follows: FLP filter – 7.16 dm ^{3} d^{-1}; CE filter – 4.8 dm ^{3} d^{-1}; SG filter – 5.0 dm ^{3} d^{-1}.

Wastewater was supplied to the laboratory model from wastewater treatment facilities arranged on A. Visockas diary farm. In the treatment facilities, P concentration contained in wastewater outlet into the environment after biological treatment was fluctuating from 8.1 to 18.9 mg l^{-1}.

At the onset of the studies all filters were filled with wastewater. During the first wastewater filtration month, no wastewater samples were taken because at the beginning of filtration process the chemical ratio of wastewater with minerals are unstable and no biological film is formed. Later the film occurs on the mineral surface. The film is formed from microorganisms contained in wastewater. After one month of filtration, wastewater was sampled 4 times every 10 days.

Chemical analysis were made by the following methods: pH-potentiometric method with glass electrode; BOD_5– titrometric (Vinkler9s method); COD_{Cr} (chemical oxygen demand)–oxidation method with potassium bichromate and sulphuric acid; N_{total} – titrometric (Kjedal9s method incineration); N-NH_4 – colorimetric; P_{total} – photocolorimetric (incineration); P-PO_4 – colorimetric method with ammonium molybdate and ascorbic acid and SS (suspended sediments) – gravimetric method. The methods of mathematical statistical analysis were applied for data processing.

Results and Discussion

Composition of wastewater used in the laboratory model is given in Table 3.

The wastewater is of natural and slightly alkaline reaction. Considering the approved rates, regulation indices for small wastewater treatment facilities are BOD_5 and SS. Average annual values of those indices must not exceed 30 and 35 mg l^{-1}, maximum annual values cannot exceed 50 mg l^{-1}. Thus after the biological treatment, wastewater fully meets the environment protection requirements.

Table 3

Composition of biologically pretreated wastewater on A. Visockas dairy farm

Index	Measure unit	Average value	Fluctuation range
pH	-	7.4	7.3-7.7
BOD_5	mg l^{-1} of O_2	24.0	11.0-31.0
COD_{Cr}	"	54.2	36.7-89.0
N_{total}	mg l^{-1}	49.5	48.6-51.0
N-NH_4	"	45.6	45.0-47.0
P_{total}	"	11.3	8.1-18.9
P-PO_4	"	9.4	6.7-14.9
SS	"	19.75	11.0-30.0

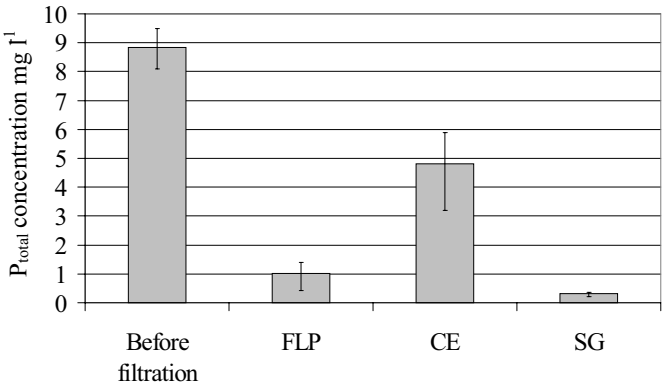

Figure 2. P concentration in wastewater before and after filtration in FLP, CE and SG filters.

P concentrations contained in wastewater outlet after biological treatment process are not limited so far, however the data presented in Table 3 indicates rather high wastewater pollution with phosphorus (11.3 mg l^{-1}). The greatest amount of P pollutants is that of mineral phosphorus (83.9%). Having approved P concentration contained in wastewater outlet into the environment, P rate should not exceed 1.5-2.0 mg l^{-1}.

During wastewater filtration through mineral filters, active phosphorus may form insoluble phosphates minerals with calcium, aluminum and other metals. In 2002, a laboratory model with filtralite P (FLP) was constructed in Norway for the studies on the kinetics of P removal from mineral solution, and formation of P compounds in the filtralite were carried out. As the study results have shown, P removal was rather efficient, however Ca, Fe and Al phosphates accumulated in FLP minerals made up about one fourth of the whole accumulated phosphates amount, and phosphates of unknown matter made up even 56% of the whole accumulated phosphates amount (Kinga A. et al., 2003).

The results of our studies on P removal from wastewater in mineral filters are presented in Figure 2.

As it is seen, the most efficient P removal was in the shulgite filter (SG). P concentration contained in wastewater after filtration was insignificant – only 0.21-0.36 mg l^{-1} (average 0.32 mg l^{-1}). In filtralite filter (FLP) specially made for P removal from wastewater, P concentration in wastewater after filtration was 1.01 mg l^{-1} and was fluctuating within a rather wide range during the study period (from 0.4 to 1.5 mg l^{-1}).

In zeolite filter (CE), P removal from wastewater was on the average 45.6%, and its concentration was fluctuation from 3.2 to 5.9 mg l^{-1} in wastewater after filtration during the whole study period.

Under different hydraulic load of filters, P removal efficiency from wastewater is best shown by P mass balance ($M_{ads.\,P} = M_{inlet\,P} - M_{outlet\,P}$). P mass balance calculation results for one m^3 of the filter during a day are given in Table 4.

As it is seen from the data in Table 4, the amounts of phosphorus retained in FLP, CE and SG filters were 5.08 g d^{-1}, 1.76 g d^{-1}, and 3.91 g d^{-1} respectively. Obviously, the most intensive P adsorption processes occurred in FLP filter.

Until now, researchers claimed P adsorption intensity to be dependent on the amounts of Al, Fe and Ca compounds contained in minerals. Diagrams given in Figure 3 show the amounts of metal compounds contained in studied minerals.

The amount of Ca, Al and Fe oxides contained in the composition of FLP, CE and SG filters are 23%, 16.1%, and 7.1% respectively. Having compared P adsorption efficiency data (Table 4) with the amounts of mentioned metals, no

Table 4

P-mass balance (filtration of 1 m³ of wastewater via FLP, CE and SG filters)

Mineral filters	$M_{inflow\,P}$, g m^{-3} d^{-1}	$M_{outflow\,P}$, g m^{-3} d^{-1}	$M_{ads.P}$, g m^{-3} d^{-1}	P-removal efficiency, %
FLP	5.74	0.66	5.08	88.5
CE	3.87	2.11	1.76	45.5
SG	4.06	0.15	3.91	96.3

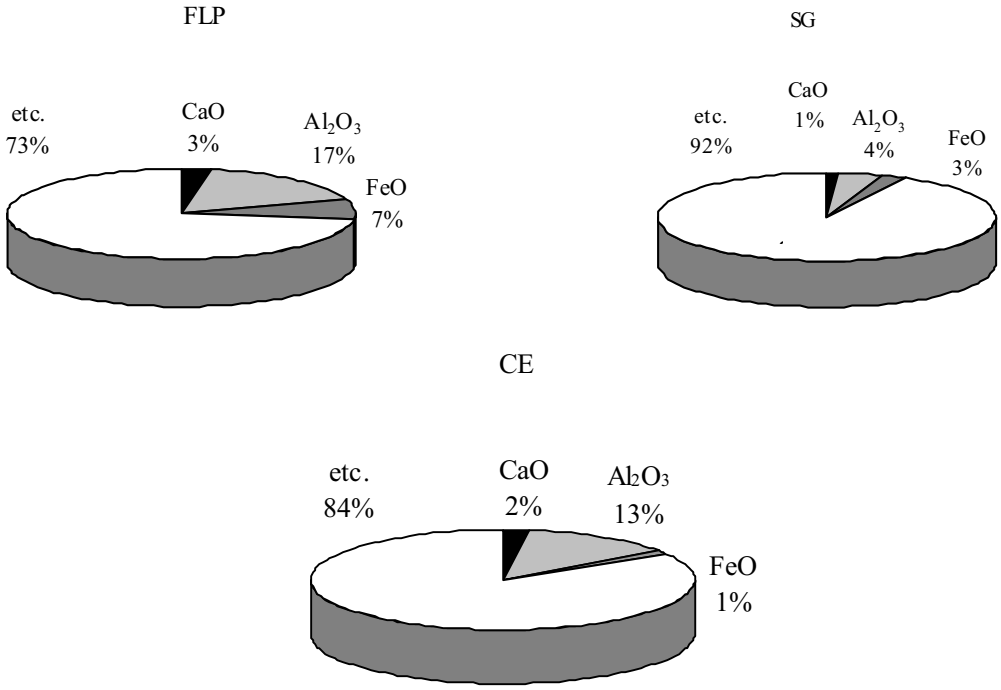

Figure 3. The amount of Ca, Al and Fe oxides contained in minerals FLP, CE and SG.

direct relation is observed. Although P adsorption from wastewater in FLP and SG filters is rather high (5.08 and 3.91 g m^{-3} d^{-1} respectively), the amounts of Ca, Al and Fe oxides contained in minerals of those filters were very different (23% and 7.9% respectively). P adsorption in CE filter with rather high amount of oxides (16.1%) is comparatively low (1.76 g m^{-3} d^{-1}).

Low P adsorption efficiency in CE filter may be explained by the fact that CE filter was made of quite large fractions, the specific area of which was 6.6 times smaller than the specific area of FLP mineral filter.

During wastewater filtration process via mineral filters, due to biochemical processes occurring in filters, other pollutants are also removed from wastewater. Therefore other pollution indices were also determined. The study results are presented in Table 5.

During the filtration process, pH index of wastewater is changing: after filtration in FLP filter pH increases from 7.4 to 9.3, after filtration in SG filter the index decreases to 6.0. Significant decrease in organic pollutants concentrations (according to BOD_5) contained in wastewater was observed: if BOD_5 was 28.9 mg l^{-1} of O_2 in wastewater before treatment, it tended to decrease to 6.6-16.6 mg l^{-1} of O_2 (42.6-77.2%) after the treatment process in different filters. Before treatment the wastewater contained rather high nitrogen compounds concentrations (50.0 mg l^{-1}). After filtration in CE filter, nitrogen compounds concentration decreased even by 93.2% to 3.4 mg l^{-1}. In other filters, N removal from wastewater was insignificant (15-16%).

It is complicated to analyze more extensive applicability of mineral filters so far, as there are no scientific-based calculation methodologies of the longevity of such filters.

Table 5

The changes in pollutants concentrations during wastewater filtration processes

Studied wastewater	Pollutants, mg l^{-1}							
	pH	BOD_5	COD_{Cr}	P_{total}	$P\text{-}PO_4$	N_{total}	$N\text{-}NH_4$	SS
Before filtr.	7.4±0.2	28.9±2.0	69.3±26.0	8.8±0.7	7.5±0.8	50.0±1.0	45.6±1.05	22.7±7.0
After filtr.on in FLP	9.3±0.3	10.3±1.4	39.4±15.7	1.01±0.5	0.75±0.5	42.5±7.5	37.1±2.0	14.0±1.0
After filtr.on in CE	7.5±0.2	16.6±1.2	43.5±13.1	4.8±1.4	4.4±1.4	3.4±0.4	0.66±0.7	14.6±1.5
After filtr. in SG	6.0±0.4	6.6±1.4	28.0±9.9	0.32±0.2	0.16±0.2	42.0±1.0	40.4±0.5	19.3±2.0

Conclusions

1. During the treatment of heavily polluted wastewater containing 10-50 mg l^{-1} of phosphorus, P removal is inefficient in the process of treatment therefore it is necessary to apply additional means to ensure better P removal results.

2. After wastewater filtration in mineral filters (filtralite FLP, zeolite CE, and shulgite SG) containing 23.0%, 16.1% and 7.9% of Ca, Fe and Al oxides respectively, P removal results from wastewater are as follows: 88.5% in FLP filter, 45.5% in CE filter, and 96.3% in SG filter.

3. Under the conditions of different hydraulic load of filters, P mass balance was calculated, according to which it was determined that 1 m^3 of FLP, CE and SG filters adsorbs 5.08, 1.76, and 3.91 g of phosphorus per day respectively.

4. During wastewater filtration through mineral filters, other pollutants are also removed. Organic pollutants removal (according to BOD_5) is 30.8 to 72.5%, the removed amount of nitrogen compounds (90% of which are in the form of ammonium salts) in CE filter is even 93.2%; however in other mineral filters nitrogen removal is insignificant.

References

1. Aplinkosaugos reikalavimai nuotėkoms tvarkyti. (Environmental requirements for wastewater handling). Žin., 2001 10 05, Nr. 87-3054, pp. 22-29. (in Lithuanian).
2. Arias C.A., Del Bubba M. and Brix H. (2001) Phosphorus adsorption maximum of sands for use as media in subsurface flow constructed reed beds. Water Res. 35(5), pp. 1159-1168.
3. Cheung K.C. and Venkitachalam T.H. (2000) Improving phosphate removal of sand infiltration system using alkaline fly ash. Chemosphere (41), pp. 243-249.
4. Dauknys R., Matuzevičius A. (2000) Veiksnių, turinčių įtakos biologiniam fosforo šalinimui iš nuotekų, eksperimentiniai tyrimai. (Experimental investigations of factors affecting the biological P-removal from watewater). Aplinkos inžinerija. 8(3), pp. 156-167 (in Lithuanian).
5. Drizo A., Comeau Y., Forget C. and Chapuis R.P. (2002) Phosphorus saturation potential: a parameter for estimating the longevity of constructed wetland systems. Environ. Sci. Technol.36, pp. 4642-4648.
6. Drizo A., Frost C.A., Smith K.A. and Grace J. (1997) Phosphate and ammonium removal by contructed wetlands with horizontal subsurface flow, using shale as a substrate. Water Sci. Technol. 35(5), pp. 95-102.
7. EPA, Office of Research and Development (2000) Manual, Constructed Wetlands Treatment of Municipal Wastewaters, Cincinnati, Ohio. 131 pp.
8. Johansson L. (1998) Phosphorus sorption to filter substrates – Potential benefits for onsite wastewater treatment, In Departament of Civil and Environmental Engineering, Royal Institute of Technology. Kungl Tekniska Högskolan, Stockholm, pp. 78-83.
9. Kinga A., Fadi R.D. Suliman, Petter D. Jessen and Arve Heistad (2003) Phosphorus sorption by Filtralite-P – small scale box experiment. In: Mander U., Voble Ch., Poom A (eds): Constructed and Riverine Wetlands for Optimal Control of Wastewater at Catchment Scale. Conference FP RTD PRIMROSE. Tartu, pp. 53-58.
10. Lookman R., Jansen K., Merckx R. anf Vlassak K. (1996) Relationship between soil properties and phosohate saturation parameters. A transect study in Northern Belgium. Geoderma 69, pp. 265-274.
11. Monterroso Martinez C. (1996) Factors influencing phosphorus adsorbtion in mine soils in Galicia, Spain.Sci. Total Envir.180, pp. 137-145.
12. Strusevičius Z., (1996) Nuotekų, atliekų ir mėšlo tvarkymas žemės ūkyje. (Treatment of wastewater, wastes and manure in agriculture). Vilainiai, 156 pp. (in Lithuanian).
13. Strusevicius Z., Strusevicienė S.M. (2003) Investigation phosphorus removal in wastewater treatment facilities on dairy farm. Water management engineering, 2003, 23(45), pp. 5-13.
14. Zhu T.M., Jenssen P.D., Maehlum T. and Krogstad T. (1998) Phosphorus sorption and chemical characteristics of lightweight aggregates (LWA)-potential filter media in treatment wetlands. Water Sci.Technol. 35(5), pp. 103-108.

OPTIMIZATION OF SEWERAGE SYSTEM IN RIGA CITY

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Abstract

In the paper there are described problems of sewerage system in Riga which essentially impede its normal functioning. There are analyzed operation regimes of two principal pumping stations which pump all wastewater of Riga to the purification plants (2001-2005). The main focus is on implementing different measures that would improve collection and pumping of wastewater. It is offered to build a third penstock from the Voleru chamber to the purification plants. It is suggested to separate the rainwater from the household wastewater. There are analyzed 11 different versions of pump operation. In the conclusions and recommendations the formation of the possible dangerous situation during heavy downpours is demonstrated. It is recommended to build a regulation reservoir near the purification plants which could essentially protect the Daugava from unpurified wastewater during the downpours.
Key words: sewerage, waste water, pumping station.

Introduction

Improvement of wastewater pumping in Riga

An aim of research is to study and give recommendations on how to optimize the operation of Riga's main pumping stations. The severage system of Riga is complex and technically incomplete yet. In the central part of the city it is a connected system and its drains (carries away) the household wastewater, production and atmosphere simultaneously along the main sewerage collectors.

The sewerage system consists of self-flow sewerage collectors, 50 pumping stations, penstocks and waste water biological purification plants (BPP). The purified wastewater is let into the Riga Gulf.

Of late years an amount proportion of the household wastewater and the rainwater going throught the pumping stations have changed to the best for rainwater and the snow melting water. Thus the functioning of wastewater pumping stations depends more from the climatic factors at present than several years ago, the role of discharges and spillways of wastewater break-down (accident) increases in the functioning of sewerage network and pumping stations. During heavy downpours the pumping stations are functioning of a full capacity, but in extreme situations they cannot even get through with the amount of wastewater as a result there ensue emergency situations. The total efficiency of the main pumping stations is larger than capacity of BPP, and it creates some limitations in taking the maximum discharge during the downpours.

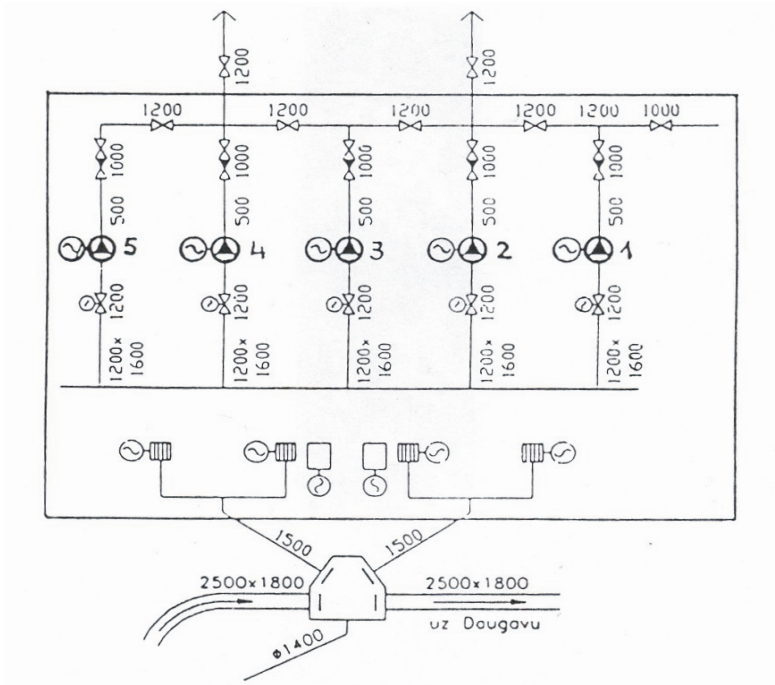

Figure 1. Scheme of main pumping station No. 34.

The brake down discharge 2500x1800 into the Daugava may function only in extreme situations, during the break of electro-energy etc.

Materials and Methods

Main operational regimes of pumping stations are defined utilizing flow maters. Different pump operation versions are defined with mathematical modeling method utilizing classical formulas of hydraulics used to calculate pipeline resistance (Чугаев, 1982). Pump's characteristics are drawn utilizing graph-analytical method (Tilgalis, 2000; Tilgalis, 2005). Wastewater flow observation data from Ltd 'Rigas udens' for 2000-2005 are used in the research. Data are systemized and mathematically processed in order to obtain maximum wastewater flow.

Results and Discussion

Measures for improving operations of sewerage pumping stations and penstocks

Pumps 34 and 15 in the pumping station pump in the wastewaters in 2 penstocks of 1400 mm diameter. The current situation – from the pumping station 34 two penstocks of 1233 m go up to Volen switching chamber. These penstocks do not cross any water obstacle. From the pumping station 15 two diameter penstocks of 1400 mm go up to Voleri switching chamber for 2500m. These penstocks go throught the switching chamber in the territory of the port, cross the Daugava and enter the Voleri switching chamber. From the Voleri switching chamber 2 penstocks of 8071m up to the discharge of BPP taking up chamber. The mark of the discharge pipe in the Baltic altitude system is 11.40 m. The wastewater pours out in the atmosphere and discharges into the taking-up chamber from above.

The character curve of the penstock may describe the possibilities of the penstock discharge best of all. The efficiencies of the pumping station 34 and 15 are such at which the numerical valves according to Reinold's criteria (Чугаев, 1982) in the penstocks are in the so-called quadratic resistance area. The hydraulic losses (because of both friction and the local ones) are proportional to the square of medium speed (or discharge) of the flow.

The coefficients of proportionality, called – pipe resistance, ($s^2 m^{-2}$) includes the index characterising the roughness of the surfaces, the inside diameter D of the pipe and the lenght L of the span of calculation. The friction losses in the quadratic resistence area - $\Sigma h_l = SQ^2$ (1). While taking into consideration – the local hydraulic losses in a long pipe, 10 percent of the losses $\Sigma h = SQ^2$ (2). Here Sh are both the total hydraulic losses and the necessary difference of the pressure elevation at the ends of the pipe for the pressure regime provided by their flow and discharge Q.

The main task of the both principal waste water pumping stations (No. 15 and No.34) is to transport the wastewater by means of pumps and penstocks from the chamber of the lower level in front of the pumps to the purification plants located higher.

Therefore pumps have to raise water both vertically and to overcome the total hydraulic resistance of the penstocks. The task of the pump is to impact such hydraulic energy to the liquid which would be sufficient to overcome both the geodesic raising elevation and the hidraulic resistance of the penstocks. The pump has to provide the pumping elevation $H=H_g+SQ^2$ (3). The relation of these activities may be described graphically in the same scale in witch the main character curve of the pump is given (HQ). The point of intersection of both curves is called the joint operation point of the pump and the pipeline which determines the solution of both two hydraulic systems – pump efficiency Q and discharge in the penstock. In reinforced concrete piping the coefficient of inside surface roughness according to Academician N.Pavlovskis is n=0.014 (Чугаев, 1982).

In the quadratic resistence area $S = 1.1 \times A \times L$ (4), where

1.1 – factor which takes into consideration the local hydraulic losses of 10 percent from the friction losses in a long pipeline;

A – specific resistance ($s^2 m^{-2}$) in dependent on the material and diameter of the pipeline, A = 0.000329 $s^2 m^{-2}$ (5) and $S = 1.1 \times 0.000329 \times L = 0.0003619 \times L$ (6);

The hydraulic losses and the character curves of the penstocks are to be known for all pipelines and their spans. Calculations have been made in the result of which the relation of total hydaulic losses calculation is obtained for each span and number of the penstocks given in Table 1. (Tilgalis, 2005)

Common character curves of principal pumping station operation

In order to analyse the common operation of both principal stations in the penstocks up to the wastewater purification station, it is necessary to transform the pump character curves to the confluence piont – Voleri switching chamber. It may be done by subtracting the hydraulic losses from the character curve at a specific efficiency of the pump in the span from the pumping station to Voleri chamber - Figure 2. Both pumping stations have 2 penstocks of 1400 mm diameter up to Voleri chamber. It is presumed that both penstocks to BBP are connected in order to align discharges and pressures. The character curves of all 4 pumps of the pumping station No.15 are summarized in the Q scale direction, assuming that both pumps equipped with the frequency transformer operate with the maximum rotation speed according to the frequency 50 Hz. But the efficiency of seperate pumps of the pumping station No.34 are summarized together with the curve of the pumps No.15. The

Table 1

Hidraulic resistance S of penstocks and common hydraulic losses

Name of penstock span	Lenght L(m) of span	S=1.1*A*L	Common hydraulic losses	Number of penstocks
Pumping station No.15 - Voleri switching chamber	2500	0.9048	0.9048 Q^2	1
			0.2262 Q^2	2
Pumping station No.34 - Voleri switching chamber	1233	0.4462	0.4462 Q^2	1
			0.1116 Q^2	2
Voleri switching chamber – Buļļupe switching chamber	7381	2.6712	2.6712 Q^2	1
			0.6678 Q^2	2
Buļļupe switching chamber - discharge from the penstock in the purification plants	690	0.2497	0.2947 Q^2	1
			0.0737 Q^2	2
Pumping station No.15 - discharge from the penstock in the purification plants	10571	3.8256	3.8256 Q^2	1
			0.9564 Q^2	2
Pumping station No.34 - discharge from the penstock in the purification plants	9304	3.3664	3.3664 Q^2	1
			0.8418 Q^2	2
Pumping station No.15 - Buļļupe switching chamber	9881	3.5759	3.5759 Q^2	1
			0.8940 Q^2	2
Pumping station No.34 - Buļļupe switching chamber	8614	3.1174	3.1174 Q^2	1
			0.7794 Q^2	2
Voleri switching chamber - flow into the Daugava	211	S=1,2*A*L=0,0833	0.0833 Q^2	1
Voleri switching chamber - flow from the penstock in the purification plants	8071	2.9209	2.9209 Q^2	1
			0.7302 Q^2	2
			0.3245 Q^2	3

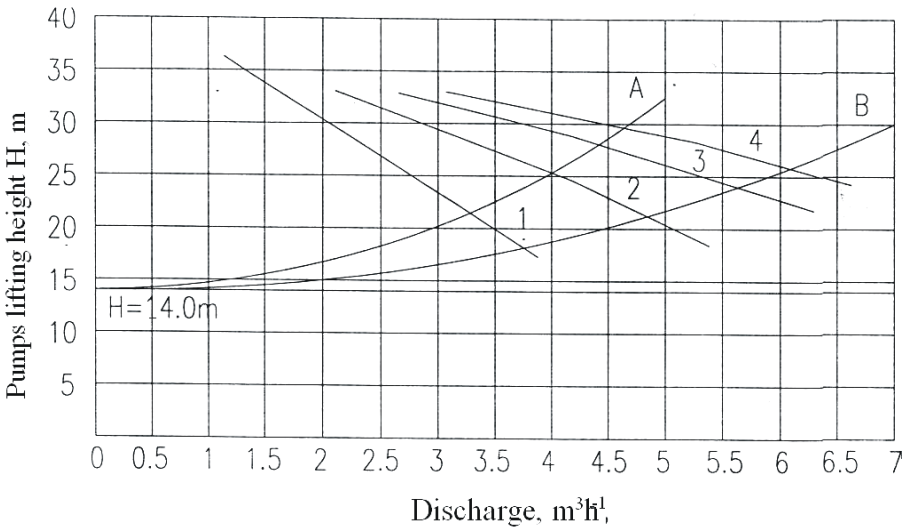

Figure 2. Common character curves of the principal pumping station operation.
Where: 1-15.Common character curve of the existing pumps of the pumping station No.15 in parallel connection;
2-15.Common character curve of 4 pumps of the pumping station No.34 and 1 pump of the pumping station No.34;
3-15.Common character curve of 4 pumps of the pumping station No.15 and 2 pumps of the pumping station No.34;
4-15.Common character curve of 4 pumps of the pumping station No.15 and 3 pumps of the pumping station No.34;
A - Common character curve of 2 penstocks of 1400 mm diameter;
B - Common character curve of 3 existing and 1 new - the third penstock with 1400 mm diameter.

penstock number functioning – 2(curve A) and 3(curve B). The penstocks of both pumping stations are connected in Voleri switching chamber. The curve B is deficted in order to obtain the data about the operation of the pumping stations in the conditions if a 3rd penstock would be built (Tilgalis, 2003).

Versions of principal pumping station and penstock operation after building the 3rd penstock

The 1st version shows that the exsisting 4 pumps of the pumping station No.15 pump into 2 penstocks to BPP (along the 3rd the pumping station No.34 pumps), their efficiency is 327 $m^3 s^{-1}$ or 11770 $m^3 h^{-1}$.

The 2nd version under conditions, when the pumping station No.15 pumps to BPP along 3 penstocks (the pumping station No.34 – into Daugava along one of the break – down discharges), the common efficiency is 13280 $m^3 h^{-1}$, it is more than 1510 $m^3 h^{-1}$ than while pumping along 2 penstocks to BBP;

The 3rd version – it is presumed that the existing 4 pumps of the pumping station No.15 are functioning and one pump of the pumping station No.34 has an unclosed fastener on the penstock. The efficiencies of the pumping stations – the pumping station No.15 will pump 11770 $m^3 h^{-1}$, but the pumping station No.34 – 2560 $m^3 h^{-1}$, together both of them – 14330 $m^3 h^{-1}$.

Version 4 – 3 penstocks are in operation; the pumps of the pumping station No.15 will pump 13280 $m^3 h^{-1}$, but No.34 – 4110 $m^3 h^{-1}$, thus the pumping station No.15 1510 $m^3 h^{-1}$ more than in the version 3, but the pumping station No.34 – more than 1550 $m^3 h^{-1}$ than in the version 3.

The version 5 shows the operation of existing 4 pumps of the pumping station No.15 and 2 pumps of the pumping station No.34: the pumping station No.15 pumps 8710 $m^3 h^{-1}$ while functioning in 2 penstocks to BBP.

In the version 6 - 3 penstocks are functioning, the pumping station No.15 pumps 10800 $m^3 h^{-1}$, the 34 th – 9360 $m^3 h^{-1}$, both together 20160 $m^3 h^{-1}$, it is 4390 m^3 more than in the version 5 along 2 penstocks. With the 3rd penstock, the pumping station No.15 pumps 2090 $m^3 h^{-1}$ more, but the 34th – 2300 $m^3 h^{-1}$ more.

Version 7 – 2 penstocks are functioning. The pumping station No.15 pumps already less than in the version 5 – 7780 $m^3 h^{-1}$, but the 34 th – 8850 $m^3 h^{-1}$ (3 pumps funkcioning), together 16630 $m^3 h^{-1}$.

In this and the following versions the pumping station No.34 (with 3 funcioning pumps) will pump more than the pumping station No.15 (with 4 funkcioning pumps).

Version 8 – with 3 funkcioning penstocks, the situation is as follows: pumping station No.15 can pump 9830 $m^3 h^{-1}$, but 34 th – already 11900 $m^3 h^{-1}$; the growth of efficiency with adding the 3rd penstock is: in the pumping station No.15 – 2050 $m^3 h^{-1}$, but in the 34th – 3130 $m^3 h^{-1}$.

Version 9. It is pressumed that one more pump of C3531 is used, and thus 5 pumps are functioning together, but in the pumping station No. 34 – 2 pumps. This version is recommended during downpours, functioning in 2 penstocks to BPP. Then the pumping station will pump 10080 $m^3 h^{-1}$, but the 34th – 6120 $m^3 h^{-1}$.

Version 10 – 3 penstocks are functioning the pumping station No 15 will pump 13000 $m^3 h^{-1}$ and the pumping station 34th – 8600 $m^3 h^{-1}$. The growth of efficiency for the pumping station No 15 after the installation of the 3rd penstock will be 2920 $m^3 h^{-1}$, but the 34th – 2480 $m^3 h^{-1}$.

Version 11 – 5 penstocks of the pumping station No 15 will pump 13600 $m^3 h^{-1}$ throughout the Voleri breakdown discharge in the Daugava (Tilgalis, 2005).

The 3rd penstock has to be built to BPP. In this version it is possible to obtain the largest pump efficiencies while keeping the possibility for each pumping station to use the breakdown discharge separately during extreme situations. In order to do it the reconstruction of Voleri switching chamber is to be carried out. 4 new flat fasteners of 1200mm diameter are to be built as well as the necessary by-pass lines.

Conclusions

1. In the present situation penstocks (if all of them operate properly) may successfully drain away the wastewater of everyday use without the rainwater from both principal pumping stations to BPP.

2. The system of household wastewater of the part of Riga right bank in the central part is not separated from the rainwater system. During the downpours the pumping station No 15 cannot discharge the amount of the rainwater and wastewater. This situation repeats several times a year.

3. When the flow exceeds 11500 $m^3 h^{-1}$, the water level in the tunnel collector and collectors connected with it raises and the wastewater floods the lower places of the territory throughout the lids of the canalization wells.

4. During the downpours the staff of the pumping station No 15 is in an almost hopeless situation, because it is almost impossible to prevent the flow of wastewater that develops in the Riga central part from the self-flow rainwater and form the pumped wastewater of 11 sewerage-pumping stations.

5. The accumulation of the wastewater in the tunnel collectors in front of the main pumping stations creates the sedimentation of silt because of the small speed of the flow. During the downpours the speed of flow grows considerably and the drifts are transported to the pumping stations.

6. The risk factor of the Voleri switching chamber is the strategically important fastener No 6, if it does not work, the wastewater of the pumping station cannot be pumped to BPP.

7. To disconnect the rainwater collectors from those of the household wastewater.

8. To provide for the 3rd penstock (diameter 1400mm) from Voleri switching chamber to BPP, at the same time considering the building of a accumulation reservoir consisting of 2 parts at BPP.

9. In case operation of breakdown discharges must be stopped the sewerage network must have accumulation reservoirs.

10. One new pump having a frequency transformer must be built instead of one existing pump in the pumping station No 34.

References

1. Tilgalis E. (2003) Notekūdeņu savākšanas un pārsūknēšanas uzlabošana (Improvement of wastewater collection and pumping), Jelgava, 125 pp. (in Latvian).
2. Tilgalis E., a.o. (2000) Pētījumi par Rīgas kanalizācijas galveno sūkņu staciju darbības optimizāciju (Studies on optimisation of operation of Rigas's main sewerage pumping stations), Riga, 160 pp. (in Latvian).
3. Tilgalis E., a.o. (2005) Rīgas notekūdeņu pārsūknēšanas un regulēšanas tehniski ekonomiskais pamatojums (The TEA of pumping and regulation wastewater in Riga city), Hydroengineering, Jelgava, 64 pp. (in Latvian).
4. Чугаев Р.Р. (1982) Гидравлика (Hydraulics), Ленинград, Енергоиздат.,Russia, 672 с. (in Russian).

INVESTIGATION OF GROUND WATER AND WATER FROM SHALLOW WELLS LOCATED IN KARST ZONE

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Abstract

The paper discusses the peculiarities of hydrological and hydrochemical regime of ground water in shallow wells and boreholes in moraine soils of active karst zone.
It was determined that the fluctuations in water levels in boreholes and wells have the same tendencies: water was closest to the ground surface when the air temperature was increasing in the cold period (November-March) and decreasing in the warm period (April - October) of the year.
Chemical composition of water in boreholes (sum of ions) was up to 1.2 times lower than that in well water. This was determined by higher sodium, sulphates, chlorine and nitrates amounts. When water level is decreasing, water chemical composition is increasing in water of wells and boreholes.
It was determined that water in wells was contaminated with nitrate nitrogen, water in boreholes was polluted with ammonia nitrogen.
Key words: borehole, well, water level, chemical composition, nitrogen.

Introduction

Human agricultural activity affects the environment and subsurface water. The most susceptible is ground water located 0.5-3 m deep in plains and 15-20 m deep in highlands. The factors influencing ground water quality include the oxidation condition in the aquifer, depth within the aquifer, and land use overlying the aquifer (Dawson, 2001).

Due to the pollution of agricultural objects in local areas, water of bad quality is forming at the distance of several hundreds of meters from the main center in sandy areas. Having made the geostatistical analysis, it was determined that nitrate affected zone is at the distance of 145 m from the well (Kutra et al., 2002).

Country dwellers usually use the water from shaft wells. In Lithuania there are about 300 thousand shaft wells, the water of which is used by about 1 mln. of inhabitants (Rutkovienė et al., 2005). As the studies of health protection and geological research have shown, 51% of wells are polluted bacteriologically, and 48% of wells are polluted with nitrogen compounds. Seasonal pollution is characteristic to the changes in water quality of shaft wells. The highest chemical pollution of water in wells is observed in the warm period of the year, while in the cold period of the year the pollution is significantly lower (Rutkoviene et al., 2003). In arable land areas, NO_3 concentration contained in ground water does not exceed maximum contaminant limit (MCL) while in gardening land areas it is even 2-6 times higher than the maximum contaminant concentration (Kadūnas et al., 1992).

Formation of water chemical composition in the karst region depends on the gypseous Devonian sediment layers of Ástra-Tatula located near the ground surface. Dispersion of those sediment determines higher sulphates and calcium concentrations as well as higher values of total mineralization (Paukštys, 1996).

The follow-up of karst sinkholes create suitable conditions for surface water and pollutants to get into the subsurface water. Composition of ground water in the karst region depends on the organic matter the dispersion of which depends on the antropogenic environment of the shaft well. High nitrate concentrations exceeding 50 mg l^{-1} make up 30% in water of shaft wells of the whole territory (Arustienė et al., 2001).

As the studies of water quality of shaft wells performed in different parts of the country, including the karst region, show country dwellers use water of bad quality, moreover, the quality of water is not getting better.

The objective of the work is to determine the peculiarities of hydrological and hydrochemical regime of ground water contained in moraine soils of active karst zone.

Materials and Methods

The studies were carried out in moraine sandy loam and light loam soils. The study object is located in the upper reaches of the stream G-1, in lands of Lyglaukiai villages (Biržai district).

Under specific karst zone conditions, ground water quality was determined in 3 boreholes: in 1^a (h = 8.8 m) and 1^b (h = 3 m) nearby the sinkholes, in 2 (h = 5 m) in the arable land, as well as in two shallow wells located in garden plots nearby the boreholes observed (h = 6.0-11.0 m).

Ground water chemical composition and ground water level (in shallow wells and boreholes) was measured once a month during water sampling. Water chemical analysis included the following methods: HCO_3 – titrometric; K, Na – flame photometric; Ca, Mg – trilonometric; Cl – argentometric; SO_4– gravimetric, NO_3 – photocolorimetric with analyzer 'FIA star 5012 system'.

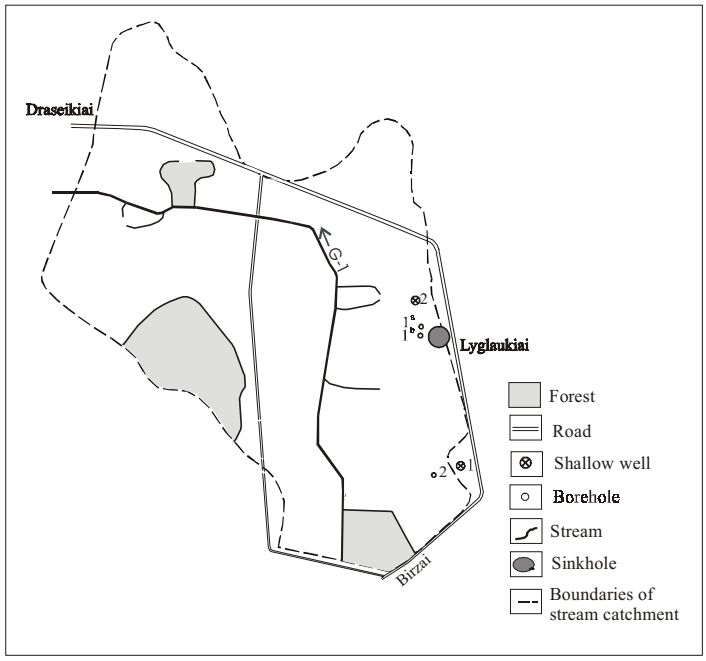

Figure1. Scheme of investigated area.

Data was analysed within the period 2004 -2005. Mathematical and statistical analysis of test study results was performed with the help of standard computer programs. To determine the interrelations, 'Excel' program was used.

According to the data of Biržai Meteorological Station, the most abundant precipitation is experienced in summer-autumn period (in June, July and October), while the least abundant precipitation is observed in spring (in March and April). The highest and lowest average air temperatures occur in July and in February respectively.

Average air temperature of both study years was 6.6 °C, which was 12% higher than the average many-year temperature. In 2004, annual precipitation amount was 758 mm and exceeded the average many-year precipitation rate by 25%; in 2005 it was 585 mm, and was 3% lower than the many-year average rate. In September-November of 2005, the precipitation amount was particularly low and made up only 35-58% of the average many-year rate (Fig. 2).

Results and Discussion

Monthly ground water fluctuations in boreholes and wells have the same changing tendencies. During the first study year, the highest water level was observed in spring (in March), and the lowest - in autumn (in September, October). During the second study year, the highest water level occurred in January and remained such until April. In June it started decreasing until the month of December (Fig. 3). Larger annual water fluctuation amplitudes were observed in wells (2.0-6.5 m) rather than in boreholes (1.0-2.8 m).

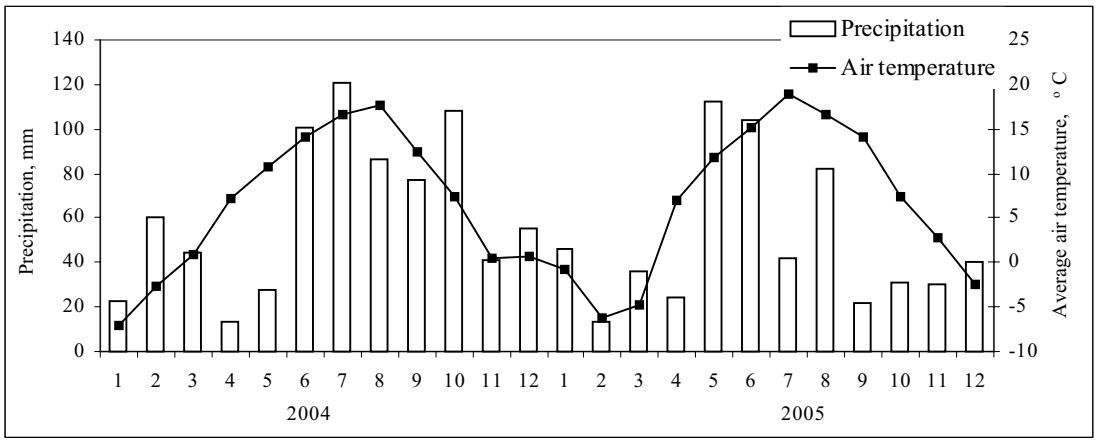

Figure 2. Monthly precipitation and average air temperature.

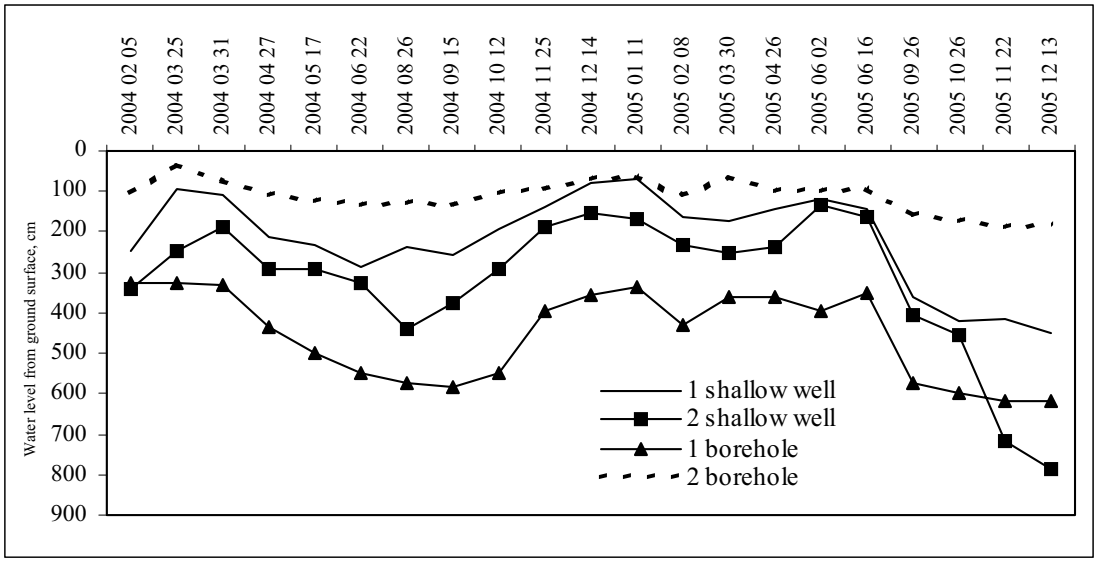

Figure 3. Dynamics of ground water level in shallow wells and boreholes.

Ground water level fluctuations depend on three main factors: hydrological or inter-river regime, seasons of infiltration nutrition, and lithology and thickness of sediment in aeration zone (Juodkazis, 1979). In drained land areas where ground water level is deeper than 5 m, water level regime almost does not depend on meteorological factors and is occurring according to the independent regime (Giedraitienė et al., 1996)

Precipitation amount had no direct effect on the fluctuations of observed ground water levels. More significant effect was made by the runoff formed in spring and winter. Those processes were mostly related with the changes in air temperature. The correlation analysis confirms that ground water level was decreasing when air temperature was decreasing in the cold period of the year (November-March) and increasing in the warm period of the year (April - October) (Table 1).

In the ground water of the studied karst zone, hydrocarbonates (HCO_3) make up 42-47% and calcium ions make up about 34% of the total sum of ions. This is calcium–magnesium hydrocarbonate water. Total amount of ions is 1.2 times higher than in water of boreholes (Table 2). This difference was determined by the amounts of sodium, sulphates, chlorine, and nitrates.

From the ground surface point of view, ground water level fluctuations in the observed wells and boreholes determined the changes in chemical composition by 50% (Table 3). Deeper layers of ground water determine higher sums of ions. The water contains more elements (Ca^{2+}, Mg^{2+}, SO_4^{2-}, and HCO_3^-) determining ground water chemical composition.

Nitrate nitrogen amounts ($N\text{-}NO_3$) contained in ground water did not exceed MCL (Maximum contaminant limit) for potable water (Table 4). Although the borehole 4 was

Table 1

Dependence of water level fluctuations on the air temperature

Location	November-March			April - October		
	Temperature, °C	Water level, cm	r	Temperature, °C	Water level, cm	r
	fluctuation			fluctuation		
Borehole						
1[a]	-5.1-3.9	326-432	-0.65	6.3-17.0	352-598	0.50
1[b]		120-180	-0.61		145-213	0.57
2		34-110	-0.42		95-160	0.60
Well						
1		71-175	-0.52		118-363	0.39
2		153-252	-0.68		134-438	0.47

Note. r – coefficient of correlation.

Table 2

Chemical composition of ground water, mg l^{-1}

Location	K	Na	Ca	Mg	HCO_3	SO_4	Cl	NO_3	Ion sum
Borehole									
1[a]	0.5	6.8	110	28	458	6.6	5.1	5.8	621
2	3.7	12.6	105	30	415	21	3.2	1.3	592
Well									
1	1.7	43	115	35	420	47	5.8	62	730
2	1.1	17	122	33	452	32	15	61	733

Table 3

Dependence of chemical composition (y) on ground water fluctuation (x) up to ground surface

Location	Form of relation	r^2
Borehole	y=0.54x+486.2	0.50
Well	y=0.486x+676.7	0.22

arranged in the arable land plot, the highest N-NO_3 concentrations were observed in a deeper borehole (8.8 m deep) nearby the sinkhole. This implies that nitrates may enter the ground water not through the aeration zone but via the sinkholes or underground water flows.

Water in wells was more polluted with nitrate nitrogen than that in boreholes. Having taken 21 water samples it was determined that in the well 1 N-NO_3 concentration exceeded MCL 15 times, in the well 2 it exceeded MAC 16 times. On the contrary, N-NH_4 concentrations were higher in water of boreholes. This may be related to different hydrochemical and biochemical conditions. As the literature refers (Mičiudienė, 1995), more intensive biochemical processes occur in the wells.

Conclusions

1. Ground water level fluctuations depended on air temperature, and the runoff formed in spring and winter thaw periods. When the air temperature was increasing in the cold period (November-March) and decreasing in the warm period (April - October), water was closest to the ground surface.

2. In the studied ground water of the karst region, 42-47% of ion sum is made up by hydrocarbonates (HCO_3^-), and about 34% is made up by calcium ions. Borehole water chemical composition (ion sum) was 1.2 times lower than that in water of wells. This was determined by higher amounts of sodium, sulphates, chlorine and nitrates.

3. It was determined that water in wells was contaminated with nitrate nitrogen, water in boreholes was polluted with ammonia nitrogen. This might have been affected by different hydrochemical and biochemical conditions.

Table 4

Change nitrogen combination in water, mg l^{-1}

Location of investigation	Depth, m	N-NO_3	N-NH_4
Borehole			
1[a]	8.8	0.4-4.20	0-0.30
1[b]	3	0.01-1.80	0.76-9.7
2	5	0.01-0.95	0.15-8.4
Well			
1	6	4.6-24.0	0-0.99
2	11	8.1-23.0	0.004-0.21

References

1. Arustienė J., Juodkazis V. and Michailova D. (2001) Adsorbuojamų halogenorganinių junginių suminės koncentracijos gėlame požeminiame vandenyje (Summarised concentrations of adsorbed organohalogens in fresh groundwater). Available at: www.geo.lt/Litosfera/n5L/n5L_13.htm, 30.03.2003. (in Lithuanian).
2. Dawson Milby B. J. (2001) Ground – Water Quality in the Southeastern Sacramento Valley Aquifer, California, 1996. Available at: http://water.usgs.gov/pubs/wri/wri014125/, 27.04.2003
3. Giedraitienė J. and Domaševičius A. (1996) Požeminio vandens lygių režimo tyrimai (Investigations of groundwater levels). Groundwater monitoring in Lithuania (1946-1996). Vilnius. Lithuania, 90 pp. (in Lithuanian).
4. Juodkazis V. (1979) Pabaltijo hidrogeologijos pagrindai (Hydrogeological background of Baltic States). Mokslas, Vilnius, Lithuania, 142 pp. (in Lithuanian).
5. Kadūnas K. and Mašanauskas V. (1992) Ūkininkavimas ir požeminio vandens kokybė (Farming and groundwater quality). Proceedings of international conference Farming and Water Quality, Kaunas, Lithuania, pp. 32-34. (in Lithuanian).
6. Kutra S., Kusta A. and Rutkovienė V. (2002) Šachtinių šulinių vandens kokybės rodiklių variacijos tyrimai (Investigations on the change of qualitative indices of water in shallow wells). Vandens ūkio inžinerija, 20, pp. 56-65. (in Lithuanian).
7. Mičiudienė V. (1995) Gruntinio vandens hidrocheminiai tyrimai Trakų poligone (Hydrochemical investigations of shallow groundwater at the polygon Trakai) Groundwater monitoring in Lithuania 1994. Vilnius. Lithuania, 64 pp. (in Lithuanian).
8. Paukštys B. (1996) Hydrogeology and groundwater protection problems in karst region of Lithuania: Scientific paper. Goelogical Soc. of Lithuania, 72 pp.
9. Rutkovienė V., Kusta A., Kutra S. and Česionienė L. (2003) Šachtinių šulinių vandens taršos sezoninė kaita (Seasonal changes in water pollution in shallow wells) Vandens ūkio inžinerija. 22 (44), pp. 15-29. (in Lithuanian).
10. Rutkovienė V. and Česonienė L. (2005) Drinking water quality problems in Lithuania. Proceedings of the second international scientific conference Rural Development 2005, Kaunas, Lithuania, pp. 75-77.

NITROGEN REMOVAL IN CONSTRUCTED WETLANDS OF VERTICAL AND HORIZONTAL FLOW

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Abstract

Constructed wetlands (CW) are considered as one of principal wastewater treatment methods containing plant and soil filters. CW may be of subsurface vertical flow (VF) and horizontal flow (HF). The objective of the studies was to estimate N-removal efficiency differences in CW of vertical and horizontal flow. To evaluate nitrogen (N) removal efficiency, the database of the studies on both construction of CW collected within the period of 1995-2005 was used.

Horizontal filter systems characterize for a 1.6 times higher N-removal efficiency than vertical filters. Generally, N-removal efficiency depends on the load of filters. When filter load was 1.5 g $m^{-2} d^{-1}$ according to TN, N-removal efficiency is 39.6 and 24.0% in HF and VF systems respectively. Considering the seasons of the year, no significant difference was observed in N-removal efficiency in HF and VF systems during cold and warm periods of the year.

N contained in water after the treatment process in filters is detected in different forms. NH_4-N is prevailing in HF, while in VF systems NO_3-N is dominant. It was also observed that NH_4-N in the effluent during the initial operation of VF after the construction works in the first two months in the warm and in four months during their operation in the cold period of the year was prevailing.

Key words: wastewater treatment, constructed wetlands, nitrogen.

Introduction

For a wastewater treatment in rural area are needs for simple, with the cheap construction and maintenance wastewater treatment facilities. Such properties characterize constructed wetlands (CW). They are considered as one of principal wastewater treatment methods containing plant-soil filters. A plant-soil filter is a certain type of wastewater treatment facilities ensuring optimal conditions for natural self-purification processes of wastewater to occur. CW may be designed as subsurface flow filters including filters of vertical flow (VF) and horizontal flow (HF).

In filters of horizontal flow, the wastewater flows horizontally from the inflow zone through the body of the filter (i.e., roots of marshy plants, rhizomes and soil), where it is purified. The functioning principle of vertical filters is similar, only here the wastewater is spread on the surface of the filter; then it flows vertically through a 0.6-1.0-m deep sand layer into the collection pipes.

Subsurface flow filters are investigated under different climatic conditions all over the world. Such filters are distinct for their efficient removal of organic matter. According to BOD_7, treatment efficiency in such filters reaches 80-98%. N and P removal efficiency is fluctuating within the range of 40 to 90% (Vymazal, 2001; Schierup et al., 1990; Mander et al., 1997; Haberl et al., 1995; Vymazal, 2002). Representative natural and constructed treatment wetlands reviewed by Kadlec (1994) ranged from highly successful to poor in percent removal of total Kjeldahl N (3–98%), NH_4-N (14–98%), and NO_2-N+NO_3-N (38–96%).

Since 1994, the first experimental wastewater treatment facilities containing CW have been constructed in Lithuania (Gasiūnas et al., 2003). The first full-scale constructed wetland comprising horizontal subsurface flow reed bed filters was built in 1995. Detailed long-term investigations on wastewater treatment efficiency were carried out in those wastewater treatment facilities as well as in those constructed later (Strusevičius et al., 1998; Strusevičius et al., 2003; Gasiūnas et al., 2005).

Major pathways for nitrogen removal in wetlands include the mineralization of organic N, ammonia volatilization, assimilation into biomass, adsorption of ammonium onto the substrate, and nitrification followed by denitrification (Reddy et al., 1984; Kadlec, 1987). Of these, nitrification and subsequent denitrification at the anaerobic–aerobic interface of the wetland substrate is thought to be the primary means of nitrogen removal (Neely et al., 1989; Reddy et al., 1994). Nitrogen removal by assimilation to plant or microbial biomass or by dissimilatory reduction to ammonium has been shown to account for 1–34% of the total N loss, with denitrification accounting for 60–95% of the total N removed (Bartlett et al., 1979; Stengel et al., 1987; Cooke, 1994).

Cooper (1999) indicates the following advantages and disadvantages of HF and VF systems: HF is good for denitrification and poor for nitrification because of limited oxygen transfer capability; VF is good for nitrification because of high oxygen transfer capability.

The objective of the studies was to estimate N-removal efficiency differences in CW of vertical and horizontal flow.

Materials and Methods

The database of investigations on CW of different construction collected within the study period of 1995-2005 was used for the estimation of N-removal efficiency. For HF, the studies were carried out in 5 wastewater treatment facilities where wastewater of different pollution was treated. All objects under investigation contain filters of similar

Table 1

Average indices ± standard deviation of wastewater supplied into the filters

	BOD_5, $mgO_2\ l^{-1}$	TN, $mg\ l^{-1}$	NH_4-N, $mg\ l^{-1}$	NO_3-N, $mg\ l^{-1}$
HF	55.2±67.7	36.3±25.1	21.5±15.9	0.85±1.62
VF	151.2±98.2	112.3±40.1	97.4±35.3	0.32±0.29

Note. TN – total nitrogen.

construction. After the primary treatment wastewater is supplied into the filters via a distribution manhole. Chippings prisms arranged in filters contain distribution pipes. Here water is distributed evenly within the whole filter. Then wastewater is filtered horizontally through a semi-coarse sand medium with the filtration coefficient of 5-8 m d^{-1}. Size of sand particles d_{10} is fluctuating between 0.15 and 0.17 mm, the ratio d_{60}/d_{10} is 2-5. The depth of filters is 0.8 m, filtration distance - 4.5-5.5 m. Filters are planted up with common reed (*Phragmites australis*). The data of about 200 measurements taken in different study periods was used for the analysis.

The investigations on VF systems were carried out in wastewater treatment facilities arranged in motels 'Nikola' and 'Pastoge' in the period of 2003-2005. After the purification in septic tanks, wastewater is supplied into VF for secondary (biological) treatment. Surface areas of filters are 300 and 250 m^2 in motels 'Nikola' and 'Pastogė' respectively. With the help of a pump, wastewater from septic tanks is supplied into a distribution manhole. Further wastewater is supplied into distribution pipes, and finally it is sprayed into a layer of chippings arranged on the surface of the filter. VF filter contains a 20-cm thick layer of fine chippings with distribution pipes arranged at the spacing of 1 m. With the help of a pump, wastewater is supplied from the pump-house into the distribution pipes. Further wastewater is spread throughout the chippings layer and is filtered downwards in a vertical direction via a 0.8-m deep sand layer into the collecting pipes arranged on the bottom of the filter. Sand filtration coefficient is 35.5 ± 5.9 m d^{-1}, the ratio of sand particles d_{60}/d_{10} is 5-6. Filters are planted up with common reed (*Phragmites australis*). After the treatment process, wastewater is directed into a water recipient. The data of 55 measurements taken in different study periods was used for the analysis. Analysis of variance and regression analysis was used for the mathematical processing of data.

Results and Discussion

The indices of average organic load and N-pollution of wastewater supplied into the filters after the primary treatment are presented in the Table.

To estimate N-removal efficiency of filters with different construction, the load for filter surface area and removed TN amount for one area unit were calculated. The load of filters according to TN is mostly fluctuating within the range of 0.2 to 4.0 g $m^{-2}\ d^{-1}$. The average loads of the studied HF and VF systems were 1.49 and 1.83 g $m^{-2}\ d^{-1}$ respectively. Most of the analyzed data was collected under the conditions of filter load fluctuating within the range of 0.5 to 2.5 g $m^{-2}\ d^{-1}$. TN removal efficiency was calculated under the conditions of the same load. Calculation results are given in Figure 1. As the given results show, different filter load results in different TN removal efficiency. Lower loads of filters result in less intensive TN removal efficiency than higher loads. HF

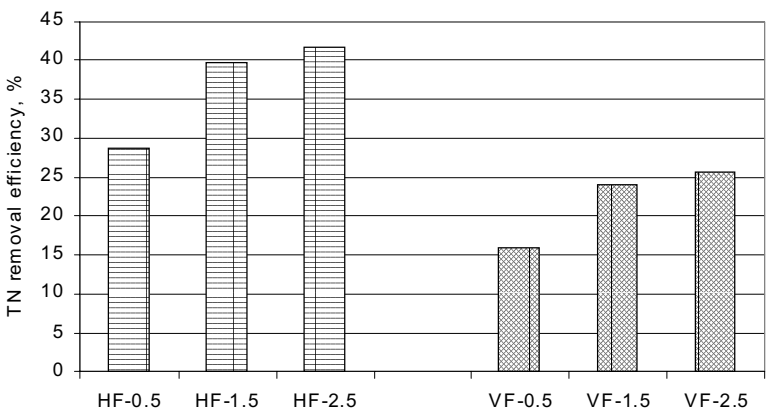

Figure 1. TN removal efficiency in filters with different load.

Note. 0.5, 1.5, and 2.5 – load of filters according to TN (g $m^{-2}\ d^{-1}$)

systems are distinct for the most intensive TN removal; VF systems are less efficient.

Researches performed by other scientists also confirm the obtained TN removal efficiency results. Similar nitrogen removal efficiency in HF was determined in other countries too. In Czech Republic, TN removal efficiency in HF is 41.6 %, in Denmark it is 42.9 % (Vymazal, 2002). The mean discharge concentrations are 25% higher in VF than in HF (Felde et al., 1997).

The results show that in HF systems the average removal of TN is 0.47 in winter and 0.56 g m^{-2} d^{-1} in summer. According to analysis of variance, the difference between the averages is statistically unreliable (LSD – least significant difference, LSD – 0.22 g m^{-2} d^{-1}, p=0.05). This is also confirmed in study results by Vymazal (1999) and Schoenborn et al. (1994). In winter the load of VF according to TN was 1.48, in summer it was 2.3 g m^{-2} d^{-1}; however, no significant difference in TN removal efficiency was observed, which was 23.6% and 23.1 % respectively.

Having performed the data analysis, it was determined that after the treatment process in filters, N contained in wastewater is of different forms and amounts. In HF systems NH_4-N is prevailing, while in VF systems NO_3-N is dominant. Interrelations between NH_4-N, NO_3-N, and TN concentrations in effluent of filters are given in Figs. 2 and 3.

Increasing TN concentrations contained in water outflow of HF determine higher NH_4-N amounts. If water outflow in HF contains 10 mg l^{-1} of TN, NH_4-N makes up 50 %; if it contains 50 mg l^{-1} of TN, then NH_4-N makes up 76 %; meanwhile, no obvious changes are observed in NO_3-N concentration. This is because wastewater treatment in HF is based on wastewater filtration through a sand medium

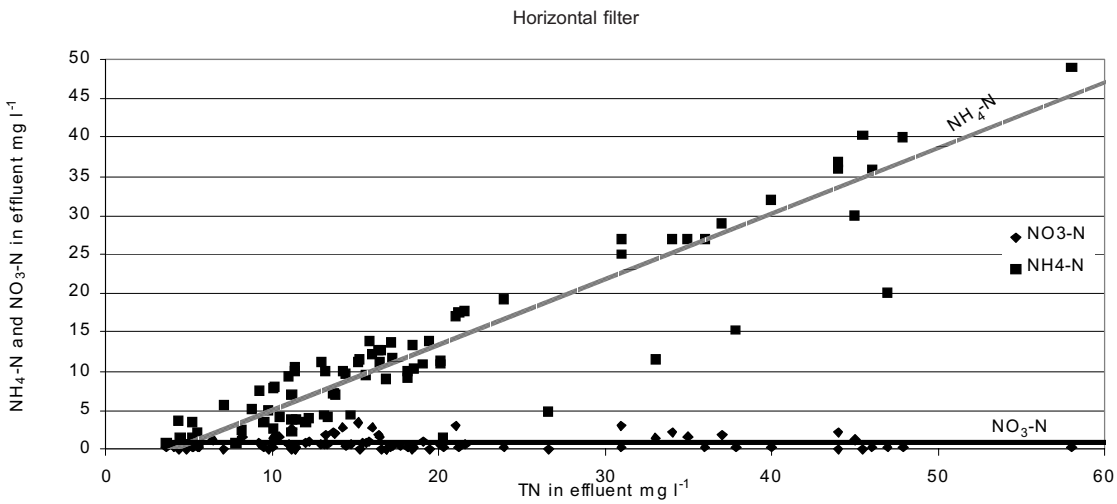

Figure 2. Interrelation between NH_4-N, NO_3-N, and TN concentrations in the effluent of horizontal filters.

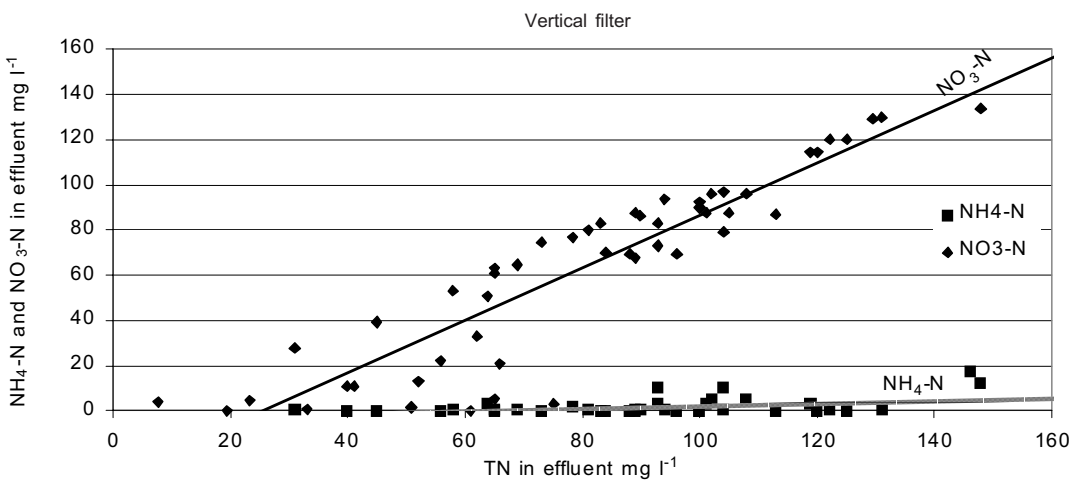

Figure 3. Interrelation between NH_4-N, NO_3-N, and TN concentrations in the effluent of vertical filters.

more under anoxic or anaerobic conditions, which predetermines low nitrification rate. Nitrification is often the rate-limiting process for N removal in HF due to slow oxygen diffusion rates under predominantly anaerobic conditions (Kadlec et al., 1996; Davies et al., 1993; Johnston, 1993).

Interrelations between NH_4-N, NO_3-N, and TN concentrations contained in the effluent of VF are given in Figure 3. It was also observed that NH_4-N was prevailing in the effluent after the treatment process and made up 50-80% of TN during the initial operation of filters after the construction works. Such results were obtained in the first two months during the operation of filters in the warm period of the year and in four months during their operation in the cold period of the year. This implies that a certain period of time is needed, the duration of which depends on the air temperature that determines the formation of microflora (nitrifying bacteria) contributing much to the transformation of nitrogen. During the cold period of the year, NH_4-N concentration contained in water after the treatment in VF is slightly increasing. In winter it makes up 8.3% of TN, while in summer only 0.6% of TN.

Other researchers have also noticed differences between N forms contained in wastewater after the treatment in VF and HF systems. Having analyzed 107 sand reed filters in Germany, it was determined that wastewater treated in HF contained 58% of NH_4-N and 5.3 % of NO_3-N from the TN amount. After the treatment in filters of vertical flow, NH_4-N and NO_3-N made up 9.5 % and 86 % respectively of TN amount contained in wastewater after the treatment process (Felde et al., 1996). Similar results were obtained by other researchers, too (Cooper, 1999a; Cooper et al., 1999b).

To estimate N-removal efficiency in filters of different construction, the filter area necessary in order to remove N completely in respect of filter load was determined. Considering the load of 1.5 g m^{-2} d^{-1}according to TN, the area necessary for a complete N removal was calculated. In such case the necessary area is 2.6 and 4.2 m^2 in HF and VF systems respectively. This implies that in HF systems N-removal efficiency is 1.6 times higher than in VF system.

Conclusions

Horizontal filter systems characterize for a 1.6 times higher N-removal efficiency than vertical filters. Generally, N-removal efficiency depends on the load of filters. When filter load was 1.5 g m^{-2} d^{-1} according to TN, N-removal efficiency was 39.6 and 24.0% in HF and VF systems respectively. Considering the seasons of the year, no significant difference was observed in N-removal efficiency in HF and VF systems during cold and warm periods of the year.

N contained in water after the treatment process in filters is detected in different forms. NH_4-N is prevailing in HF, while in VF systems NO_3-N is dominant. Increasing TN concentrations contained in water effluent of HF predetermine higher NH_4-N amounts. If water outflow in HF contains 10 mg l^{-1} of TN, NH_4-N makes up 50 %; if it contains 50 mg l^{-1} of TN, then NH_4-N makes up 76 %. However, NO_3-N concentration remains unchanged (on the average 0.7 mg l^{-1}). If water outflow in VF contains 50 mg l^{-1} of TN, NO_3-N makes up 60 %; if it contains 100 mg l^{-1} of TN, then NO_3-N makes up 85 %, while no significant changes were observed in NH_4-N concentration (up to 2 mg l^{-1}). During the cold period of the year, a slight increase in ammonia-N concentration was observed in effluent water after the treatment in VF system. In the warm period of the year NH_4-N makes up only 0.6 %, while in cold period of the year it makes up even 8.3% of TN amount.

References

1. Bartlett M.S., Brown L.C., Hanes N.B., Nickerson N.H. (1979) Denitrification in freshwater wetland soil. J. Environ. Qual. 8, pp. 460–464.
2. Cooper P. (1999) A review of the design and performance of vertical-flow and hybrid reed bed treatment systems. Water Sci. Technol., 40, pp. 1-19.
3. Cooper P.F. (1999a) Review of the design and performance of vertical-flow and hybrid reed bed treatment systems. Water Sci. Technol., 40 (3), pp. 1-9.
4. Cooper P., Griffin P., Humphries S. and Puond A. (1999b) Design of hybrid reed bed system to achieve complete nitrification and denitrification of domestic sewage. Water Sci. Technol., 40 (3), pp. 283-289.
5. Cooke J.G. (1994) Nutrient transformations in a natural wetland receiving sewage effluent and the implications for waste treatment. Water Sci. Technol., 29, pp. 209–217.
6. Davies T.H., Cottingham P.D., and Hart B.T. (1993) Application of constructed wetlands to treat wastewaters in Australia. In: G.A. Moshiri (eds) Constructed Wetlands for Water Quality Improvement, Levis Publ., Florida, pp. 577-584.
7. Felde K., Hansen K., Kunst S. (1996) Pflanzenklaeranlagen in Niedersachsen – Bestandsaufnahme und Leistungsfaeigkeit. Korrespondenz Abwasser, 8/96, pp. 1382-1392.
8. Gasiunas V. and Strusevicius Z. (2003) The experience of wastewater treatment using constructed wetlands with horizontal subsurface flow in Lithuania. In: Mander Ü., Vohla C. and Poom A. (eds) International Conference Constructed and Riverine Wetlands for Optimal Control of Wastewater at Catchment Scale, Tartu, Sept. 29 - Okt. 2. 2003; Publicationes Instituti Geographici Universitatis Tartuensis, 94, pp. 241-248.
9. Gasiunas V., Strusevicius Z., Struseviciene S. (2005) Pollutant removal by horizontal subsurface flow constructed wetlands in Lithuania. Journal of Environmental Science and Health. Part A, 40, 6-7, pp. 1467-1478.
10. Haberl R., Perfler R. and Mayer H. (1995) Constructed wetlands in Europe. Water Sci. Technol. 32 (3), pp. 305-316.

11. Johnston C.A. (1993) Mechanisms of wetland-water quality interaction. In: G.A. Moshiri (eds) Constructed Wetlands for Water Quality Improvement, Levis Publ., Florida, pp. 293-299.
12. Kadlec R.H. (1994) Wetlands for wastewater polishing: free water surface wetlands. In: Mitsch, W.J. (eds.) Global Wetlands: Old World and New. Elsevier, Amsterdam, pp. 335–349.
13. Kadlec J.A. (1987) Nutrient dynamics in wetlands. In: Reddy K.R., Smith W.H. (eds.), Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publishing, Orlando, FL, pp. 393–419.
14. Kadlec R.H., Knight R.L. (1996) Treatment Wetlands. Lewis Publishers, CRC, New York.
15. Mander Ü. and Mauring T. (1997) Constructed wetlands for wastewater treatment in Estonia. Water Sci. Technol., 35 (5), pp. 323-330.
16. Neely R.K., Baker J.L. (1989) Nitrogen and phosphorus dynamics and the fate of agricultural runoff. In: van der Valk A.G. (eds), Northern Prairie Wetlands. Iowa State University Press, Ames, IA, pp. 92–131.
17. Reddy K.R., Patrick W.H. (1984) Nitrogen transformations and loss in flooded soils and sediments. CRC Crit. Rev. Environ. Control, 13, pp. 273–309.
18. Reddy K.R., D'Angelo E.M. (1994) Soil processes regulating water quality in wetlands. In: Mitsch, W.J. (eds.), Global Wetlands: Old World and New. Elsevier, Amsterdam, pp. 309–324.
19. Schoenborn A., Zuest B. (1994) Long term performance of a sand-plant-filter for domestic wastewater treatment. In: Newsletter of the Specialist Group on the Use of Macrophytes in Water Pollution Control, 10, pp. 15-18.
20. Schierup H.-H., Brix H., Lorenzen N. (1990) Wastewater treatment in constructed reed beds in Denmark—state of the art. In: Cooper P.F., Findlater B.C. (eds.), Constructed Wetlands in Water Pollution Control. Pergamon Press, Oxford, UK, pp. 495–504.
21. Strusevicius Z. and Struseviciene S.M. (2003) Investigations on wastewater produced on cattle-breeding farms and its treatment in constructed wetlands. In: Mander Ü., Vohla C. and Poom A. (eds) International Conference Constructed and Riverine Wetlands for Optimal Control of Wastewater at Catchment Scale, Tartu, Sept. 29 - Okt. 2. 2003; Publicationes Instituti Geographici Universitatis Tartuensis, 94, pp. 317-324.
22. Strusevicius Z., Gasiunas V. (1998) Treatment of the wastewater from a cattle-shed by means of natural processes. In: International Conference on Agricultural Engineering, Oslo, 24-27 August 1998, pp. 225-226.
23. Stengel E., Carduck W., Jebsen C. (1987) Evidence for denitrification in artificial wetlands. In: Reddy K.R., Smith W.H. (eds.), Aquatic Plants for Water Treatment and Resource Recovery. Magnolia Publishing, Orlando, FL, pp. 543–550.
24. Vymazal J. (2001) Constructed wetlands for wastewater treatment in the Czech Republic. Water Sci. Technol., 44 (11-12), pp. 369-374.
25. Vymazal J. (2002) The use of subsurface constructed wetlands for wastewater treatment in the Czech Republic: 10 years experience. Ecol. Eng., 18 (5), pp. 633-646.
26. Vymazal J. (1999) Nitrogen removal in constructed wetlands with horizontal sub-surface flow – can we determine the key process? In: Vymazal J. (eds) Nutrient Cycling and Retention in Natural and Constructed Wetlands, Backhuys Publishers, Leiden, The Netherlands, pp. 1-17.
27. Felde K., Hansen K., Kunst S. (1997) Bestandsaufnahme Reinigungsleistung und Einsatzmoeglichkeiten von Pflanzenklaeranlagen in Niedersachsen. In: Pflanzenklaeranlagen. Schriftenreihe der komunalen Umwelt-Aktion, 30, pp. 39-45.

INVESTIGATIONS OF THE POLLUTION OF SURFACE (RAIN) WASTEWATER AND ITS IMPACT ON THE ENVIRONMENT

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Abstract

The paper presents the analysis of legal acts and normative documents regulating the management of surface (rain) wastewater in Lithuania. On the basis of the results, the investigations on treatment efficiency of pollution of surface wastewater accumulated in the territory of the cattle and pigs slaughterhouse of 'Krekenavos mėsa' Ltd were carried out. Having applied differentiated runoff coefficients, calculations of the dependence of wastewater amount on territory of the company were suggested. According to the monitoring program, wastewater pollution indices and investigation frequency were determined in respect of the requirements of surface water monitoring. Wastewater pollution dynamics in treatment facilities of the company was estimated. As it was determined, the main index specifying treatment necessity of surface wastewater accumulated in company's territory is suspended solids. Considering this index it was determined that maximum wastewater pollution exceeded the determined rate of environmental requirements 2.13 times within the study period. After treatment in the facilities, the average wastewater pollution with suspended solids decreased from 31.44 mg l^{-1} to 8.67 mg l^{-1}.

Other pollutants concentrations contained in wastewater were insignificant and did not exceed the rate determined in the environmental requirements, thus they may be released into open water bodies.

It was also determined that the average amount of suspended solids contained in the Upytė stream reached 17.55 mg l^{-1}. Considering this index, pollution of wastewater outlet is 50.6% lower than the background pollution of the stream.

Key words: surface wastewater, monitoring, pollution, treatment efficiency.

Introduction

In Lithuania, rapid development of industries results in increasing amount of population in towns, larger amounts of accumulated wastewater and higher pollution indices. Considering wastewater composition it is divided into industrial, domestic and surface. Until the last decade, treatment processes of industrial and domestic wastewater were performed in mixed treatment systems and treatment systems of partial and full separation. Surface wastewater was attributed to the group of relatively clean waters and was untreated released into water bodies. Recently, a number of legal acts and normative documents regulating surface wastewater management have been approved in this Lithuania. Those documents include Strategy of surface (rain) wastewater treatment (Paviršinių …, 1995) determining treatment process of surface wastewater accumulated in territories of industrial companies and heavily polluted objects (companies producing oil, fertilizers, chemicals, etc.). When surface (rain) wastewater is collected during the activity of a certain object and is released from the area larger than 10 ha, it is necessary to evaluate pollution extent and carry out surface (rain) wastewater monitoring (Dėl apsaugos…, 2005).

Having analyzed all pollution indices of the monitoring, the main indices of surface wastewater pollution were determined, i.e. suspended solids (SS), dissolved organic pollution BOD_7, and pollution with oil products carbohydrates.

The factors influencing pollutants concentration contained in surface (rain) wastewater and their transport into open water bodies are as follows:

- hydrogeological characteristics of the territory and its pollution;
- atmospheric pollution and pollution formation duration;
- precipitation intensity and duration;
- surface characteristics of the territory cover;
- surface wastewater purification in the sewerage system.

Some factors (hydrological characteristics of the territory, surface characteristics) are typical to the territory and thus their values remain stable. Meanwhile, other factors affecting wastewater amount and its pollution are incidental and changing in respect of pollutants accumulation in the territory, precipitation amount, rain intensity and duration, as well as wastewater purification degree in the sewerage system.

In the new company 'Krekenavos mėsa' Ltd, wastewater is treated in a special system. Here wastewater after pretreatment is canalized into the pump chamber aranged in the flotation construction. Further, pretreated wastewater is being pumped with domestic wastewater into wastewater treatment facilities of Kėdainiai town. Surface wastewater is collected from the company's territory and treated in special treatment facilities of the sewerage system.

Surface (rain) wastewater monitoring is carried out by Water Management institute of the Lithuanian University of Agriculture according to the recommendations of monitoring program (Ūkio subjektų …, 2003).

The objective of the work was to determine the amount

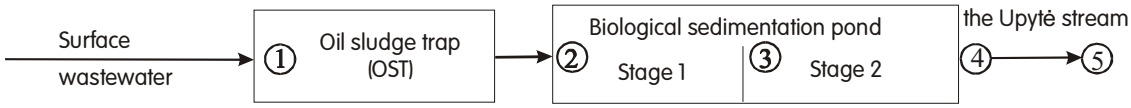

Figure 1. Test scheme.

of accumulated wastewater, investigate pollution and treatment efficiency of surface wastewater collected in the territory of sewerage network and treated in the facilities, as well as compare the data with allowable pollution rates of surface wastewater.

Materials and Methods

'Krekenavos mėsa' Ltd is a new up-to-date slaughterhouse of pigs and cattle built in 2003. Capacity of the company is 60 pigs and 10 cattle units per hour (150000 pigs and 25000 cattle units per year). The company is located in Montviloniai village (Kėdainiai district). The territory is surrounded by roads in western and northern parts, and by arable land plots in eastern and southern parts. The whole area of the territory is drained with close drainage. In places of constructions and other communications, the drainage is reconstructed. As the engineering-geological investigations carried out by 'Hidroprojektas' Ltd show, glacial-lacustrine (lgIII) fine and dusty sand is prevailing at 1–4.2-m deep layer. At deeper layers, hard glacial (gIII) loam mixed with sandy loam pebbles of low filtration capability is found. Ground water was found to be at a 1.2–1.5-m deep layer. As the territory is drained, seasonal fluctuations of aquatic horizon are possible within the range of ± 0.5m.

Surface wastewater collected from the sewerage system of the territory is canalized through closed collectors and directed into wastewater treatment facilities containing oil pollutants trap and biological sedimentation pond. Changes of surface wastewater pollution in treatment facilities and its impact on the environment were studied in certain points on the basis of the scheme given in Figure 1.

Capacity of oil pollutants trap is 158 m^3, the one of biological sedimentation pond is 1500 m^3. The pond is made of two levels: 1/3 of the pond (at the wastewater inlet zone) is 1.8 m deep and contributes to the sedimentation process of dust and sand particles; 2/3 of the pond is shallow (0.7 m deep) planted with aquatic vegetation (cats-tails, calamus, reed).

The studies were carried out in 2004-2005. Surface wastewater pollution indices and frequency of investigations were determined considering the requirements of surface water monitoring (Ūkio subjektų …, 2003). Qualitative indices were determined applying unified methods (Unifikuoti nuotekų …, 1994) in Chemical Analytical Laboratory of Lithuanian Water Management Institute. Concentrations of oil pollutants were determined with the help of a spectrophotometric device of infrared rays IKAN-1 in the Analytical Department of Agrochemical Study Center of Lithuanian Agricultural Institute. To summarize the obtained study data the correlation analysis methods were applied.

Results and Discussion

As the company has no surface wastewater discharge measuring device arranged in the territory, qualitative indices of surface wastewater were determined in the calculation way during the study period. The analysis of recommended discharge calculation methods estimating rain intensity, its duration and distribution unevenness was made (Rimeika, 1999; Burinskienė et al., 2003). The following dependence was used for the calculation of actual surface wastewater amount collected from the territory (Dėl aplinkosaugos …, 2004):

$$W_m = 10 \cdot H \cdot F \cdot \alpha \cdot K, \quad (1)$$

where

H – average precipitation amount during the study period, mm;

α – surface runoff coefficient;

F – territory area, ha;

K – 0.9 (when territory is cleared of snow).

To calculate the surface wastewater discharge amount

Table 1

Average precipitation amount during the study period (mm)

Index	2004				2005			
	Quarter				Quarter			
	1	2	3	4	1	2	3	4
Precipitation, mm	98	83	236	147	74	121	149	74
Average deviation from the many-year rate, %	108.3	48.0	123.6	103.0	79.0	72.3	124.3	76.6

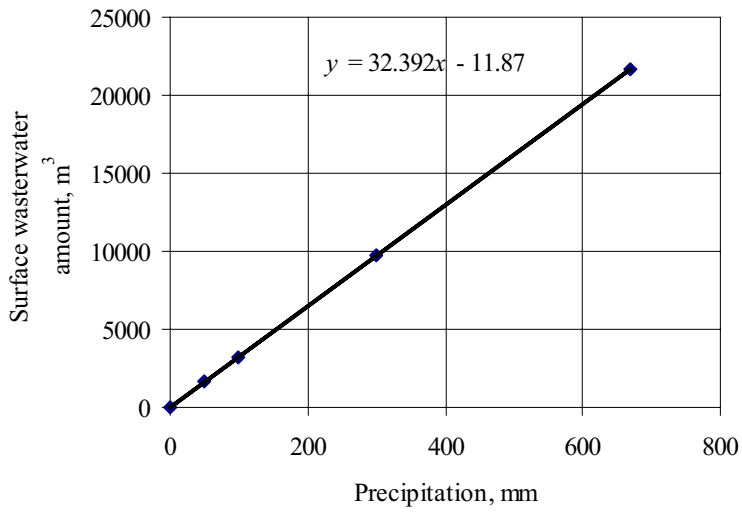

Figure 2. Dependence of surface (rain) wastewater amount of the territory on precipitation rate.

from the company's territory, the data of Dotnuva Meteorological Station was used. The mentioned data is presented in Table 1.

To determine surface wastewater amount from surface sewerage network of the territory, coefficients were differentiated in respect of the type of the surface cover and taken as follows (Burinskienė et al., 2003):

α – 0.95 roofs, territory covered with asphalt or concrete, roads;

α – 0.1 green lawns, grass-plots;

K – 0.85 correction value of surface flow coefficient estimating transport of snow.

Surface (rain) runoff amount was determined having made natural measurements of cover areas of the territory. In the total of 10.6 ha area of company's territory, 1.5 ha area is built up with constructions, 1.9 ha area contains asphalt covered roads, and 7.2 ha area is covered with green grass-plots. Surface wastewater amounts for each type of cover were calculated in respect of the type of cover applying differentiated runoff coefficients according to the dependence (1). Considering the results obtained, the dependence of wastewater amount flowing from the territory on the precipitation rate is depicted in Figure 2.

Precipitation flowing via the company's territory forms wastewater that is collected and directed through the sewerage network into wastewater treatment facilities. On the basis of the pollution indices of monitoring, considering the Law of taxes for environment pollution (Mokesčio …, 2005),

Table 2

Fluctuations in surface wastewater pollution indices in wastewater treatment facilities

Index	Wasterwater pollution concentration (mgl^{-1}) in sampling spots (2004 -2005)				Pollution fluctuation, %			MAC, mgl^{-1}	Effi-ciency, %
	1	2	3	4	1-2	2-3	3-4		
SS	9.87-67.0 31.44	7.4-43.5 18.5	3.3-23.33 9.25	1.7-13.0 8.67	32.87	19.4	11.46	30.0	53.73
BOD_7	3.00-12.27 5.79	2.7-6.85 4.88	2.4-5.57 3.99	2.43-6.80 4.21	7.45	10.0	-9.5	15.0	7.94
P_{total}	0.1-0.34 0.19	0.09-0.24 0.145	0.04-0.12 0.076	0.05-0.13 0.07	16.13	44.7	1.16	4.0	61.99
N_{total}	1.64-5.6 3.23	0.87-5.77 2.99	1.02-7.4 3.68	1.12-6.9 3.59	9.03	-20.75	1.19	30.0	-10.53
Oil	0.02-0.23 0.12	0.02-0.11 0.06	-	-	-	-	-	1.0	40.0

Note. Numerator – minimum and maximum values, denominator – average values

the paper presents the analysis of changes in principle surface (rain) wastewater indices, including suspended solids (SS), organic pollution (BOD_7), total phosphorus (P_{total}), total nitrogen (N_{total}), and oil products. Study results of surface wastewater pollution are presented in Table 2.

As it is seen from study results given in Table 2, in respect of pollutants concentrations, surface (rain) wastewater of the company's territory is attributed to the group of low polluted wastewater (Kaimo …, 1992). Considering the requirements (Dėl aplinkosaugos …, 2003), in respect of most pollution indices, the wastewater may be released untreated into open water bodies. Only the concentration of suspended solids contained in surface wastewater exceeds the maximum allowable concentration (MAC). Dynamics of suspended solids concentrations contained in surface wastewater in treatment facilities were compared to the pollution load of the stream Upytė and maximum allowable concentration (MAC). The results are presented in Figure 3.

During the study period, the average pollution of suspended solids contained in surface wastewater supplied into oil products trap of wastewater treatment facilities reached 31.44 mg l^{-1} maximum suspended solids concentration exceeded MAC 2.13 times.

After the treatment process of surface wastewater in treatment facilities, suspended solids concentration decreases to 22.8 mg l^{-1}, i.e. it decreases to 12.9 mg l^{-1} in oil products trap, and to 9.25 mg l^{-1} and 0.6 mg l^{-1} in the 1st and 2nd stage of biological sedimentation pond respectively. During the study period, the average amount of suspended solids contained in water of the Upytė stream was determined to be 17.5 mg l^{-1}. Concentration of released suspended solids was 50.6% lower than the background concentration of the stream.

There is a close relationship between wastewater pollution with organic compounds and amounts of suspended solids. Nearly 90% of all organic matter determining BOD_7 is suspended. Pollution with other materials (oil products, heavy metals) is incidental (Jakubauskas, Račys, 1997).

Dynamics of surface wastewater pollution with organic matter is presented in Figure 4.

As Figure 4 shows, surface wastewater pollution with organic matter is comparatively low (on the average 5.79 $mgO_2\,l^{-1}$): in some study periods it is fluctuating within the range of 3.00 to 12.27 $mgO_2\,l^{-1}$ and does not exceed maximum allowable concentration (15.0 $mgO_2\,l^{-1}$). When organic pollutants concentration contained in wastewater is low, after the treatment in the facilities this pollution decreases by 7.94% on the average, i.e. by 7.45% in oil sludge trap

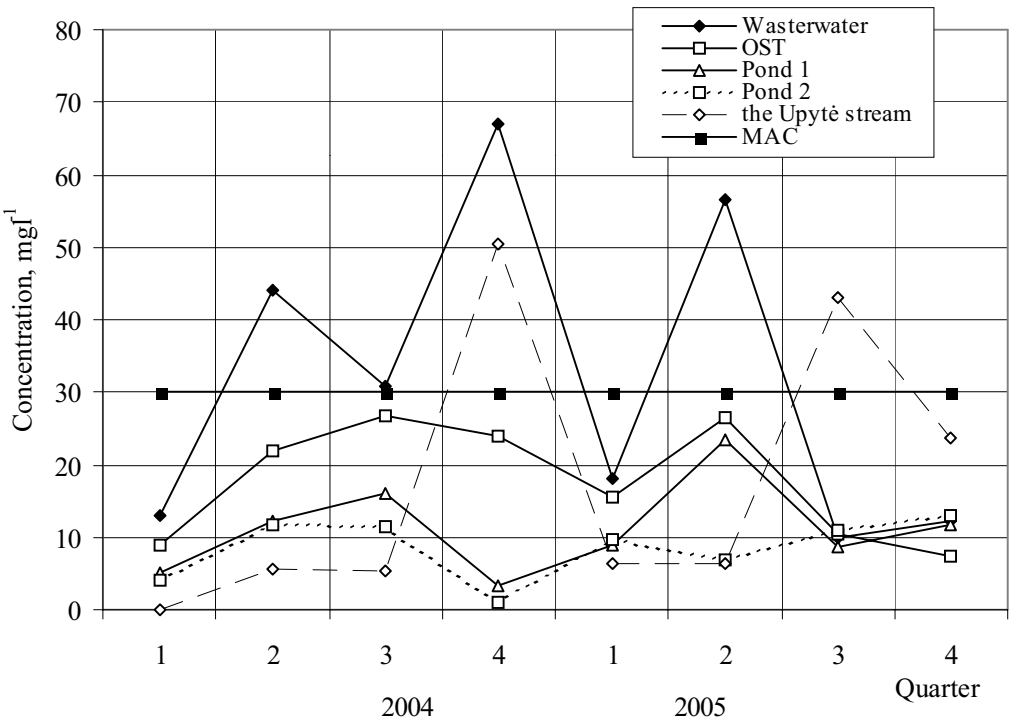

Figure 3. Dynamics of suspended solids contained in surface wastewater and comparative results. wastewater pollution with organic matter.
here: OST- oil sludge trap; MAC – maximum allowable concentration.

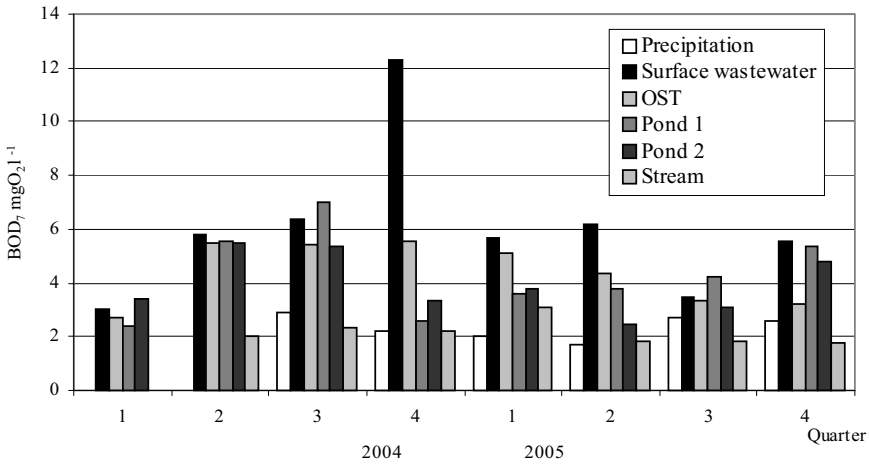

Figure 4. Dynamics of surface wastewater pollution with organic matter.
here: OST- oil sludge trap.

and by 10.0% in the 1st stage of biological sedimentation pond. Meanwhile, in the 2nd stage of biological sedimentation pond, negative 7.94% treatment effect was obtained. Such negative treatment effect is explained by more intensive oxygen uptake due to biocenosis process in wastewater, which results in increased amount of total nitrogen contained in wastewater (Aškinis, 2002; Jansen et al., 1993).

Dynamics of surface wastewater pollution with carbohydrates is presented in Figure 5.

During the study period, the concentrations of oil products contained in surface wastewater supplied into oil sludge trap were rather low and did not exceed MAC (1.0 mg l^{-1}). Maximum removal rate of oil products from surface wastewater in the oil sludge trap reached 91.4%, and maximum oil products concentration contained in surface wastewater outlet into water bodies did not exceed 0.11 mg l^{-1}.

Conclusions

1. Considering legal acts and normative documents regulating surface wastewater management approved in Lithuania, having estimated surface areas and types of cover of the company's territory, also having applied differentiated runoff coefficients, a dependence on precipitation rate was elaborated for the calculation of surface wastewater amount.

2. Analysis of the main pollution indices of surface (rain) wastewater was made. On the basis of the analysis results, it was determined that the need for wastewater treatment depends on suspended solids concentrations.

3. In respect of most studies indices, pollutants concentrations contained in surface (rain) wastewater of the company are low. After treatment process in the oil sludge trap, wastewater pollution satisfies the environment protection requirements and thus may be untreated released into open water bodies.

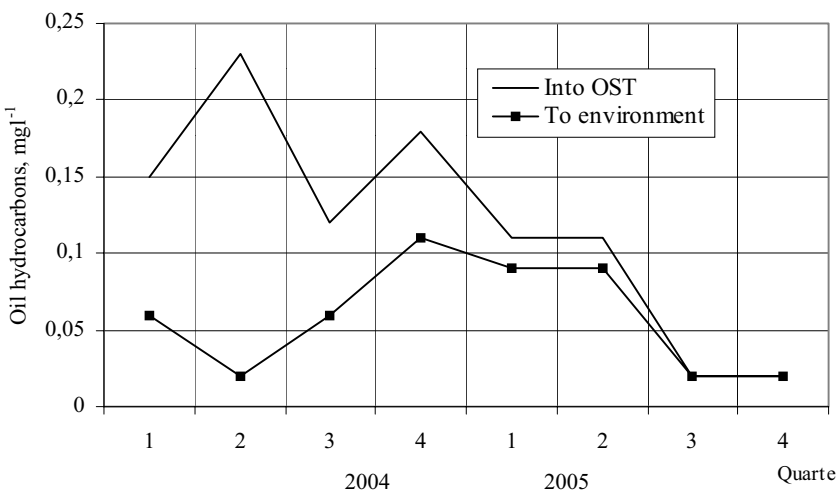

Figure 5. Surface wastewater pollution with carbohydrates.
here: OST – oil sludge trap.

References

1. Aškinis S. (2002) Organinių teršalų apsivalymo biologiniuose tvenkinėliuose tyrimai (Investigations on organic pollutants removal in biological ponds). Vandens ūkio inžinerija: Mokslo darbai 21(43), pp. 21–26. (in Lithuanian).
2. Burinskienė M. (2003) Miestotvarka. (Town Management) VGTU, pp. 66–75. (in Lithuanian).
3. Dėl aplinkosaugos reikalavimų paviršinėms nuotekoms tvarkyti. (2003) LR Aplinkos ministro įsak. Nr. 987 (Due to the requirements for the handling of surface wastewater. Order of the Minister of Environment of the Republic of Lithuania No.987). (in Lithuanian).
4. Dėl aplinkosaugos reikalavimų paviršinėms nuotekoms tvarkyti. (2004) LR AM įsąk. Nr.687 (Due to the requirements for the handling of surface wastewater . Order of the Minister of Environment of the Republic of Lithuania No.687). (in Lithuanian).
5. Dėl aplinkosaugos reikalavimų paviršinėms nuotekoms tvarkyti patvirtinimo. (2005) AM įsak. Nr. D1-486 (Due to the approvement of the requirements for the handling of surface wastewater. Order of the Minister of Environment of the Republic of Lithuania No. D1-486). (in Lithuanian).
6. Dėl aplinkosaugos reikalavimų mėšlui tvarkyti. (2005) AM ir ŽŪM įsak. Nr.D1-367/3D-342 (Environment protection requirements for manure handling. Order of the Minister of Environment and Minister of Agriculture of the Republic of Lithuania No D1-367/3D-342). (in Lithuanian).
7. Jakubauskas T., Račys V. (1997) Paviršinių nuotekų valymo laipsnio nustatymo metodika. (Methodology of the determination of surface wastewater treatment degree). Aplinkos tyrimai, inžinerija ir vadyba, Nr.2 (5), pp. 42–47. (in Lithuanian).
8. Jansen P.D., Maklum T. and Krogstad T. (1993) Potential use of construceted Wetlands for Wastewater Treatment in Northern Environments. International Conference 'Small Wastewater Treatment Plant'. Trondheim, Norway 28–30 June, pp. 10–15.
9. Kaimo gyvenamųjų vietovių ir žemės ūkio įmonių paviršinių nuotekų nuvedimo ir valymo projektavimo normos. (1992) IST, G 03.02 P. (Desing rates of discharge and treatment of surface wastewater in rural settlements and agricultural companies). Vilnius, pp. 21–40. (in Lithuanian).
10. Mokesčio už aplinkos teršimą įstatymas. (2005) LR Aplinkos ministro įsak. Nr. VIII-1183 (Law on the tax for environment pollution. Order of the Minister of Environment of the Republic of Lithuania NoVIII-1183). (in Lithuanian).
11. Paviršinių (lietaus) nuotekų kanalizavimo ir išleidimo normatyvų nustatymo, mokesčio už taršą taikymo ir laboratorinės kontrolės vykdymo taisyklių 1 ir 2 punktų papildymai. (1995) LAND 3-95 patvirtinti AM įsak. Nr. 29 (Appendix of points 1 and 2 of the rules on surface (rainfall) wastewater canalization, discharge and the application of the tax for pollution and laboratory control No 29). (in Lithuanian).
12. Rimeika M. (1999) Lietaus intensyvumo, trukmės ir pasikartojimo dėsningumai Lietuvoje. (Peculiarities of rainfall intensity, duration and frequence in Lithuania). Aplinkos inžinerija, VII t, Nr.3. VGTU, pp. 142–150. (in Lithuanian).
13. Unifikuoti nuotekų ir paviršinio vandens kokybės tyrimų metodai. D1. (Unified study methods of wastewater and surface water quality. D1). Cheminės analizės metodai. AAM leidybos biuras, (1994) Vilnius. 68 pp. (in Lithuanian).
14. Ūkio subjektų aplinkos monitoringo vykdymo tvarka. (2003) AM įsak. Nr.50–2240, 2 priedas (Order of monitoring management of economy subjects AM order No. 50-2240, appendix 2). (in Lithuanian).

TREATMENT OF WASTEWATER IN MILK COLLECTING STATION

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Abstract

The paper presents the results of studies on the treatment of wastewater in experimental treatment facilities in a milk collecting station. The treatment process of wastewater was as follows: aeration-flocculation device – sedimentation pond – two-stage constructed wetlands.

The laboratory investigations have shown that the primary treatment with quicklime (1 kg m^{-3}) reduces wastewater pollution by 54%, while the treatment with coagulant 'ZETAG 8660' (4 g m^{-3}) reduces it by even 68%. Such results were not obtained in the primary wastewater treatment stage under industrial conditions: biological oxygen demand (BOD_5) in wastewater was reduced 27.2%, the amount of suspended sediment was reduced by 48.1%, the amounts of N_{total} and P_{total} decreased by 15.8% and 27% respectively. Such results much depended on the air temperature, inaccurate dosage of chemicals as well as on insufficient capacity of reaction and sedimentation reservoirs for 2.5 times higher amount of wastewater. However, despite such unfavourable conditions, this stage of treatment process was rather efficient: the pollution of wastewater with organic matter flowing into the stream did not exceed the maximum allowable rates. The average value according to BOD_5 was 4 mg O_2 l^{-1}, the highest BOD_5 value was 9.6 mg O_2 l^{-1}. From the environment protection point of view, it is particularly important that the removal of biogenic pollutants is quite sufficient in the wastewater treatment facilities. After the treatment process in wastewater treatment facilities, the amount of N_{total} decreased by 82.4%, and the amount of P_{total} was reduced by even 97.3%.

Key words: primary treatment of wastewater, quicklime, coagulants, constructed wetlands, treatment efficiency.

Introduction

The restructuralization period in Lithuania enhanced significant changes in dairy companies. A large number of small companies that did not succeed in improving their production efficiency and provide the market with up-to-date high-quality dairy products were eliminated from the dairy market and went bankrupt. Currently, the dairy industry is concentrated in large modern companies 'Rokiškio sūris', 'Pieno žvaigždės' and 'Žemaitijos pienas'. The largest companies competing in different regions of the country organize the collection of milk and its partial or total processing. Currently, there is a wide network of milk collecting stations created. Milk chilled in the milk collecting stations is transported for further processing into the companies mentioned. Such milk collecting stations produce heavily polluted wastewater. The pretreatment of such wastewater in a septic tank (primary treatment) before supplying it into the filter is insufficient. Therefore a link of primary treatment process is necessary in such wastewater treatment technology. Here the wastewater pollution according to BOD_5 is reduced to 400-600 mg O_2 l^{-1}, and further biological treatment is performed in the aerotank (Henze et al., 1995; Šeškevičius, 1977). Currently, heavily polluted wastewater from meat processing companies (BOD_5 1200 – 6000 mg O_2 l^{-1}) is pretreated using the hydration and carbonization method (Strusevičius et al., 2001; Strusevičius et al., 2002). Applying this method, wastewater pollution with organic matter is reduced by about 50% according to BOD_5. In 'Agaras' Ltd further treatment of wastewater is performed not in the aerotank, but in constructed wetlands arranged, where the biological treatment process of wastewater is performed using no electrical energy at all (Gasiūnas et al., 2003; Strusevičienė et al., 2004).

The methods discussed were also applied for the treatment of wastewater produced in milk collecting stations. Constructed wetlands have been used so far for the treatment of slightly polluted domestic wastewater. As the result of studies carried out in Lithuania have shown, different complex physical and biochemical processes occur in constructed wetlands resulting in the elimination of organic matter and biogenic compounds by 86-96% and 57-89% respectively. The normative wastewater treatment level may be achieved if pollutant removal coefficient in the calculations of constructed wetlands is taken to be K_c = 0.06 (Strusevičienė et al., 1997).

Due to their treatment efficiency and many other advantages the filters have become very popular therefore there is a need to apply them for the treatment of heavily polluted wastewater from dairy companies and other similar enterprises.

The principle of wastewater treatment process in constructed wetlands is based on the wastewater filtration through a sand medium containing boggy plant roots, and different physical, biological and chemical processes occurring in the sand layer. The retention of coarse particles is a physical process, while the bounding of phosphorus with the help of soil particles is considered as a physical-chemical process. The biological treatment is induced because bacteria contained in the soil are using different matter (proteins, fats, carbon hydrates) contained in wastewater as nutrition and thus are disintegrating the substances into simpler compounds, such as water and carbon dioxide. If

the filtration of water through a sand media is a rather long-lasting period, nitrogen compounds may be disintegrated as well. Wastewater treatment facilities receive nitrogen mostly in the form of ammonia, therefore first of all nitrogen should turn into nitrate nitrogen due to its exposition to oxygen, and due to the effect of oxygen it should turn into gaseous nitrogen that later is eliminated from the wastewater.

The relation between the constant of organic pollutants removal in wastewater of milk collecting post chemical oxygen demand (COD_{Cr}) and biological oxygen demand (BOD_7) is 1.31. This implies that the wastewater contains a large amount of quickly disintegrated organic pollutants. The negative feature of those pollutants is that they cannot be accumulated for a long period of time. After 1-2 days, the concentration of mobile hydrogen ions H^+ significantly decreases – the wastewater is getting fermented until pH 4.3-4.7, and in the acid media the quantitative and qualitative composition of pollutant-disintegrating microorganisms is significantly reduced. Therefore the wastewater from milk processing is to be treated as soon as possible.

The objective of the studies was to determine the efficiency of treatment process of wastewater from milk processing performed in two-stage constructed wetlands, when quicklime or coagulants are used for the pre-treatment process of wastewater.

Materials and Methods

The studies were carried out in wastewater treatment facilities arranged in the milk processing station in Padargupiai village (Ariogala county, Raseiniai district) within the period of 2003–2005. The technological scheme of wastewater treatment facilities is presented in Figure 1. The designed wastewater amount was 5 m^3d^{-1}; however due to the development of production it has expanded up to 12.5 $m^3 d^{-1}$. The wastewater is directed from the company into a well-type pump-house via two sewerage collectors. Further from the pump-house the wastewater is supplied to the aeration-flocculation equipment through a pressure line (useful storage capacity of 8 m^3). In the reaction chamber of this equipment, the wastewater is treated with chemicals and air mixtures. Then the wastewater is directed into a sedimentation pond (useful storage capacity of 8 m^3). A dosing device of chemicals is arranged above the reaction chamber. In 2003-2004, quicklime CaO (1 kg for 1 m^3 of wastewater) was supplied into the reaction chamber for the coagulation of pollutants. In 2005, the quicklime was replaced with coagulant 'ZETAG 8660' (40 g for 1 m^3 of wastewater). Compared to the quicklime, this coagulant has certain exploitation advantages: it is simple to dose (dissolved in water (40 g l^{-1}) it is dripped from a vessel with a tap into the wastewater), moreover smaller amounts of sediment are formed in the sedimentation pond. The wastewater is purified in the sedimentation pond; here the sludge is accumulated. The useful storage capacity of the sedimentation pond is calculated so that it would be able to contain the amount of sludge accumulated within a 3-4 month period, and there should also be enough space for flocculants to deposit. Further the wastewater is directed from the sedimentation pond into two succeeding constructed wetlands. The size of the filters is 200 m^2 each. Here the wastewater is treated to the allowable rate and then is directed into the drainage channel.

Wastewater samples for chemical analysis were taken once per two-month period from those places:

- before treatment – from the pump-house;
- after the pre-treatment in physical-chemical treatment facilities – from the outflow from a chamber of chemical reaction;
- after the purification in a sedimentation pond – from the wastewater distribution manhole of the first constructed wetlands;
- after the treatment in the first stage of constructed wetlands – from the distribution manhole of the second constructed wetlands;
- before the outlet into the environment – from the control manhole.

Wastewater analyses were performed in the Chemical Analysis Laboratory of Water Management Institute of Lithuanian University of Agriculture considering the unified. The following indices were determined: BOD_5, pH, N_{total}, P_{total}, suspended sediments, and fat. To summarize the

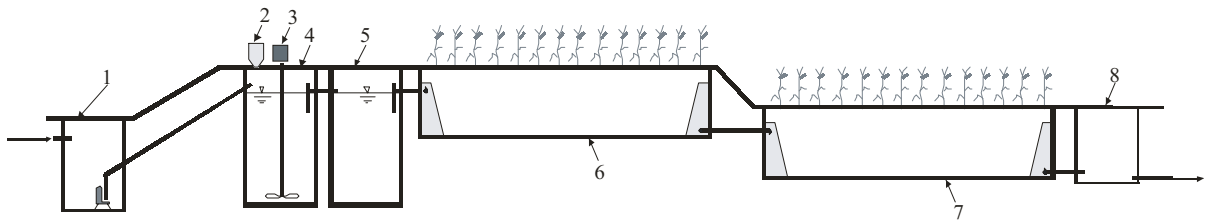

Figure 1. Technological scheme of wastewater treatment facilities:
1 – wastewater pump-house; 2 – dosing device of chemicals; 3 – ejector-type wastewater mixing device; 4 – chamber of chemical reactions; 5 – sedimentation pond; 6 – first constructed wetlands; 7 – second constructed wetlands; 8 – control manhole.

Table 1

The main chemical indices of domestic wastewater inflow and its pretreatment in constructed wetlands, mg l^{-1}

Index	Before treatment	After treatment in primary treatment facilities	After treatment in the first constructed wetlands	After treatment in the second constructed wetlands
BOD_5	369 – 1388 821	103 – 926 521	10 – 104 60	1 – 10 4
pH	6.0 – 7.6 6.9	6.4 – 10.7 7.5	6.9 – 7.7 7.3	6.9 – 8.1 7.5
N_{total}	17.7 – 82.0 38.0	6.6 – 58.0 32.0	7.0 – 23.0 14.6	0.7 – 12.8 6.7
P_{total}	3.7 – 11.0 6.3	0.6 – 9.1 4.6	0.4 – 7.9 3.3	0.04 – 0.4 0.17
SS	291 – 944 534	103 – 496 277	14 – 118 43	4 – 54 23
Fat	176 – 364 252	76 – 184 178	17 – 64 34	1 – 12 7

obtained study data the correlation analysis methods were applied.

A meter showing the work time of the pump was arranged in the wastewater treatment facilities. According to the discharge of the pump, it was possible to calculate the amount of wastewater inflow into the treatment facilities.

Results and Discussion

Constructed wetlands were applied only for the treatment of domestic wastewater. Having estimated their advantages, the constructed wetlands were used for the treatment of wastewater in milk collecting station of Padargupiai village. As the wastewater of this milk collecting station is particularly heavily polluted (BOD_5 reaches up to 1400 mg l^{-1}), a two-stage constructed wetlands were arranged. As the study results have shown, the treatment efficiency in constructed wetlands is very good right after the arrangement of the facilities. As the first chemical analysis has shown, the outflow of wastewater contained the following amounts of pollutants: 24.3 mg O_2 l^{-1} of organic matter (according to BOD_5), 2.4 mg l^{-1} of $N_{total,}$ and 0.2 mg l^{-1} of P_{total}. The data of the whole study period (min value – max value / the average value) is presented in Table 1.

The pump-house is supplied with wastewater from the milk collecting station, the average pollution of which is easily disintegrated with organic pollutants and reaches 821 mg O_2 l^{-1} according to BOD_5. The pollution dynamics of the wastewater is presented in Figure 2.

Pollution of the wastewater produced in the milk processing station is fluctuating within the range of 369 to 1388 mg O_2 l^{-1} and is changing not only in separate periods of the year, but in different periods of the same day. This depends on the amount of collected milk and the amount of water used for washing milk trucks and milk fridges.

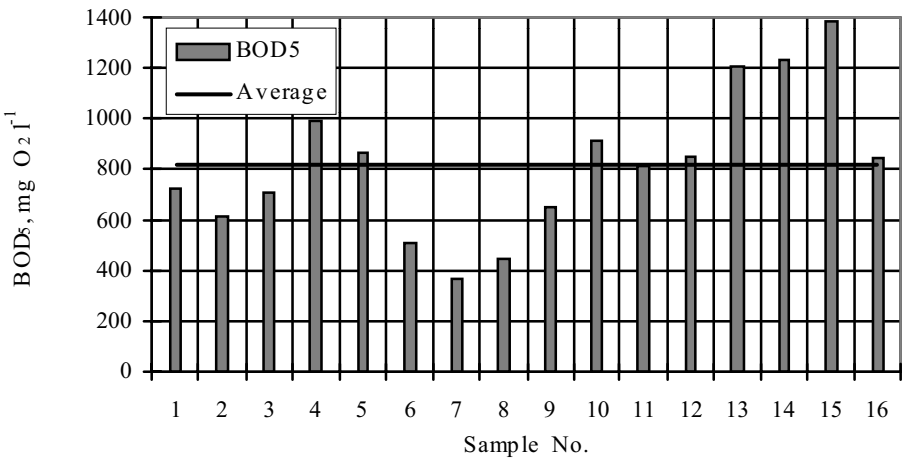

Figure 2. Dynamics of the initial pollution of wastewater according to BOD_5.

Modern up-to-date devices 'Karker' were suggested for washing milk trucks. Using those devices, the washing of one milk truck requires 50 l of water. As the devices have not been fully arranged yet, the washing of milk truck requires twice as much water.

The treatment of such wastewater in constructed wetlands is impossible, therefore first of all it is to be pretreated using chemical matter. In the physical-chemical treatment device, the wastewater was supplied with calcite quicklime (1.0 kg m^{-3}) in order the coloids containing more rapidly disintegrated organic matter could form the flocculants during the chemical processes in the mixing chamber with the presence of calcium. In the sedimentation pond, the wastewater is in a quiet state, therefore the flocculants transported with wastewater from the mixing chamber deposit on the bottom here. As the laboratory studies have shown, such rate of lime reduces the wastewater pollution according to BOD_5 by 54% in 12 hours. Having increased the lime rate up to 1.5 kg m^{-3}, the treatment efficiency increases by 75%. However, the alkalinity of wastewater increases, too (pH = 9.7). In alkaline media, the biocenosis is rather weak therefore the biological treatment of wastewater is complicated.

Our studies have shown that in the milk collecting station 90% of wastewater is formed within a 5-hour period, therefore it is expedient to use such chemical matter that would ensure as short treatment process as possible. For this purpose we have chosen the coagulant 'ZETAG 8660'. Having poured 4 g of this coagulant into 1 m^3, the pollution load of wastewater with organic matter decreased by 68% in the mixing-aeration device; having applied 6 g, the pollution load was reduced by 75%. Further increasing the rate up to 8 g, treatment efficiency did not increase. It is not expedient to prolong the aeration time, because after 18 hours the amount of removed organic pollutants was 81% (6 g m^{-3}). Using this coagulant, the treatment of biogenic matter was also quite efficient: the amounts of N_{total} and P_{total} were reduced 2.2 and 2.6 times. In order the filter was not clogged, the wastewater should contain as little suspended sediments as possible. The amount of suspended sediments much depended on the amount of coagulant: having mixed 4 g m^{-3}, the amount of suspended sediments decreased from 186 mg l^{-1} to 43 mg l^{-1}; having inserted 6 g and 8 g of the coagulant, the amount of suspended sediments decreased to 17 mg $l^{-1}$and 10 mg l^{-1}. After 6 hours, the reaction of wastewater (pH) did not change.

In other study variants, the following ratios of the mixtures of lime and coagulant were used: 250/2, 500/3, and 750/4 g. The most efficient wastewater treatment was determined with higher amounts of chemicals applied: after 6 hours here the wastewater pollution according to BOD_5 decreased by 61%, after 12 hours it was reduced by 75%, and after 18 hours it decreased by 79%. Suspended solids made 72 mg l^{-1} after 6 hours, while pH value increased from 6.7 to 8.9. Amounts of N_{total} and P_{total} contained in the wastewater decreased from 9.6 to 6.3 mg l^{-1} and from 2.0 to 0.3 mg l^{-1} respectively.

Under industrial conditions, such results were not obtained in the first stage of the treatment process: the amount of BOD_5 contained in the wastewater decreased by 27.2%, the amount of suspended solids was reduced by 48.1%, and amounts of N_{total} and P_{total} decreased by 15.8% and 27%. This much depended on the air temperature regime, inaccurate dosage of chemicals, and insufficient storage capacity of the reaction tank and settling reservoir for 2.5 times larger amount of wastewater.

The principal index evaluating the efficiency of wastewater treatment facilities is BOD_5. This index is best

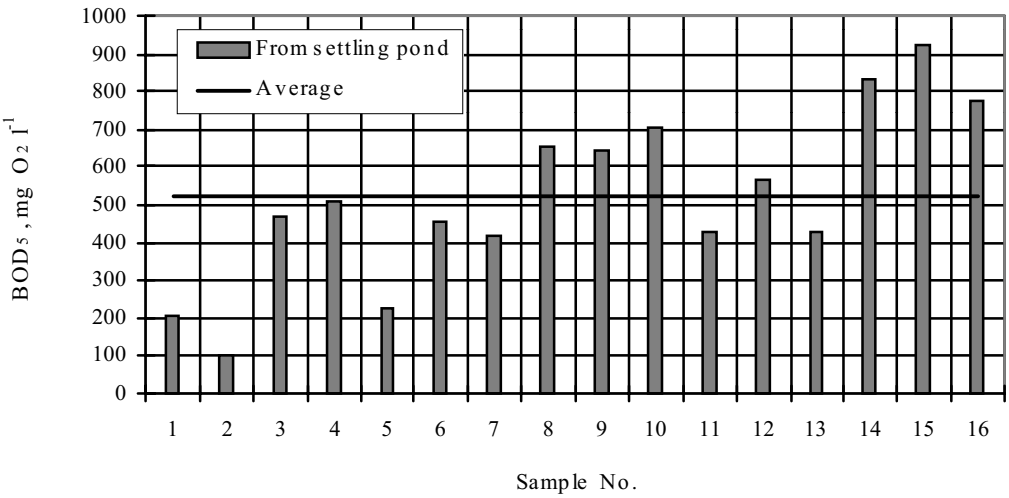

Figure 3. Dynamics of wastewater inflow into the first constructed wetlands according to BOD_5.

for the integration of all quickly disintegrated pollutants. As in the first stage of treatment the amount of those pollutants decreases only by ¼, the basic load is directed on the first filter during the removal process of organic pollutants. The dynamics of pollution of wastewater flowing from the settling tank according to BOD_5 is presented in Figure 3.

As it is seen, pollution of wastewater is fluctuating within a wide range; the average value reaches 521 mg O_2 l^{-1} and exceeds the value of domestic wastewater 2 times. The first filter removes 90% of pollutants. Thus, the effect of lime or coagulant does not stop in the first stage of wastewater treatment process, but is proceeding in the constructed wetlands. However, the pollution of wastewater outflow from the first constructed wetlands does not correspond to the environment protection requirements, the colour of wastewater is often blackish and the wastewater gets purified only after a certain period of time. Therefore a second stage of wastewater treatment in the constructed wetlands is necessary. The pollution load of wastewater inflow from the first filter according to BOD_5 is only 60 mg O_2 l^{-1}, therefore in the second filter they are treated to even 4 mg O_2 l^{-1}. Thus, it is possible to make the second filter narrower (this would decrease its arrangement costs), and it is also possible to reduce the wastewater filtration path until the pollution of wastewater outflow approaches to the allowable limit. However, this requires a thorough study.

The removal of biogenic pollutants from wastewater is particularly an urgent issue, because they enhance the eutrophication of open water bodies. As it is seen from Table 1, the treatment of wastewater is very efficient: the amount of N_{total} decreased by 82%, the amount of P_{total} was reduced by even 97%. N_{total} concentration in wastewater outflow from the first sand-reed filter never exceeded the allowable rate, and the highest N_{total} concentration in wastewater outflow from the second sand-reed filter was only 12.8 mg l^{-1}. On the basis of the study results, a functional dependence of wastewater treatment in the first sand-reed filter on the pollution load contained in wastewater

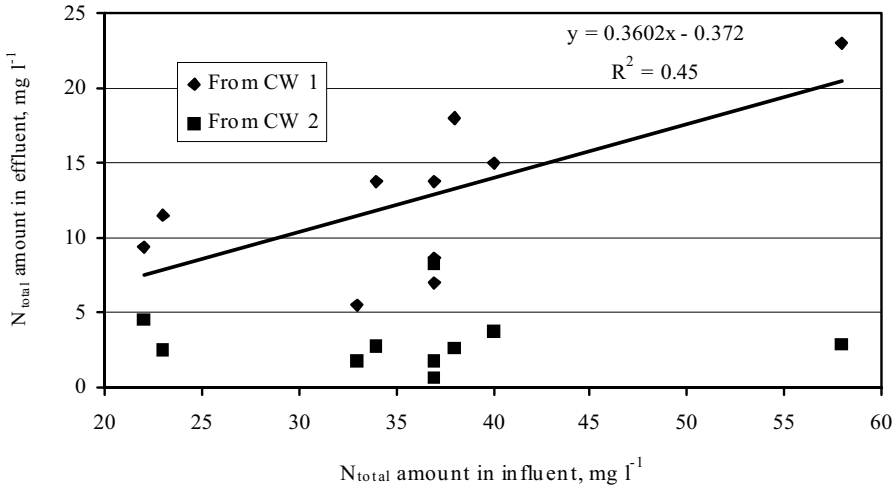

Figure 4. N_{total} amount contained in wastewater inflow and outflow from filters.

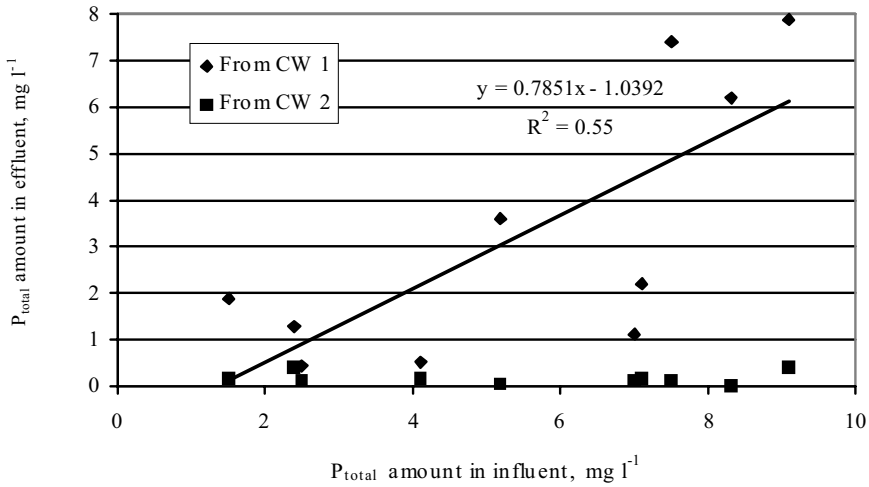

Figure 5. P_{total} amount contained in wastewater inflow and outflow from filters.

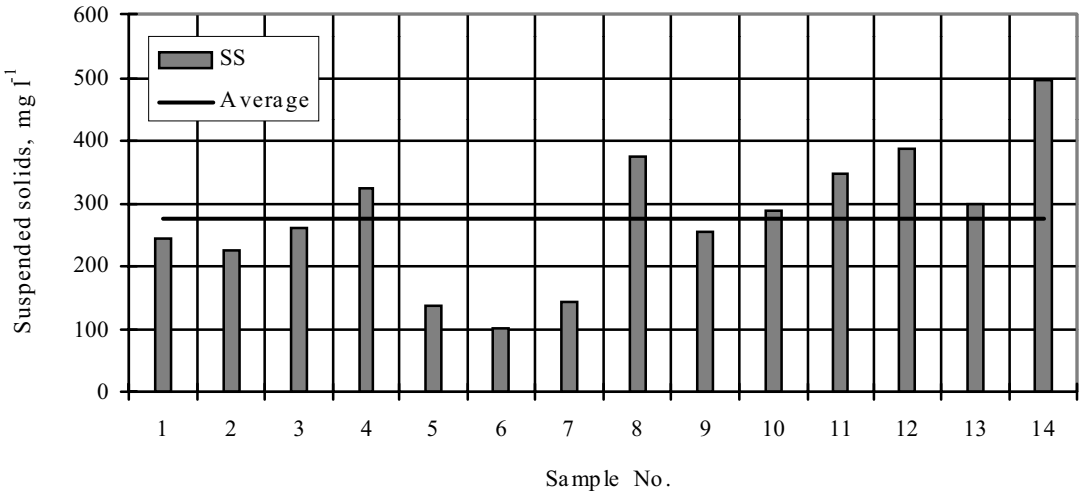

Figure 6. Dynamics of suspended solids contained in wastewater inflow into the first constructed wetlands.

inflow was determined (N_{total} – Fig. 4, P_{total} – Fig. 5). No similar dependence was observed in the second filter, because here the wastewater treatment efficiency did not depend on the pollution of wastewater inflow with biogenic matter.

Coarse sand was used for the arrangement of constructed wetlands. The sand contained 10% of particles with the diameter less than 0.2 mm; sand porosity was 30%, filtration coefficient – 16 m d^{-1}. Although the sand used for filters was coarse enough, the duration of the functioning of filters is adversely affected by suspended solids contained in wastewater. The amount of suspended solids contained in wastewater inflow into the facilities of primary treatment was on the average 534.5 mg l^{-1} and was fluctuating within a wide range – from 291 to 944 mg l^{-1}. After the treatment in the primary treatment facilities, the amount of suspended solids was reduced by 48.2% (in aeration-flocculation chamber – by 15.2%). However, the wastewater outflow from the settling tank still contains a large amount of suspended solids (on the average 277 mg l^{-1}, maximum determined amount 496 mg l^{-1}). The dynamics of suspended solids contained in wastewater inflow into the constructed wetlands is presented in Figure 6.

When wastewater volume increased 2.5 times, the settling tank appeared to be too small. In order to reduce the amount of suspended solids and to protect constructed wetlands from colmatation, it is necessary to arrange an additional manhole as soon as possible.

After filtration in the first filter, the amount of suspended solids contained in wastewater decreased to 43.2 mg l^{-1}; after filtration in the second filter it decreased to 22.8 mg l^{-1}. Higher amount of suspended solids (up to 54 mg l^{-1}) contained in wastewater outflow from the treatment facilities was observed only at the beginning of the exploitation.

To ensure a normal and satisfying treatment process of wastewater in constructed wetlands, an active reaction of wastewater is particularly important. Optimal media for biological processes is when pH of wastewater equals to 7-8. When quicklime was used for the treatment of wastewater, there were some problems due to its dosage, therefore pH of wastewater was fluctuating from 6.8 to 10.7 depending on the changes in quicklime rate. When alkalinity of wastewater is so high, even nitrate bacteria are inanimate.

Using coagulant 'ZETAG 8660', the average pH value of wastewater outflow from the settling tank was 6.8. But after filtration in the first constructed wetlands, pH of wastewater increases up to 7.4, and after filtration in the second constructed wetlands pH increases to 7.6. The main reason for this is lime accumulated in filters.

Wastewater inflow into the pump-house contains on the average 252 mg l^{-1} of fat. After the primary stage of treatment process the amount of fat decreased by 29% (down to 178 mg l^{-1}). Considering the experience of researchers (Strusevičius, 1996) it can be stated that wastewater inflow into facilities of biological treatment should not contain higher than 50 mg l^{-1} fat concentration. Thus, a special fat separator is to be arranged in the link of primary wastewater treatment.

Summarizing the study results it can be stated that even with inaccurate dosage of chemicals in the first stage of treatment process, the wastewater treatment in constructed wetlands is always efficient – here the wastewater is treated to the allowable rates. When the first filter is out of operation, the second filter is able to function for a certain period of time; thus, in such case the damage to nature is minimal.

Conclusions

1. In milk collecting stations the pollution of wastewater, depending on the amount of water supplied, is fluctuating within a wide range: according to organic pollutants amount (BOD_5) – 3.8 times, according to N_{total} and P_{total} amounts – 4.6 and 3 times respectively, according to the amount of suspended solids – 3.2 times.

2. For the treatment of wastewater in milk collecting stations it is expedient to use two-stage constructed wetlands. Here the wastewater is treated to 4 mg O_2 l^{-1} according to BOD_5, the amount of N_{total} decreases to 6.7 mg l^{-1}, the concentration of P_{total} is reduced to 0.17 mg l^{-1}, and the amount of suspended solids decreases to 23 mg l^{-1}.

3. After the primary treatment, the wastewater still contains large amounts of suspended solids (on the average 277 mg l^{-1}, maximum determined amount – 496 mg l^{-1}). In order to reduce the amount of suspended solids and to protect the filters from colmatation, a settling tank with higher storage capacity is necessary.

4. Wastewater inflow into the first constructed wetlands contains 3.5 times higher fat amount than the maximum allowable rate. Therefore a special fat separator is to be arranged in the link of primary wastewater treatment.

References

1. Gasiūnas V., Strusevičius Z. (2003) The experience of wastewater treatment using constructed wetlands with horizontal subsurface flow in Lithuania. In: Publicationes Instituti Geographici Universitatis Tartuensis, pp. 242-249.
2. Henze M., Harremoes P., Jansen J., Arvin E. (1995) Wastewater treatment. Biological and Chemical Processes. Berlin: Springer-Verlag, pp. 24-47.
3. Strusevičienė S.M., Strusevičius Z., Gasiūnas V. (1997) Treatment of wastewater from private farmsteads in constructed wetlands. Water Management Engineering, 3(25), pp. 133–143.
4. Strusevičienė S.M., Strusevičius Z., Radzevičius A. (2002) Application of hydratation and carbonization method for the treatment of wastewater from food industry. Water Management Engineering, 21(43), pp. 13–20.
5. Strusevičienė S.M., Strusevičius Z. (2004) Investigations on treatment efficiency of wastewater from cattle slaughterhouse. Water Management Engineering, 26(46), pp. 5–11.
6. Strusevičius Z., Strusevičienė S.M. (2001) Investigations of primary treatment of wastewater in meat processing company. Water Management Engineering, 16(38), pp. 76–84.
7. Strusevičius Z. (1996) Handling of Effluents, Wastes and Manure in Agriculture. Vilainiai, pp. 77-78.
8. Šeškevičius V. (1977) Treatment of sewerage water from meat and milk industry. Vilnius: LIMTI, pp. 65-66.

EFFECT OF GROWN PLANTS ON DRAINAGE WATER QUALITY

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Abstract

In 1999-2003, the investigations were carried out in Juodkiškis study object of Water Management Institute of Lithuanian University of Agriculture. Study scheme is composed of three treatments: treatment I – slurry applied, treatment II – mineral fertilizers applied, treatment III – no fertilization. Test field is drained, drain spacing is 15 m, draining depth is 1.2 m. During the crop rotation the following plants were grown: spring wheat with undercrop, red clover (1st year of use), red clover (2nd year of use), sugar beet, and spring rape. The objective of the studies was to determine the effect of cultivated crops on drainage water quality.

As the study results have show, N_{total} concentrations contained in drainage water increased due to higher fertilization rates and inorganic nitrogen accumulated in the soil. Neither fertilization nor amount of mobile phosphorus contained in the soil made any effect on P_{total} concentrations in drainage water.

In arable land, N_{total} concentrations contained in drainage water were 2.3 times higher than those in drainage water of the field, where red clover was grown. P_{total} concentrations were higher in the field with red clover.

According to the rates determined in Lithuania, drainage water is not polluted with phosphorus, while average annual N_{total} concentrations exceeded the maximum allowable (MAC) when spring wheat with undercrop and sugar beet was grown.

Key words: N_{total}, P_{total}, concentration, drainage water.

Introduction

As Lithuanian agricultural sector occupies more than 53% of the total country's area, the main environmental problem related to the agriculture is the leaching of biogenes. Biogenes are plant available nutrients; however, abundance may adversely affect drainage and ground water quality. Rivers flowing via agricultural land areas collect water saturated with those elements. Having determined chemical composition of water in rivers and other surface water bodies, it was observed that drainage water quality tends to decrease in areas with intensive agricultural activity (Sileika, 2000). In territories containing forests, where agricultural activity is not intensive, average amount of leached nitrogen is 5.6 kg ha^{-1} per year, while in agricultural fields this value is 2.5 times higher (Dumbrauskas et al., 1994).

According to the data of the year 2000, the river Nevėžis contains higher pollution concentrations than the river Skroblus, because the average nitrate nitrogen and total phosphorus concentrations in the river Nevėžis were 4.5 and 0.389 mg l^{-1} respectively in that period, while in the river Skroblus in the same period concentrations of those elements were 0.13 and 0.075 mg l^{-1} respectively (Lietuvos upių…, 2002).

Due to intensive fertilization with nitrogen in 2000, the leached amount of nitrogen was 16 kg ha^{-1} in the Graisupis basin of the Middle Lithuanian Plain, i.e. 2.6 times more than in the Vardas basin of Baltic Highlands and 4 times more than in the Lyžena basin of Žemaičiai Highlands (Kutra et al., 2001). Due to intensive farming activity, the average annual 14.4 kg ha^{-1} N leaching in the streams of Middle Lithuanian Plain mostly depended on high nitrogen concentrations (5.9 mg l^{-1}) (Gaigalis et al., 2001).

As nitrogen is a particularly mobile element, its leaching into the environment from the soil is easiest. In such a way nitrogen pollutes water in wells, rivers and lakes, which results in overgrowth of water bodies. Moreover, nitrogen pollutes water of wells until concentrations hazardous for human health (Kutra et al., 2002). In Lithuania, water of more than 1/3 of all wells is polluted with nitrates. Nitrate concentrations in those wells are sometimes 100 times higher than those contained in drainage water outflow from agricultural fields (Sileika, 2001).

As the Marine Research center of the Ministry of Environment of Lithuania has determined, particularly intensive eutrophication processes occur in the Curonian Lagoon (Olenina, 1998). According to the study results of Lithuanian Water Management Institute, although recently agricultural activity and applied fertilization rates have significantly decreased, the pollution of most rivers with nitrate nitrogen has shown an even increasing tendency (Sileika, 2000).

Due to its lower mobility, phosphorus leaching into ground water is insignificant. However, this element tends to accumulate in the soil. In most states (Denmark, France, Germany), nitrogen amount allowable for the fertilization of agricultural fields is regulated. However, in such countries as the Netherlands and Belgium, fertilization rates are limited in respect of phosphorus amount. This is because in many European countries the soils are over-fertilized with this element, which results in high P losses due to the leaching and soil erosion processes (Sibbesen et al., 2003)

Although leached amounts of P are insignificant, P concentrations of 0.03-0.05 mg l^{-1} already enhance eutrophication processes (Sharpley et al., 1997).

According to the EU classification of surface water for

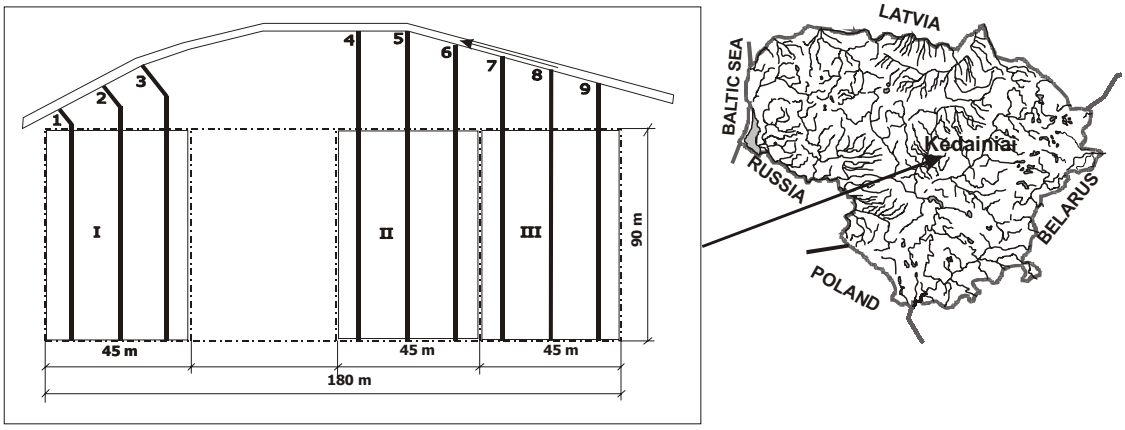

Figure1. Geographical location and scheme of the study object:
treatment I – slurry applied, treatment II – mineral fertilizers applied, treatment III – non - fertilized, 1-9-number of drainage outlet.

life-support, total P concentration should not exceed 0.025 mg l^{-1}. Unfortunately, under agriculture development conditions, it is difficult to achieve such concentration therefore Swedish scientists suggest the concentration of 0.05 mg l^{-1} (Gustafson et al., 1995).

The objective of the studies was to determine the effect of cultivated crops on drainage water quality.

Materials and Methods

In 1999-2003, the investigations were carried out in Juodkiškis study object of Water Management Institute of Lithuanian University of Agriculture.

The experimental scheme comprises treatments I, II, and III in three replications (Fig. 1).

The area of the study object (1.22 ha) is drained with drainage, drain spacing - 15 m, draining depth - 1.2 m. Three replications of each treatment are arranged on separate drains. In-between two adjacent drains there are polythene screens arranged to separate one drain from the other and to avoid nutrient leaching from one drainage system into the other. Each separate drainage system covers the area of 0.135 ha.

The following crops were grown in the test field:

1) spring wheat (slurry $N_{62}P_{29}K_{103}$ and mineral fertilizers $N_{62}P_{29}K_{103}$);

2) red clover, 1st year (slurry $N_{41}P_{16}K_{29}$ and mineral fertilizers $N_{43}P_{16}K_{29}$);

3) red clover, 2nd year (slurry $N_{88}P_{43}K_{97}$ and mineral fertilizers $N_{87}P_{43}K_{97}$);

4) sugar beet (slurry $N_{190}P_{76}K_{271}$ and mineral fertilizers $N_{200}P_{100}K_{150}$);

5) spring rape (slurry $N_{75}P_{32}K_{98}$ and mineral fertilizers $N_{75}P_{32}K_{97}$).

Soil grain-size composition was determined by Kačinskis pipette method. Soil samples were taken from 0-120 cm deep soil layers every 10 cm.

Soil of the study object is calcareous gley brown soil (RDg4-k2) (Buivydaitė et al., 2001). According to grain-size composition, the soil is attributed to sandy loam soils. In treatments I and II, sandy loam soils are prevailing, in treatment III sandy loam on loam is dominant.

The soil is of alkaline reaction (pH>7), low and medium in humus content (on the average 1.47-2.94% of humus in the arable layer), contains low nitrogen concentrations (31.8 – 45.6 kg ha^{-1} N_{min} at a 0-40 cm deep layer). The soil is not rich in phosphorus and potassium concentrations as its arable layer contains only 73.0 - 81 kg ha^{-1} and 58.0 - 78 kg ha^{-1} of plant available P_2O_5 and K_2O respectively.

Samples for the determination of drainage water chemical composition were taken once a month. Analysis of water samples were made at Chemical Analysis Laboratory of Water Management Institute on the basis of the methodology described in literature (Unifikuoti…, 1994).

Drainage runoff was measured every five days. During the periods of spring and autumn floods, the runoff measurements were taken every day in a volumetric way. Discharges were calculated on the basis of linear interpolation, drainage runoff heights were estimated according to everyday discharges.

A binary correlation method was used for data processing.

Results and Discussion

According to the data of five study periods, precipitation amount never exceeded the perennial rate. In the study period of 1999-2000, precipitation amount corresponded to the perennial rate, in 2000-2001 - 99% of total perennial rate. Study periods of 1999 and 2001-2002 were dry with precipitation amounts of 86 and 89% of total perennial rate respectively; in the study period of 2002-2003 the precipitation amount made up 66% of total perennial rate (Table 1).

Table 1

Meteorological conditions of the study periods

Index	1999	1999-2000	2000-2001	2001-2002	2002-2003
	January-November	December-October	November-September	October-October	November-August
Precipitation, mm	469	533	536	567	326
% from perennial rate	86	100	99	89	66
Average air temperature, °C	9	8	8	10	6
Deviation from perennial average value, °C	+2	+1	+2	+4	0

During the whole study period, the average air temperature exceeded the perennial temperature in four successive periods by 2, 1, 2 and 4 degrees respectively. During the last study period, the air temperature was equal to the perennial rate. Dry and hot weather conditions influenced formation of drainage runoff, therefore due to such meteorological conditions no drainage runoff occurred in the particularly dry study period of 2002-2003. In the dry study periods of 1999 and 2001-2002 drainage runoff lasted 3 and 7 months respectively. In the study periods of 1999-2000 and 2000-2001, when the territory experienced 100% and 99% of perennial precipitation rate, drainage runoff lasted 7 and 6 months respectively.

Data of drainage runoff distribution in different seasons of the year is presented in Table 2.

Due to higher air temperature than the average in winter as well as frequent snowmelt periods, drainage runoff made up 47.2% of the average value of drainage runoff of a five-year period. During snowmelt in spring, drainage discharged 43.7% of water. In summer and autumn, drainage runoff was insignificant - 0.03 and 9.0% respectively.

Changes in nutrients concentrations contained in drainage water were different. Average total N and P

Table 2

Drainage runoff distribution (mm) in different seasons of the year

Investigation period	Treatment	Season of the year				Total
		Winter (December-February)	Spring (March-May)	Summer (June-August)	Autumn (September-November)	
1999 (January-November)	I	0	53.08	0	0	
	II	0	38.92	0	0	
	III	0	46.94	0	0	
	Average	0	46.31	0	0	46.31
1999 –2000 (December-October)	I	139.31	64.7	0.15	0.09	
	II	124.17	58.6	0.14	0.10	
	III	142.22	65.95	0.17	0.08	
	Average	135.23	63.08	0.15	0.09	198.55
2000 – 2001 (November-September)	I	96.48	51.49	0	0	
	II	59.99	46.62	0	0	
	III	93.27	67.11	0	0	
	Average	83.25	55.07	0	0	138.32
2001 – 2002 (October-October)	I	13.79	50.08	0	40.26	
	II	16.68	54.48	0	43.21	
	III	15.98	51.89	0	50.74	
	Average	15.48	52.15	0	44.74	112.37
2002 – 2003 (November-August)	I	0	0	0	0	
	II	0	0	0	0	
	III	0	0	0	0	
	Average	0	0	0	0	0
1999 - 2003	Average	46.79	43.32	0.03	8.97	99.11

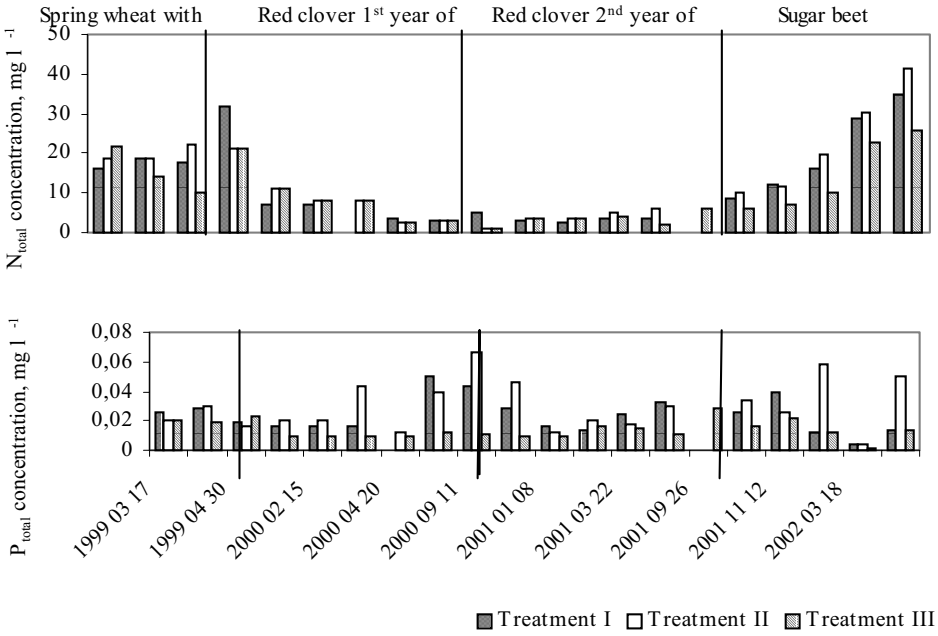

Figure 2. Fluctuations in total N and total P concentrations in drainage water (mg l^{-1}).

concentrations did not exceed maximum allowable concentrations (MAC) for drainage water (Dėl aplinkos…, 2005) and were fluctuating from 9.6 to 12.4 mg l^{-1} and from 0.018 to 0.027 mg l^{-1} respectively (Fig. 2).

However, the highest total N concentration exceeded MAC even 1.7 times in the control variant and reached 25.6 mg l^{-1}. The highest total P concentration was observed in the variant with mineral fertilizers applied (0.1 mg l^{-1}), however it is even 20 times lower than MAC. Thus it can be stated that applying slurry or mineral fertilizers, or not applying fertilizers at all, there were cases when N concentration in drainage water (most often at the onset of drainage runoff) exceeded MAC.

The highest N concentrations contained in drainage water occurred in April of 2002: in treatments with slurry or mineral fertilizers applied, N concentration was 35.1 and 36.9 mg l^{-1} respectively, which is 2.3 and 2.5 times higher than MAC. In control variant, total N concentration also exceeded MAC 1.7 times. This may be due to the fact that in autumn of 2001 the field of red clover was ploughed up. Mineralization processes of plant residuals contributed to the increasing amount of nitrogen in the soil. As it is found in the literature (Tripolskaja et al., 1995), nitrification processes may occur at low temperatures as well, which results in the supplement of N content in the soil. However autumn-winter period is favorable for N leaching, because at that time fields are empty and precipitation is scarce. Higher air temperature in spring enhances more intensive mineralization processes in the soil, which results in higher amounts of nitrogen contained in the soil. Plant unavailable nitrogen is leached into drainage.

The lowest N concentration contained in drainage water during five study years occurred in 2001 when red clover (2nd year of use) was grown, and the average N concentration of that period reached 3.5 mg l^{-1} in the control variant. In variants with slurry and mineral fertilizers applied, N concentrations exceeded those of the control variant by 20.6 and 53.9% respectively.

In 1999, spring wheat with red clover undercrop was grown in the test field. Then the average N concentrations in drainage water reached 8.6 mg l^{-1} in the control variant and 13.1 mg l^{-1} in the variant with mineral fertilizers. Such concentrations occurred due to vegetables previously grown in the test field. Moreover, unfavorable meteorological conditions determined poor yield of spring wheat and red clover undercrop. Therefore plant unavailable nutrients were leached intensively. N concentration was fluctuating within a wide range during a year: the highest N concentration occurred at the onset of drainage functioning (in December of 1999 – from 21.0 to 31.7 mg l^{-1}) and in spring (in April of 1999 – from 14.1 to 19.9 mg l^{-1}) when drainage runoff was highest.

In 2000, drainage runoff started rather early – in the first ten-day period of December of 1999, when the average air temperature was comparatively high (exceeded the many-year rate by 3.1 °C). These reasons enhanced nutrient leaching therefore nutrient concentrations in winter were higher than in the summer of the study period, because in summer nutrients were used for growing green mass of red clover.

Table 3

Dependence of nutrient concentrations in drainage water on fertilization rates

Element	Form of dependence	r	$t_{theor95\%}$	t_{actual}	n
N_{total}	y=0.1319x + 6.5568	0.83	2.2	8.5	12
P_{total}	y=0.0002x + 0.0219	0.22	2.2	0.7	12

Note. Dependence is reliable when $t_{actual} > t_{theor95\%}$

The average P concentration in drainage water was insignificant – only 0.018-0.027 mg l^{-1} in the study period (MAC – 2 mg l^{-1}).

However, there were cases (especially when red clover (2nd year of use) was grown in 2001), when momentum concentrations increased and reached 0.08-0.1 mg l^{-1}. As it is referred to in the literature (Блэк, 1973), increase in P concentrations depended on the grown perennial grass and other plants with stronger root system. Roots of such plants dissolve calcium phosphates contained in the soil, using calcium and phosphorus. Although P leaching is insignificant, the researchers affirm that even such P concentrations as 0.03-0.05 mg l^{-1} enhance eutrophication processes of water bodies (Sharpley et al., 1997). In the variant with mineral fertilizers applied, P concentration was highest (0.08-0.1 mg l^{-1}). In the variant with slurry applied, P concentration was 0.02-0.03 mg l^{-1}. Having analyzed the data of five study years, it was determined that there is a close relationship between increase in P concentrations and grown plants: when red clover was grown in 2000 and 2001, the average annual total P concentrations were 0.026 and 0.027 mg l^{-1} respectively. According to the literature (Komparskas, 1961), large plant root mass accumulates more phosphorus. When perennial grass is grown, the amount of bacteria increases. Bacteria decompose plant unavailable P compounds contained in the soil; a certain part of P compounds is leached.

Nutrient concentrations depend on the type of applied fertilization. The effect of fertilizers on drainage water quality is proved by correlation dependence between fertilization rates applied per year (x) and elements concentrations contained in drainage water (y) (Table 3).

In 1999-2003, total N concentrations depended on fertilization in the test field, and P dependence was unreliable $t_{actual} < t_{theor95\%}$.

In spring, inorganic nitrogen content in the soil determined total N concentrations by 29%. The following dependence was obtained:

$$y = 0.4013x - 3.53,\ r = 0.54,\ n = 27,\ t_{actual} = 3.78 > t_{theor95\%} = 2.1 \quad 1)$$

As drainage runoff often starts in autumn, total N

Table 4

Drainage runoff and N and P leaching

Study period	Index values						Land use
	Treat-ment	Runoff	N_{total}		P_{total}		
		mm	mg l^{-1}	kg ha^{-1}	mg l^{-1}	kg ha^{-1}	
1999 (January-November)	I	53.08	17.63	9.3	0.024	0.01	Spring wheat with undercrop
	II	38.92	21.30	8.0	0.017	0.01	
	III	46.94	15.3	6.6	0.021	0.01	
	Average	46.31	18.08	7.97	0.021	0.01	
2000 (December-October)	I	204.25	10.56	28.5	0.028	0.03	Red clover (I year of use)
	II	183.0	12.86	32.3	0.025	0.04	
	III	208.42	8.95	22.0	0.024	0.03	
	Average	198.56	10.79	27.60	0.026	0.03	
2001 (November-September)	I	147.97	3.49	4.1	0.023	0.03	Red clover (II year of use)
	II	106.61	5.14	5.8	0.047	0.04	
	III	160.38	2.77	4.6	0.012	0.03	
	Average	138.32	3.80	4.83	0.027	0.03	
2002 (October-October)	I	104.13	20.16	19.9	0.019	0.02	Sugar beet
	II	114.37	14.82	16.7	0.015	0.02	
	III	118.61	12.96	15.4	0.016	0.01	
	Average	112.37	15.98	17.33	0.017	0.02	
2003 (November-August)	I	0	0	0	0	0	Spring rape
	II	0	0	0	0	0	
	III	0	0	0	0	0	
	Average	0	0	0	0	0	

concentration dependence on inorganic nitrogen content in the soil in autumn was calculated, which determines total N concentrations by 45%:

$y = 0.0623x + 3.02$, $r = 0.67$; $n = 28$, $t_{actual} = 6.2 > t_{theor95\%} = 2.1$ (2)

where

y – N_{total} concentration;

x – inorganic nitrogen.

No dependence of total P concentrations on P_2O_5 content in the soil was determined.

As it is seen from data in Table 4, grown plants affect nutrient leaching.

When summer wheat with undercrop was grown in 1999, N_{total} concentration was 18.1 mg l^{-1}. When red clover (1st year of use) was grown in the second study period (2000), N_{total} concentration was 10.8 mg l^{-1}. In 2001, when red clover of the 2nd year of use was grown, the average N_{total} concentration decreased significantly and reached 3.8 mg l^{-1}. When sugar beet was grown, during the study period the average N_{total} concentration increased up to 16 mg l^{-1}.

P_{total} concentrations contained in drainage water increased when red clover was grown. When spring wheat with undercrop or sugar beet were grown, the concentrations of this element were lower.

Conclusions

1. Higher fertilization rates enhanced the increase in N_{total} concentrations contained in drainage water. No significant effect of fertilization on P_{total} concentrations was determined.

2. N_{total} concentrations contained in drainage water increased due to inorganic nitrogen content in the soil. No effect of mobile phosphorus on P_{total} concentrations was observed.

3. In arable land N_{total} concentrations contained in drainage water were 2.3 times higher than those in drainage water of field where red clover was grown. P_{total} concentrations were higher 1.4 times in the field of red clover.

4. Drainage water pollution with nitrogen was observed when spring wheat with undercrop (18.1 mg l^{-1}) and sugar beet (16.0 mg l^{-1}) was grown. Average annual concentrations of phosphorus contained in drainage water were lower than MAC.

References

1. Buivydaitė V.V.,Vaičys J., Juodis J., Motuzas A. (2001) Lietuvos dirvožemių klasifikacija (Classification of the soils of Lithuania). 'Lietuvos mokslo' redakcija. Vilnius. Lithuania. 137 pp. (in Lithuanian).
2. Dėl aplinkosaugos reikalavimų mėšlui tvarkyti patvirtinimo. Lietuvos respublikos aplinkos ministro ir žemės ūkio ministro 2005 m. liepos 14 d. įsakymas Nr. D1-367/3D-342 (Environment protection requirements for manure handling. Order of the Minister of Environment and Minister of Agriculture of the Republic of Lithuania No. D1-367/3D-342). (2005) Valstybės žinios. pp. 92-3434. (in Lithuanian).
3. Dumbrauskas A., Tumas R. (1994) Lietuvos gamtinė aplinka. Būklė. Procesai. Tendencijos (Natural environment of Lithuania. Processes. Tendencies). Aplinkos apsaugos ministerijos leidybos biuras. Vilnius. Lithuania. 114 pp. (in Lithuanian).
4. Gaigalis K., Račkauskaitė A. (2001) Azoto ir fosforo išplovimo agroekosistemose ypatumai (Peculiarities of N and P leaching in agroecosystem). Vandens ūkio inžinerija: Mokslo darbai. 16 (38). pp. 39–46. (in Lithuanian).
5. Gustafson A., Bergstrom L. and Ulen B. (1995) Losses of N. P and Pesticides from Agriculture and Environment Sustainability. Framework of the Baltic Agricultural Run-Off Programme. SLU.
6. Komparskas J. (1961) Drenažo įtaka augalams prieinamo P_2O_5 dinamikai velėniniame-glėjiškame nujaurėjusiame dirvožemyje (Effect of drainage on the dynamics of plant available P_2O_5 in soddy-podzolic gley soils). Lietuvos hidrotechnikos ir melioracijos mokslinio tyrimo instituto darbai. 3. pp. 105-112. (in Lithuanian).
Available at: http://www.iscu-scope.org/downloadpubs/scope54/4sibbesen.htm., 30.12.2005.
7. Kutra G., Račkauskaitė A. (2001) Ūkinės veiklos poveikis upeliø vandens kokybei (Effect of agricultural activity on water quality in streams). Vandens ūkio inžinerija. Mokslo darbai. 16 (38). pp. 34–38. (in Lithuanian).
8. Kutra S., Kusta A., Rutkovienė V. (2002) Šachtinių šulinių vandens kokybės rodiklių variacijos tyrimai (Investigations of variation of water quality indices in shaft wells). Vandens ūkio inžinerija. Mokslo darbai. 20(42). pp 56-65. (In Lithuanian)
9. Lietuvos upių vandens kokybės 2000 m. metraštis (Annals of Lithuanian river water quality 2000). (2002) Available at: http:www.am.lt/LSP/water_chronicle.php3?10=160-22k, 03.02.2006. (in Lithuanian).
10. Olenina I. (1998) Long-Term changes in the Kuršių Marios lagoon: Eutrophication and phytoplankton response. Ekologija. 1. pp. 56–65.
11. Sharpley A.N., Rekolainen S. (1997) Phosphorus in Agriculture and its Environmental Implications. Phosphorus Loss from soil to water. SAB International. pp. 1–43.
12. Sibbesen E., Runge – Metzger A. (2001) 4 Phosphorus balance in European Agriculture – Status and Policy Options.
13. Šileika A.S. (2000) Nutrient losses from agriculture in Lithuania. Landbauforschung Volkenrode. ½. pp. 3-5.
14. Šileika A.S. (2001) Mėšlidžių statyba įgyvendinant Europos Sąjungos Nitratų direktyvą 91/676/EEB (Construction of manure storage places according to the EU Nitrate Directive 91/676/EEB). Kėdainiai. Vilainiai. Lithuania. 56 pp. (in Lithuanian).
15. Tripolskaja L., Panamariovienė A. (1995) Medžiagų migracija dirvožemyje intensyviai tręšiamoje pašarų sėjomainoje (Migration of nutrients in the soil in crop rotation with intensive fertilization). Žemdirbystė: Mokslo darbai. 50. pp. 76–84. (in Lithuanian).
16. Unifikuoti nuotėkų ir paviršinių vandenų kokybės tyrimų metodai. D. 1. (Unified study methods of wastewater and surface water quality. D.1. (1994) Vilnius. Lithuania. 223 pp. (in Lithuanian).
17. Блэк К.А. (1973) Растение и почва (Soil-Plant relationships). "Колос". Москва. 503 с. (in Russian).

THE INFLUENCE OF THE CLIMATIC CONDITIONS ON THE SANITARY STATE OF WINDROWS

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Abstract

Staphylococci and *Salmonella* bacteria have the influence on the quality of the compost. The samples of the compost were taken before and after the period of low outside temperature (till -20 °C) to obtain different numbers of Staphylococci and *Salmonella* bacteria. Comparing to the data at the end of 2005, the number of *Salmonella* sp. at the beginning of 2006 decreased till zero, but the number of *Staphylococcus aureus* at the beginning of 2006 increased. The results showed that low outside temperature does not impede the functioning of the *Staphylococcus aureus* bacteria.
Key words: Germination tests, organic waste, quantification, temperature.

Introduction

For the use of compost in gardens and other places where people are in touch with soil, the compost must satisfy some strict requirements. One of them is the absence of *Staphylococci* bacteria and *Salmonella* bacteria (Zariņa et al., 2005b). *Staphylococci* can cause many forms of infection – for example, deep-seated infections, such as osteomyelitis and endocarditis, also can cause soft tissue infections and toxic shock syndrome. The problem with *Staphylococci* is that these bacteria are able to survive for a long time in the environment (Mezapuke et al., 2005). *Salmonella* on the other hand are the cause of two diseases called salmonellosis. The influence of the low temperature of environment on these bacteria's survival in windrows is shown in this study. The objective of the present study is to evaluate the sanitary state of compost windrows, to observe the influence of the low surrounding temperature on the *Staphylococci* bacteria and *Salmonella* sp., and to estimate the obtained compost using seed germination tests and total number of bacteria.

Materials and Methods

Inspected windrows in experimental composting field were 1-2 m in height, 2 m in width, and 12 m in length. In the beginning (during the first two months) the composting process in the windrows was realized under anaerobic conditions (Viesturs et al., 2004), and then it was continued under aerobic conditions (Zariņa et al., 2005a). The composting material was prepared as follows: domestic organic waste with sawdust was mixed and humidified. The windrows were mixed with special mixing machinery two times a week during first month and one time a week after that.

The samples were taken at the end of 2005 and at the beginning of 2006. The outside temperature during this period fluctuated from 0 °C to -20 °C. Samples 1, 2 and 3 were for finished compost from different places but from the same compost pile. Samples 4 and 5 were for finished compost from other different compost windrows. Finished compost was obtained by composting sawdust and domestic organic waste. Sample 6 was for unfinished compost (unfinished compost was in windrow for two months); sample 7 was for finished compost, which was obtained from sewage sludge composting. Samples 1/M and 2/M were two average samples which were taken from different previous samples.

The quantification of the total number of microorganisms, *Staphylococcus aureus* and *Salmonella* sp. in the compost was performed. Three repetitions were done for each quantification. The plate count method was used for estimation of the total number of microorganisms per 1 g of dry compost. The medium for quantification of the total number of bacteria was Bacto nutrient agar (DIFCO LABORATORIES, USA); for *Salmonella* and *Staphylococcus aureus* – RidaCount® Tests media (R-Biopharm AG, Germany) was used. For the processing of the obtained data the method of the descriptive statistics was used. The mean numbers of bacteria are shown in Table 2 and Table 3.

The quality of finished composts (finished compost was in windrow for four months) was determined using the seed germination tests (using cress salad) (Dubova et al., 2004). During the tests, three repetitions were performed using ten cress salad seeds in each repetition. Plates with seeds were evaluated after five days from tests' beginning. Data in Table 1 is obtained from the comparison between the roots of seeds germinated with a trace of compost and the roots of seeds germinated without of trace of compost.

Results and Discussions

The quality of finished compost was determined by seed germination tests and microbiological analyses. Table 1 shows the seed germination tests' results – root's length in various samples. Mean relative standard error showed that the accuracy of tests was satisfactory in most tests.

Seeds germination tests (see Table 1) showed that

Table 1

Compost quality (seed germination tests with cress salad) in November 2005

Sample's No.	Germination, %	Root's length (average)		Mean relative standard error
		mm	% of control*	%
1	100	61.3	94	5
2	100	56.6	86	4
3	100	54.9	84	6
4	90	53.0	81	10
5	100	58.3	89	4
6	100	67.8	104	5
7	93	50.0	76	5

**- control sample is a sample without a trace of compost*

samples 4 and 7 contained toxic compounds – not all seeds germinated, but all of them had the same conditions for the germination. It was also reflected on the root's length – samples 4 and 7 had the smallest root length from all samples.

Performed quantification of the total number of bacteria, *Staphylococcus aureus* and *Salmonella* sp. is shown in Table 2. Results of the compost microbiological analysis are compared and it shows that activity of bacteria is dropping – total number of bacteria decreased. Number of *Salmonella* sp. also decreased, but *Staphylococcus aureus* behaved variously – only in two samples it decreased, in others – increased.

Although the mean relative standard error for data in Table 2 is rather high this is explicable by the small quantity of experiments and diversity of composts.

Table 2

Survival of pathogenic agents in compost (2005)

Sample's No.		1		2		3		4
		Nov.	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.
Total number of bacteria	number of bacteria, cells g^{-1} dry compost	$9.47 \cdot 10^9$	$0.12 \cdot 10^9$	$7.27 \cdot 10^9$	$0.15 \cdot 10^9$	$9.22 \cdot 10^9$	$0.05 \cdot 10^9$	$10.7 \cdot 10^9$
Mean relative standard error	%	9	11	10	2	11	13	3
Salmonella sp.	number of bacteria, cells g^{-1} dry compost	0	0	16	6	0	0	33
Mean relative standard error	%	-	-	12	6	-	-	9
Staphylococcus aureus	number of bacteria, cells g^{-1} dry compost	0	8	198	103	0	6	22
Mean relative standard error	%	-	13	7	14	-	13	13

Table 2 – continuation

Sample's No.		4	5		6		7	
		Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.
Total number of bacteria	number of bacteria, cells g^{-1} dry compost	$0.07 \cdot 10^9$	$8.29 \cdot 10^9$	$0.08 \cdot 10^9$	$4.83 \cdot 10^9$	$0.16 \cdot 10^9$	$1.81 \cdot 10^9$	$0.09 \cdot 10^9$
Mean relative standard error	%	12	11	13	9	10	6	12
Salmonella sp.	number of bacteria, cells g^{-1} dry compost	0	0	0	28	0	52	0
Mean relative standard error	%	-	-	-	11	-	10	-
Staphylococcus aureus	number of bacteria, cells g^{-1} dry compost	15	0	6	28	49	26	87
Mean relative standard error	%	12	-	13	5	11	12	14

Another analysis of the compost samples was made in February 2006 (see Table 3). It showed that compared to the results in Table 2, the number of *Staphylococcus aureus* did not decrease but just opposite – increased and continued to progress. So *Staphylococcus aureus* underwent low temperatures and unlike *Salmonella* sp. it was not an obstacle for their capability to function.

Microbiological analyses described the quality of finished compost. Total number of bacteria and zero number of *Salmonella* sp. (see Table 3) satisfied the requirements of high quality compost, but existence of *Staphylococcus aureus* showed that the compost was not sanitary clean, so it cannot be used in gardens and fields – this compost may be used for the remediation of old dumpsites.

Conclusions

- The sample of sewage sludge compost and one of the samples of the compost obtained from organic waste contained toxic compounds.
- The number of *Salmonella* sp. under the influence of low outside temperature decreased till zero.
- The obtained compost is not of high quality and is applicable only for waste dump recultivation.
- Low temperature does not impede the functioning of the *Staphylococcus aureus*.

Table 3

Survival of pathogenic agents in compost (February 2006)

Variant	1/M	2/M
	Number of bacteria (cells g^{-1} dry compost)	
Total number of bacteria	$2.84 \cdot 10^9$	$2.82 \cdot 10^9$
Salmonella sp.	0	0
Staphylococcus aureus	$2.68 \cdot 10^2$	$1.62 \cdot 10^2$

References

1. Dubova L., Zarina Dz. (2004) Application of Toxkit microbiotests for toxicity assessment in soil and compost. Environmental Toxicology, 19, pp. 274-279.
2. Mezapuke K., Bendere R., Zarina Dz. and Dubova L. (2005) Biowaste recycling technologies in Latvia. In: Hogland W., Broby T. (eds), Waste to Energy, Bioremediation and Leachate Treatment. Kalmar ECO-TECH ´05, RVFs Utvecklingssatsning Deponering, Kalmar, Sweden, pp. 105-112.
3. Viesturs U., Zariņa Dz., Strikauska S., Dubova L. and Bērziņš A. (2004) Solid state fermentation systems for bioremediation and biodegradation. LLU Raksti, 12 (307), pp. 1-18.
4. Zariņa Dz., Dubova L., Bendere R., Bērziņš A. and Viesturs U. (2005a) Comparison of different types of solid state fermentation techniques for waste biodegradation by composting. In: Tzonkov S., Pencheva T. (eds), International Symposium Bioprocess Systems Proceedings. 18th International Symposium Bioprocess Systems '05, Sofia, Bulgaria, pp. 27-40.
5. Zariņa Dz., Mutere O., Strikauska S., Dubova L. and Berzins A. (2005b) Survival of pathogenic agents in compost with added inoculum. In: Cygas D., Aksamitauskas C. (eds), Selected papers, vol. I Environmental Projection. Water Management and Hydraulics, The 6th International Conference Environmental Engineering, Vilnius, Lithuania, pp. 510-515.

ASSESSING PUBLIC PERCEPTION OF URBAN LANDSCAPE WITH USE OF PHOTOGRAPIC METHOD

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Abstract

The study looks at a non - traditional way of perception and assessment of urban landscape, using the photographic method. Advantages and disadvantages of this method have been explained. As an example, a complicated urban area with different landscape types, including historical, aesthetical, functional and emotional aspects, has been studied. The territory in the existing functional zones was mapped. Typical or representative views of each functional zone were photographed. Out of 590 slides, 25 were chosen and presented on a wall in an auditorium. For each slide, six questions were asked, which represented a public perception of landscapes from the standpoint of Environmental Psychology. These were: the aesthetical value, harmony, order and sense of locality, variety of forms and diversity, secrecy, safety. The results show differences of perception between men and women, younger and older people, and locals and visitors. Most of the respondents were Latvian, and for that reason cultural and mentality aspect was one of the most important in the results of this study. Almost everybody chose slides with harmonized, safe and greener space, which are the main features of the historical Latvian country yard.
Key words: landscape perception, urban landscape, Environmental Psychology, photographic method.

Introduction

Numerous approaches have been used to study people's aesthetic reactions to landscapes. In all approaches the visualization of the landscape can be a good instrument. While people are usually good at understanding images, they tend to have difficulties in understanding information presented in other forms. While also other senses influence the perceiving and experiencing of landscape, the main part of landscape perception occurs through the sense of sight. Thus visualizations are the primary method in the description of landscapes (Karjalainen et al., 2001).

Many of the traditional landscapes in Europe and other parts of the world combine high natural values with high cultural values and may also be considered as aesthetically pleasing (Phillips, 1998). There is also movement towards an increased generation of these different values in research and policy. For planning and conservation the aesthetical perspective is important, since humans' wishes and consequent use of landscape is a major force in landscape change (Hägerhäll, 1999b). This study is looking for a different method of perception of landscape. This method is used to look at the landscape through a photo camera. Of course, there are advantages and also disadvantages. There are mainly two directions of the photographic method. Both start with taking photos. One of the directions is to compare two visual unedited slides or analyze one slide by elect criteria or questions (Gracia et al., 2002; Fairweather et al., 2002; Hägerhäll, 2000; Hägerhäll, 1999b). The other is to compare two slides, from which one is visually edited to add or remove some features from a slide (Rodiek et al., 2004; Tyrväinen et al., 2003; Karjalainen et al., 2001; Hägerhäll, 1999a). In Latvia this method has been used for the fist time.

There are some main aspects, which substantially affect the results of the study. At first, the process of taking photographs. The experience of the photographer and quality of slides are important. Secondly, the process of sampling slides.

Concerning the sampling of visual stimuli, it is agreed by all researchers that it is of utmost importance for the outcome of the study. The criteria, upon which to choose the stimuli are, however, in most studies based much on the intuition and experience of the researcher as well as criteria used in earlier studies. Furthermore, the purpose of the study plays a large role in the sampling of scenes. This sometimes leads to samples that are broad in content and include many different landscape types. It is also entirely up to researcher to judge whether or not the scenes are representative. The sample could also be considered as more narrow in content than many studies, since slides represented the variation within one landscape type (Hägerhäll, 2000).

The last aspect is the sampling of respondents. Choosing different categories of respondents, the results would be different. They can fall under several categories such as professional experience and field of research or interests, age, gender, place of residence: urban or rural area, locals or visitors.

In Latvia this method has been used for the fist time in current research. There was creating mobile landscape research laboratory. The aim of the current study was with help of this laboratory proposed to use photography for assessment of public perception of structure and texture of Latvia urban landscape. After according findings there has been formulate recommendations for future landscape development planning. The photographic method and use

possibilities of this method in analysing Latvian urban landscape are estimated in this article.

Materials and Methods

Object of the study

The capital of Latvia – Riga - with a wide-ranging landscape was chosen as a study object. It is a complicated urban landscape, having parts with high heritage value, as well as territories with soviet time's architecture, and territories developed nowadays. The main objective of the study was to find out differences in the emotional, aesthetical and cultural aspects and perception of them. To divide the territory of the study for taking photographs, the existing division based on functional zones of urban space was used (Buka et al., 1987).

Visual stimuli

The visual stimuli were chosen to cover different functional areas of the urban landscape. For detailed classification visual and scale aspects were taken. The photographed territories were mapped in the areas related to the history of civilization – the old town and heritage elements like churches and bridges; residential areas – landscapes of many-storied dwelling houses, garden and cottage houses; industrial and transit areas –railway, main roads and streets; water landscapes – the main river Daugava, smaller rivers and channels, lakes and ponds; green spaces – parks, small public gardens, protected natural areas, cemeteries, city forest (Tyrväinen et al., 2003) and natural grasslands; recreational territories – sport complexes and public places for swimming (Figure 1.).

The photographs were taken by the researcher, with the help of a digital camera, in autumn 2005, in different weather conditions – sunny, cloudy and rainy days, and full daylight. All the photographs were taken from places accessible to general public for a better and more complete analysis of the site and views.

Out of 590 photos, 25 slides (Figure 2) were chosen for the assessing of emotional perception of the respondents, each time showing one picture. The criteria for preference were quality aspects of the photographs: contrast, darkness, lightness, colors, absence of the sun light and smudgy defects; typicality or representation of functional area; and most affected perception of the respondents' specific elements or actions represented on slides.

The questionnaire and respondents

The presentation started with explanation of the task. The color slides one by one were shown on a wall in the auditorium. Each slide was examined for ten seconds. Questions were asked and graded. Three sessions were held.

Six questions for each slide were asked. The preference of questions was based on criteria of landscape perception in Environmental Psychology (Hägerhäll, 2000; Ziemeļniece, 1998). These aspects affect a person's senses in landscape most of all. These are: aesthetical value, harmony, order and sense of locality, a variety of forms and diversity, secrecy and safety. The question of aesthetical value was asked: "How much do you like this view? Is it visually attractive?" The criterion – harmony – means the level of unity and consensus of landscape features. The

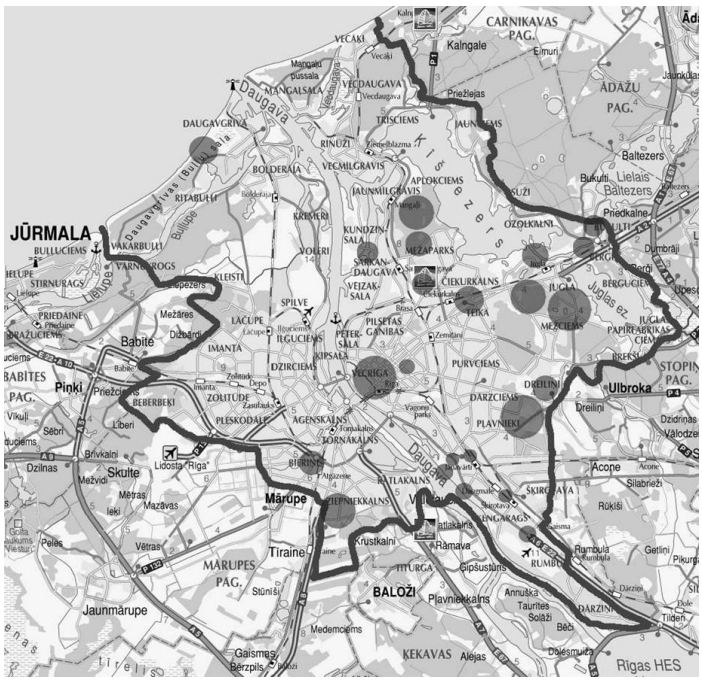

Figure 1. Location of photographed areas.

Figure 2.1. New area of dwelling houses.

Figure 2.2. New area of dwelling houses with playground.

Figure 2.3. Soviet time block houses.

Figure 2.4. Housing estate with pond.

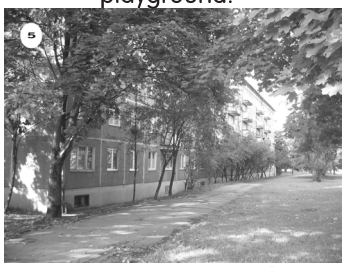

Figure 2.5. Soviet time five-storied block houses.

Figure 2.6. Soviet time block houses.

Figure 2.7. Soviet time block houses.

Figure 2.8. Soviet time block houses.

Figure 2.9. Soviet time block houses with new playground.

Figure 2.10. Soviet time architecture of block houses.

Figure 2.11. Cottage houses in urban forest (Mežaparks).

Figure 2.12. Cottage houses.

Figure 2.13. Contrast between historical and nowadays buildings.

Figure 2.14. Area related to the history old town.

Figure 2.15. Area related to the history with new fashion landscape features solution.

Figure 2.16. Old town with flower beds.

Figure 2.17. Area related to the history with new architectural features.

Figure 2.18. Water landscape. Costal territories.

Figure 2.19. Water landscape.

Figure 2.20. Water landscape with transformed banks.

Figure 2.21. Water landscape. Costal area.

Figure 2.22. Natural grasslands and urban forest.

Figure 2.23. Water landscape. City lake.

Figure 2.24. Industrial area near housing estate.

Figure 2.25. Typical view of the center of the city.

Figure 2. - continuation. Photos analysed in the study.

question of order and sense of locality was asked, if the landscape was easy to understand and oriented oneself, or the landscape was complicated. The variety of forms and diversity indicate views from biological, ecological, geographical, and aesthetical and visual aspects. The criterion of secrecy presents the level of mystery and intrigue in the chosen view of the landscape. The question, regarding safety, was asked, if you felt safe, and if it included some feeling of refuge in that landscape.

For every question, three variants of judgment – high, medium, and low were given.

The respondents were chosen from different fields of research and interests to give a diversity of response. Three major groups consisted of specialists from horticultural, environmental and landscape architectural fields of science. The smallest group was made of people from different other fields. In all, 18 respondents were chosen who represented a diversity of differences in many aspects – the professional field, gender, and age and research level. These aspects were taken into consideration in the process of data sorting and analyzing. All participants were older than 19 years. The main role was played by the place

of residence. The respondents were divided into two groups – residents of the city of Riga and nonresidents. It was important because the features, which seem to be customary and common for the residents of Riga, for most of the nonresidents were unusual and interesting.

After filling in the questionnaire all respondents were asked to offer their opinion about advantages and disadvantages of that method.

All results were collected, sorted and computerized by using simple statistic operations – setting up dominance between the chosen criteria. The simple statistic operations were chosen due to several considerations. Firstly, the aim of the study was to point out advantages and disadvantages of the method. Secondly, the small number of the respondents.

Results and Discussion

At first, data were sorted by criteria. Aesthetical evaluation is the main and important, and easiest indicator to understand, which gives attraction to a landscape. The slides with views of the old town (Figures 2.14., 2.15.) and a cottage near the city lake (Figure 2.23.) got the highest scores. The slides with visually degraded Soviet time block houses and yards near them (Figures 2.6. and 2.7.) got the lowest number of points. The next criteria were harmony and unity of landscape. They were mostly pointed out in the areas related to history – views of the old town (Figures 2.14. and 2.15.) The most disharmonized views were in the degraded yards of the Soviet time block houses (Figure 2.7.) and in the slide with a historical house beside a modern house (Figure 2.13.). The third criterion – order and sense of locality - was highly rated almost in all slides. A slide with the old town (Figure 2.15.) and a newly built multi-stored house (Figure 2.1.), with a clear and understandable landscape, got a higher score. The sense of disorder was perceived in the slides with bushes and neglected grasslands (Figures 2.3. and 2.4.). The criterion – diversity – makes an attractive and dynamic landscape, but this criterion should be looked at together with the aspect of harmony. Great, noncompositional diversity may cause chaos in the landscape. More diversity of a landscape was shown in Figure 2.15., less diversity – in Figure 2.1. The next criterion – secrecy – provides the sense of intrigue and mystery. The most secret views develop in a narrow, intercept landscape with great greenery (Figures 2.4. and 2.12.). Open landscapes with block houses (Figures 2.1., 2.6. and 2.7.) got the lowest score. The indicator of safety characterized the level of comfort in the landscape. The slides with the old town (Figures 2.15. and 2.17.) got more points. The slides with block houses (Figures 2.3. and 2.7.) and the old / new house (Figure 2.13.) got a negative evaluation. By summarized marks of all criteria there were two main leading groups – positive and negative. Slides with areas related to history (Figure 2.15.) got positive scores, and areas of Soviet time block houses (Figure 2.7.) negative.

Some recommendations for future prospects

For better results, it is necessary to formulate the subjects and objects clearly, as well as the aims of using the photographic method. For example, tourism route planning, developing panorama of the city, etc. The quality of photos affects the respondent's choice to a large extent. For this reason high quality technical equipment and a professional photographer is needed in the process of the study. An optimal number of slides for keeping attention of respondents and paying more attention to the explanation of the meaning of criteria are needed.

Conclusions

The advantages and disadvantages of the photographic method are explained.

The advantages are as follows: an easy way of analyzing the landscape and features in it. A good practice for planning a tourist route. Easy to estimate what changes are needed for the depicted view, because photos are taken from places accessible to people. Good conditions for respondents: they could fill in a questionnaire in an auditorium in silence. Weather and light conditions did not affect the process of survey. Without traveling, the respondents could see landscapes and interesting features, which they had never seen before.

The respondents pointed out the unusual way of analyzing the urban landscape, which was more different and interesting than the traditional methods of site analyzing, like functional, visual, etc., mapping.

The disadvantages are as follows: it was not possible to feel all the spectrum of landscape preferences, like sounds, smells, cold or warmth, streams of wind, etc. It was difficult to assess a view without feeling the whole context of the surrounding landscape. The questionnaire, using six specific criteria, was complicated and required great attention during all the presentation time. For that reason, most of the respondents lost their attention and patience at slide 25. The chosen criteria, in terms of Environmental Psychology, required certain preliminary knowledge of this study. Therefore respondents from research fields other than landscape architecture hardly oriented in and answered the given questions.

The subjectivism of the photographic method was pointed out, having positive and also negative aspects.

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References

1. Buka O., Volrāts U. (1987) Pilsētbūvniecība (Urban planning), R: Zvaigzne, 251 pp. (in Latvian).
2. Fairweather J.R., Swaffield S.R. (2002) Visitors' and Locals' Experience of Rotorua, New Zealand: An Interpretative Study Using Photographs of Landscapes and Q Method. International Journal of Tourism Research, 4, pp. 283-297.
3. Gracia Perez J.D. (2002) Ascertaining Landscape Perceptions and Preferences with Pair-wise Photographs: planning rural tourism in Extremadura, Spain. Landscape Research, 3, pp. 297-308.
4. Hägerhäll C.M. (2000) Clustering predictors of landscape preference in the traditional Swedish cultural landscape: prospect-refuge, mystery, age and management. Journal of Environmental Psychology, 20, pp. 83-90.
5. Hägerhäll C.M. (1999 a) Associations triggered by specific landscape characteristics. In: Usher M.B. (eds) Character: Perspectives on Management and Change. Post conference book. The Stationary Office Limited, Norwich, UK, pp. 83-87.
6. Hägerhäll C.M. (1999 b) The Experience of Pastoral Landscapes, Doctoral thesis, Acta Universitatis Agricultural Sueciae, subserie Agraria no 182, Swedish University f Agricultural Sciences, Sweden, ISSN 1401-6249, ISBN 91-576-5724-6.
7. Karjalainen E., Tyrväinen L. (2001) Visualization in forest landscape preference research: a Finnish perspective. Landscape and Urban Planning, 59, pp. 13-28.
8. Phillips A. (1998) The Nature of Cultural Landscapes – a nature conservation perspective. Landscape Research, 23, pp. 21-38.
9. Rodiek S.D., Fried J.T. (2004) Access to the outdoors: using photographic comparison to assess preferences of assisted living residents. Landscape and Urban Planning, 73, pp. 184-199.
10. Scott A. (2002) Assessing Public Perception of Landscape: the LANDMAP experience. Landscape Research, 3, pp. 271-295.
11. Tyrväinen L., Silvennoinen H., Kolehmainen O. (2003) Ecological and aesthetic values in urban forest management. Urban Forestry & Urban Greening, 1, pp. 135-149.
12. Ziemeļniece A. (1998) Estētiskā kvalitāte ainaviskajā telpā (Aesthetical quality in landscape space), Jelgava:LLU, 98 pp. (in Latvian).

ECONOMICS

DEVELOPMENT OF AGRICULTURAL INFORMATION SYSTEM IN LITHUANIA

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Abstract

Analysis of statistical reports provided by the Statistical Department of Lithuania shows that a rapidly increasing number of agricultural enterprises are using computers for the preparation of documents and processing of accounts, and the Internet for sourcing information and sending correspondence to business partners and other institutions. There is also a steady increase in the number of e-services, such as transference of payments, which are available via the Internet.

To identify the needs of agricultural specialists and rural citizens for e-services, a survey of available on-line services and potentially necessary e-services was carried out in August 2004. On the basis of these responses, the e-services of most importance to agricultural institutions and rural citizens now and in the near future were identified. These results also could be useful for other newly-joined EU countries of central and Eastern Europe.

Key words: rural development, rural citizens, demand of e-services, information technologies, Agricultural Information System.

Introduction

Lithuania, seeking to implement the e.Europa action plan of Lisbon strategy, has prepared the Lithuanian Information Society Development Strategy (Government …, 2005). The implementation of this strategy will allow up to 40 % of Lithuanian citizens to use the public electronic service (e-service) by 2010, and 70 % of e-service would be presented according to the 'one window' principle. The plans to transfer public services to an electronic environment are the main foundation of the modernisation of the public sector in Lithuania.

The actions stimulating actors in the rural economy and private citizens to use computers and the Internet can be split into three areas: support for Internet access, organisation of training courses, and the provision of e-service.

In 2002, the alliance of private enterprises 'Window to the future' initiated the development of public Internet access in rural areas. Later the Ministry of the Interior and Information Society Development Committee joined this movement. Upon the completion of a Phare project in 2003, 300 rural Internet access points had been installed in rural areas and, by the beginning of 2005, the total number of such points exceeded 450.

Government supports and the low price of computers allowed the information and communication technologies in households in rural area to develop rapidly as well. According to Statistics Lithuania reports, the number of personal computers in households has increased particularly rapidly in the last few years. In 1996, just one per cent of households had a personal computer, while 25 % of households had one by the first quarter of 2004. At this time the percentages of households in urban areas and rural area having a personal computer were, respectively, 32 % and 11 %. The Internet was used by 10.6 % of households: 7.2 % in urban areas and 3.4 % in rural area. According to household survey results in 2002, just 4.1 % of households used the Internet at home; whereas by the third quarter of 2003, 7.7 % of households did so. In the first quarter of 2004, the surveyed who bought or ordered goods and services for their personal needs amounted to 0.7 % or made up 2.1 % of the surveyed who were using the Internet (Department …, 2004).

This expansion of the information technology infrastructure has had a direct impact on the increase on demand for various e-services. The technical infrastructure will not stimulate the rural citizens to use the service by itself. It is necessary to spread the topical information for agriculture specialists and rural citizens and propose the service by electronic communication channels. Evidently, the service, provided by electronic communication channels and gained benefit from that, will move agriculture subjects and rural citizens, especially local communities, positively participate in the projects of development of information infrastructure and ICT courses.

The purpose of research was to identify e-services and information which could be presented in the portal for agriculture subjects and rural citizens.

Materials and Methods

The research was undertaken in two steps. Firstly, the portals for agricultural institutions and rural citizens, actual information collected by various institutions in Lithuania, and the most popular e-services in three EU countries (France, Italy and Netherlands) were analysed. Secondly, a survey of available on-line services and potentially necessary e-services in Lithuania was done.

To identify the needs of agricultural institutions and rural citizens for e-services, the questionnaire was prepared on the basis of research and review of the most popular e-services in France, Italy and Netherlands. The survey was carried out in August 2004. The questionnaire was delivered to specialists in agriculture in fifty-one local municipalities and to advisors in the central and all regional offices of the Lithuanian Agricultural Advisory Service. These two groups of respondents were chosen that they have access to the Internet, they constantly communicate and consult with agriculture enterprises, specialists and rural citizens, and they know the needs of e-services.

Recipients of this questionnaire were asked to evaluate the importance of the e-services included in the list and to provide suggestions for other e-services which they considered to be very important. Forty-four correctly fulfilled questionnaires were returned by specialists in local municipalities and forty-three by advisors of the Lithuanian Agricultural Advisory Service. The data were gathered from 11 municipalities and from 18 regional offices of the Lithuanian Agricultural Advisory Service.

Results and Discussion

Agricultural electronic public service in Lithuania

The best agriculture e-service is provided by the portal of the Agriculture Information and Rural Business Development Centre (ZUIKVC). ZUIKVC has been charged with the arrangement of the register for the implementation of Common Agricultural Policy (Raupeliene, 2003). The centre collects, stores, updates and provides data about cattle, farm holdings, agriculture and rural business, agriculture and food market and administrates the milk quota. Unfortunately, the portal can only support the service for cattle growers and present information about indexes of milk quality. Other information is not available via the portal.

The Ministry of Agriculture presents a lot of general information and the required forms for the agriculture and rural sectors on the portal www.zum.lt. Therefore, users can print the requisition forms only and send them to another institution.

The main weakness of such portals is that the services are not publicised and agricultural and rural actors cannot get the necessary information.

Presently, other institutions offer the following agricultural public service and information via the Internet:

- Lithuanian Agricultural and Food Products Market Regulation Agency – receives the requisition forms for buying of agriculture and food products - http://www.litfood.lt;
- Druskininkai, Ignalina, Svencionys and Utena regions municipalities – present information on how to register the rural holdings - http://www.druskininkai.lt, http://www.ignalina.lt, http://www.svencionys.lt, ttp://www.utena.lt;
- Druskininkai municipality – registration of tractors and self-propelled trucks and information on how to get a licence for earthworks;
- Utena municipality – presents information about the state funded work for reconstruction of melioration equipment.

These e-services are at a very low level and cannot meet the users' needs.

The portals for rural citizens in EU countries

Many EU countries have the possibility to use the Internet for the dissemination of information and e-services to specialists in agriculture and to rural citizens. The analysis of the gains of three countries – Italy, France and Netherlands - was done by consulting specialists in these countries.

The analysis showed that the most important portal for rural citizens is WEBAGRI.it in Italy. Its main purpose is to allow the agricultural enterprises and institutions attendant to agriculture, researchers and consultants to exchange information. In addition to specific information about agriculture there is presented information about the possibilities to implement new information-communication technologies into agriculture. There is also the possibility to organise discussions about topical issues. There are two levels of the portal usage: one for registered users and another for simple users.

Other important agricultural portals in Italy include the following:

- various institutions have created portals for rural citizens in Italy:
- federation of Italian Farmers - http://www.agricolturaweb.com;
- institutes of technologies - http://www.tuttoagri.com, http://www.agricolturaweb.com.;
- associations of Italian Animal Raisers and Food Producers - http://www.aia.it, http://assalzoo.it;
- leading agricultural newspapers and banks;
- various regional institutions.

The following institutions have created portals for agriculture in France:

- various technical institutes - http://www.inst-elevage.asso.fr, http://itcf.fr;
- growers of sugar beet - http://www.labetterave.com and organisations or growers of fruits and vegetables http://www.fruits-et-legumes.net;
- leading agricultural newspapers and banks.

The newsletters, which have been sent to recipients since 1997, are very popular in France. The frequency and concentrated attention to the specific questions determine the popularity of newsletters. Every day about 28 000 reg-

istered users receive the newsletters from March of 2003, and about 20 000 users receive ISAGRI weekly newsletters. In addition, associations of agricultural producers have been sending newsletters too.

In 2002 the Internet portal ZIEZO.biz started work in Netherlands. Its main role is to allow Dutch farmers and horticulturists to receive information and e-market service which will help to optimise their activities. The Institute of Animal Health, Agrifirm, Rabobank Group and Union of Netherlands farmers have developed the portal together. The portal is based on the Linux operating system and more than 50 000 users are paid up to use it.

On the basis of analysis of Italian, French and Dutch experience of developing information systems for agricultural specialists and rural citizens it can be stated that:

1. the analysis of portals showed that effectiveness of such portals is not enough. They presently oversupply information which is not connected with users' needs;

2. in France, ACTA Informatique prepares newsletters and sends them to registered users by email since 1997. The information, in such letters, is placed in the ACTA-Informatique.fr portal;

3. the main information on of mention before portals are:
- market of agriculture products,
- events and shows,
- news of information and communication technologies,
- information about technologies of agronomy, husbandry, eco-farming, and other topics,
- legal information;

4. the main service which is provided via the Internet for agricultural specialists and rural citizens:
- presentation of topical information in the portals,
- ordering the insemination of cattle,
- submission of tax declarations to administrative institutes,
- electronic banking services,
- electronic commerce services,
- consulting,
- disputes;

5. two ways for revenue from the spread of information – advertisements and payment for service - are not widely used. Very few firms subscribe to the advertisements on these portals and there is no universally accepted way for payment of e-service.

The opinion of specialists in these countries is that:

1) economic promotion of e-service development is found wanting, especially in Italy. Agriculture and food product producers are too small and weak to invest their own money;

2) users are reluctant to pay for service provided via the Internet;

3) a lot of time and finance are necessary for the management of portals, especially to prepare the newsletters.

The results of survey in Lithuania

Altogether 86 % of specialists from Lithuanian Agricultural Advisory Service and its regional offices noted that they were in urgent need of information and advice about support from structural funds, 81 % of respondents felt luck of consultations about rural development and the Common Agricultural Policy (Fig. 1).

72 % of respondents noted that urgent need e-service for preparing the necessary documents to get direct payments. Out of total 63 % of specialists stated that it is necessary to have e-service for ordering the maps and application form for direct payments. Just 28 % of respondents stated that they need on-line possibility to register the farm in the Farmer's farm register. This can be by the fact explained that at present there are discussions about the necessity for this register.

Some of respondents appointed additional services which could be provided by Internet, for example: taxes of consulting, agriculture and environmental law, the questions of accounting, etc. It was suggested to submit the projects of legal acts for public discussions.

The data from local municipalities has showed the same situation; however, 16 specialists from agriculture departments of local municipalities noted that they don't use Internet or use it very seldom.

Entirely 93 % of specialists thought they need information about the Common Agricultural Policy and data necessary to get direct payments, 86 % of respondents noted that would be good to get advice about rural development, 82 % lacked consultations about support from structural funds, 75 % of specialists noted they need e-service for documentation of direct payments and 71 % – for ordering the maps and application form for direct payments, and 68 % thought it is necessary to have e-service for registering the farm in the Farmer's farm register.

Results and Discussion

The survey showed that agriculture specialists, advisers, agriculture business and rural citizens fell a big need of public information and e-services providing by Internet. It is possible to predicate, according to the summarised survey results, that the follow e-services are topical and can be available on-line mode:
- registration of the farm in the farmer's farm register;
- registration of activity in the Register of Agriculture and Rural Business;
- ordering of passports for cattle;
- registration of newly born cattle and ordering of the signs of its identification;
- ordering of maps and application form for direct payments;

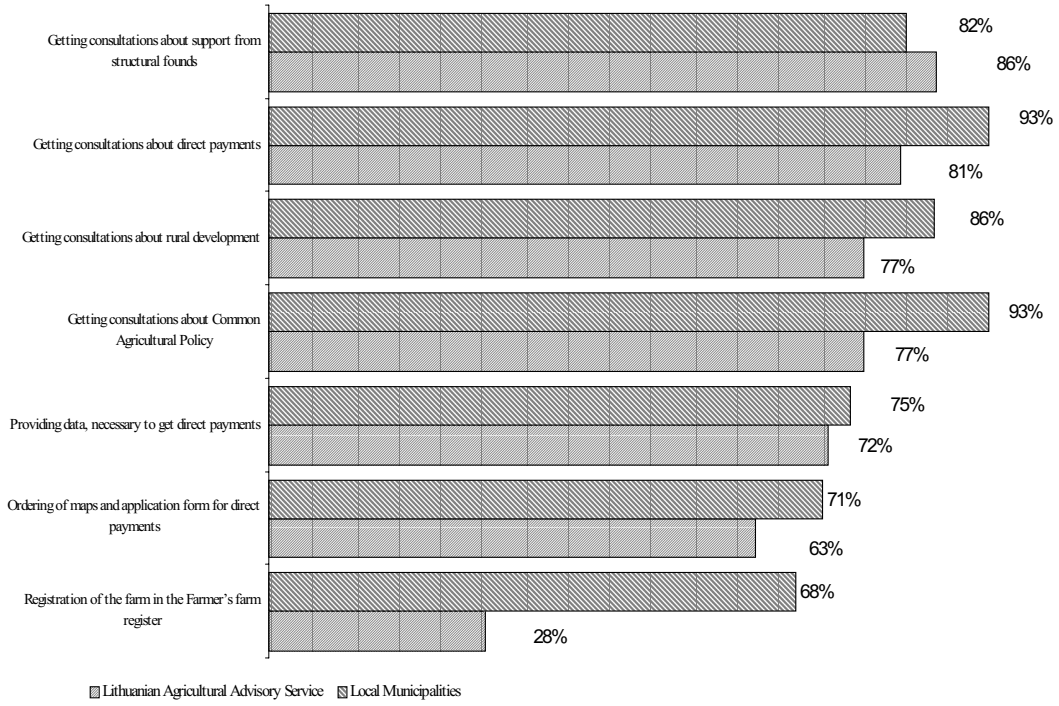

Figure 1. The respondents' opinion on the demand for e-services.

- providing data necessary to get direct payments;
- providing data about ecological products for sale;
- providing data about certificated seeds for sale;
- getting advice about the Common Agricultural Policy;
- getting advice about direct payments;
- getting advice about support from structural funds;
- getting advice about rural development;
- providing messages about newly presented information on websites.

The analysis of the portals in Lithuania showed that there is a lack of portals which could provide full e-service for agriculture enterprises, specialists, and rural citizens. Therefore it is necessary to create a new portal. The portal should join all separate subsystems of the Agricultural Information System and the main registers in Lithuania. The e-services should be presented according to the "one window" principle in the portal too. The e-services concentrating in one portal will ensure the saving of time, transport costs to the agriculture businesses and rural citizens, and agriculture subjects' business effectiveness.

The Ministry of Agriculture could be a promoter, and the Agriculture Information and Rural Business Development Centre could be the main creator and administrator of the new portal. Seeking to provide qualified information to agriculture specialists and rural citizens it is necessary to join the work of institutions of the Ministry of Agriculture, Lithuanian Agricultural Advisory Service, Lithuanian University of Agriculture, and other institutions.

These results could be very important for the development of separate subsystems of the Agricultural Information System in Lithuania, particularly for the planning of measures for the development of information society in rural areas. These results also could be useful for other newly-joined EU countries of Central and Eastern Europe.

References

1. Government of the Republic of Lithuania (2005) The strategy for development of information society in Lithuania. No 73, 2649 pp.
2. Department of Statistics (2004) Usage of information technologies in households 2004. Newsletter No. 3.
3. Raupeliene A., Ciutiene A., Stabingis L. (2003) Pasėlių deklaravimo ir kontrolės informacinės sistemos kokybės vertinimas (The Evaluation of Quality of Crop Declaration and Control Information System). International Scientific Conference 'Rural Development 2003 –Globalization and Integration Challenges to the Rural Areas of East and Central Europe': Proceedings book. – Kaunas – Akademija, pp. 242-244. (in Lithuanian).

DOCUMENTARY AND INSTITUTIONAL SYSTEM (FRAMEWORK) OF EUROPEAN UNION COHESION FUND

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Abstract

The research work of current paper is dedicated to the problems that appear in resource attraction processes of the Cohesion Fund (CF) in Latvia. Latvia has an access to branches of financing covered by CF – transport and environment. These branches require harmonized legislation. Successful administrating is assured by effective institutional system. The weaknesses of CF management system in Latvia are figured out so rendering ideas to the reader to be studied further.
Key words: cohesion, financial assistance, support, Management and Control system.

Introduction

The Cohesion Fund is one of the European Union's (EU) financial instruments for regional policy. Its purpose is to equalize the existing economical and social differences between the member states. Initially it was established as a certain compensation mechanism for EU member states with comparatively low finances. CF covers a large scale infrastructure developmental arrangement (projects) in environmental protection and transport areas. The Fund gives financial supply for projects to achieve the goals defined by EU for environmental and transport areas, to realize policies of EU and to realize the requirements defined in its directives.

Since the accession to the European Union, Latvia has an opportunity to attract the resources of Cohesion Fund. In the 2004–2006 financing period, the total of 711 million Euros of CF resources have been made available to Latvia. For successful attraction of the resources of CF, a suitable institutional system is necessary along with efficient legislation aligned to the requirements pertinent to management of CF resources.

The institutional Management and Control system for CF and its efficiency in Latvia has not been widely studied yet.

The lack of scientific basis was the main reason for choosing the topic. The present study is based on the concept that successful inflow of financial support from the EU depends primarily on all legislation that meets the standards of the EU and is subordinated to them.

These circumstances were the reason to establish the Objective for this research – to evaluate and analyse the Management and Control system and documentary basis of the CF.

As regards the objective of this research work, there are several tasks to carry out:

- to analyse the regulatory basis of the EU in the field of the Management and Control systems for the CF;
- to investigate and estimate the documentary and institutional framework of the Management and Control system;
- to identify the weaknesses of the Management and Control systems for CF.

Materials and Methods

To implement the investigation program and to achieve the objective, information was searched for and found in electronic data bases and printed publications.

As a source for this research a Cohesion Fund Reference Framework 2004–2006, as well as other national regulations pertinent to CF Management and Control systems were used. The Treaty of the EU and other pieces of Community legislation were used as well.

There are two main methods used – analytical method and comparative method – to assess the compliance and consistency of all Documents.

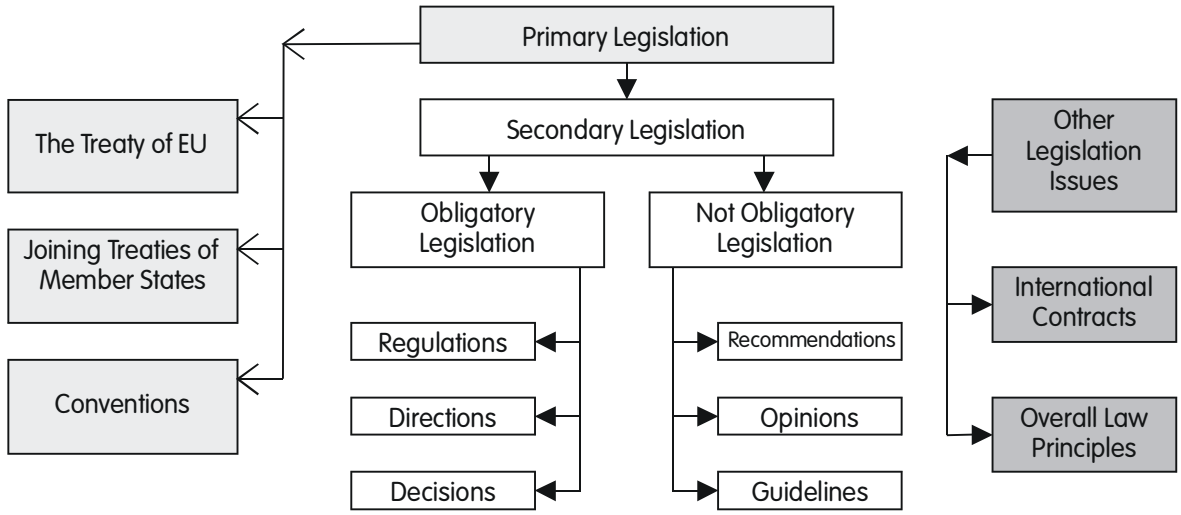
Results and Discussion

1. The EU legislative framework of the Cohesion Fund Management and Control System

The legal basis of EU for CF administration consists of three groups of legislative acts. The structure is shown in Figure 1.

The necessity to establish CF is defined in the Treaty of European Community, Article 158: "In order to promote its overall harmonious development, the Community shall develop and pursue its actions leading to the strengthening of its economic and social cohesion. In particular, the Community shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions or islands, including rural areas" (European Community, 1997).

The establishment of CF is also defined in the Treaty of Community, Article 161: "Without prejudice to Article 162, the Council, acting unanimously on a proposal from the Commission and after obtaining the assent of the European Parliament and consulting the Economic and Social Committee and the Committee of the Regions, shall define



Source: Author's construction

Figure 1. The legal basis of EC.

the tasks, priority objectives and the organization of the Structural Funds, which may involve grouping the Funds. The Council, acting by the same procedure, shall also define the general rules applicable to them and the provisions necessary to ensure their effectiveness and the coordination of the Funds with one another and with the other existing financial instruments. A Cohesion Fund set up by the Council in accordance with the same procedure shall provide a financial contribution to projects in the fields of environment and Trans European networks in the area of transport infrastructure." (European Community, 1997).

On the basis of the Treaty Regulation 1164/94 regarding establishment of CF on 16 May 1994 in Brussels was approved (European Commission, 1999a). This establishment was motivated by necessity of further activities in work of the EU Structural Funds and other financial instruments to facilitate the economic and social cohesion (European Commission, 1999a). It provides financial support to projects that facilitate the achieving of aims defined in the Treaty of Community in the environmental domain and infrastructural development, i.e. Trans–European transport network (European Commission, 1999a).

The Regulation determines that financing from CF depends on the following two conditions:

- the gross national product (GNP) per capita must not exceed 90% of the average European GNP per capita;
- the participating country should have an already developed program to implement the conditions of economical convergence, as stated in the Treaty of Community, Article 104.c (European Commission, 1999a).

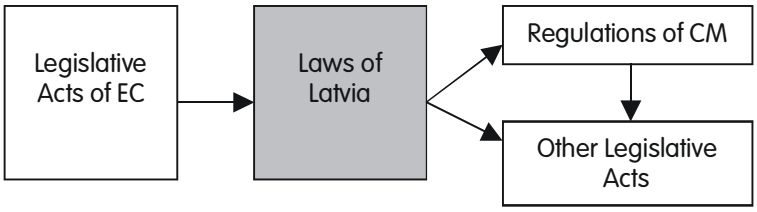
Situation in Latvia to fulfil the conditions.

The Regulation also determines the aim of CF – to strengthen the economical and social cohesion. It also identifies objects to be financed – they are separate projects, the technically and financially independent links of a particular project or groups of projects that have a clear common strategy and represent an integral part of a single initiative (European Commission, 1999a).

The support measures for environmental and transport infrastructure projects defined in the Regulation are in compliance with the objectives of the Treaty of Community (European Community, 1997). The distribution of finances provided is defined in accordance to the number of residents in participating country, GNP per capita and area of the country. If in the implementation of a particular project the CF resources are used, the project is not allowed to use resources from other EU funds. In the Article 12 of the Regulation, the general activities of attraction, management and control systems of CF are defined (European Commission, 1999b).

This Article is used as basis for Regulation 1386/2002 (European Commission, 2002). The rules elaborated in the Regulation provide responsibilities of member countries to develop the management and control systems of CF administration. The Regulation points to the developmental directions of Management and Control systems, at the same time allowing the member country to choose participating institutions (European Commission, 2002). The main task of current Regulation is to ensure compliance of measures with legislation of Community mentioned in Regulation 1164/99, Article 3 (European Commission, 1999a).

Based on Regulation 1164/99, Article 14, and especially on item 3 of this Article "As soon as this Regulation enters into force, the Commission shall adopt detailed rules on information and publicity, shall inform the European



Source: Author's Construction

Figure 2. Hierarchy of Legislation.

Parliament thereof and shall publish them in the Official Journal of the European Communities" (European Commission, 1999a), another Regulation 621/2004 was issued in the year 2004. This Regulation is intended for improving public awareness of projects being financed from CF resources and the role of Community in these processes (European Commission, 2004). The Regulation determines the measures of information and publicity, which should be made in conjunction with use of CF resources, as well as the form of measures being realised and liability distribution of participating institutions (European Commission, 2004).

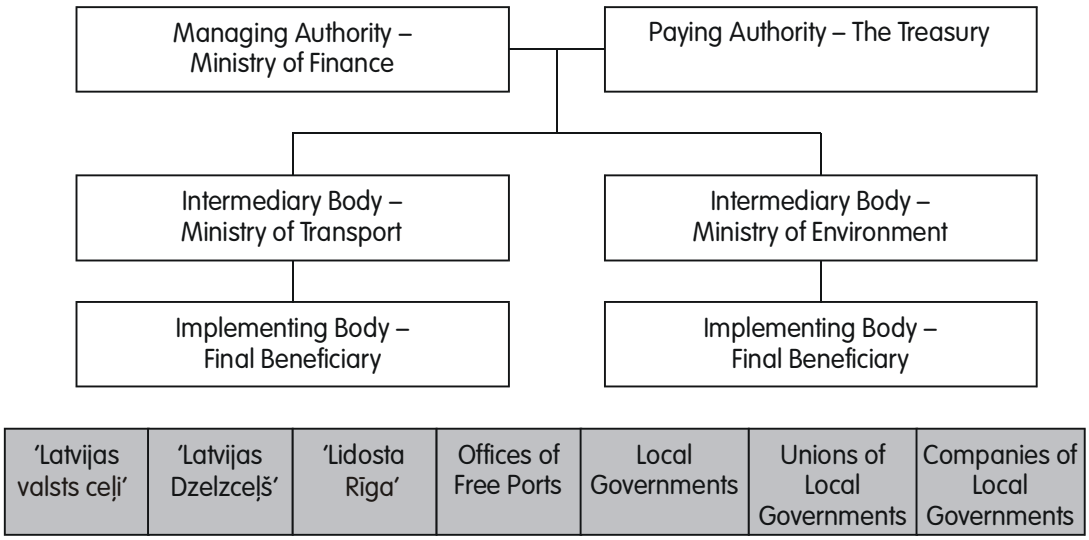
2. The Legal Basis of the CF Management and Control Systems in the Republic of Latvia

The regulatory basis of the Republic of Latvia complies with the EC legislation, as shown in Figure 2.

With the regulations of the Cabinet of Ministers of Latvia (CML) No.120 about the Reference Framework for assistance from the Cohesion Fund established in year 2006, February 14, the Cohesion Fund Reference Framework 2004–2006 was approved (Ministru Kabinets, 2006). This Cohesion Fund Reference Framework determines that the Republic of Latvia will use the resources of CF in financing of projects of environmental and transport–related sectors. The CF Framework document comprises three sections (Ministru Kabinets, 2006).

In the first section of the CF Reference Framework an institutional framework of the management of CF is also described (Ministru Kabinets, 2006). Managing authority is responsible for administrative managing of CF resources, for the working coordination of participating bodies and for collaboration with EC. Managing authority submits the conformed announcements of projects to EC.

As shown in Figure 3 outline of Institutional System of CF in Republic of Latvia, the function of the Managing Authority is performed by the Ministry of Finance. The head of this Managing Authority is the Deputy State Secretary,



Source: Author's construction being guided by EU regulations and legislation of Latvia

Figure 3. Outline of Institutional System of CF in Republic of Latvia.

Ministry of Finance. The responsibility of the Project Appraisal Department, Ministry of Finance, is to fulfil the function of managing the CF.

The Treasury performs payment functions. The Paying Authority is responsible for CF financial management and for certifying the expenses. Functions of Intermediate Bodies are performed by the Ministry of Environment in projects of environmental infrastructure and technical support and by the Ministry of Transport in projects related to transport infrastructure and technical support. The Intermediary Body in accordance with deputation of Managing Authority is responsible for administrative, technical and financial managements. Intermediary Body is also responsible for projects to be arranged in accordance with legislative acts of EU. The Intermediary Body submits a project announcement to Managing Authority which assesses it for accordance to procedures in budgetary and financial areas defined in LR legislative acts.

In specific cases the Ministry of Finance or the Treasury have the status of a Final Beneficiary, Managing Authority and Paying Authority performs the functions of Intermediate Bodies in technical assistance projects. So the execution and control functions are adequately and duly separated.

The Implementing Body is either state administration authority, local government or a legal person, registered in LR, which ensures the implementation of the project.

If Implementing Body is not a Final Beneficiary, it can delegate particular functions to the Final Beneficiary by concluding a contract for project implementation. This means that Implementing Body ensures the control over functions performed by Final Beneficiary maintaining full responsibility for the functions being delegated.

Reference Framework determines the administration and management of CF implementation. Intermediate Bodies are responsible for preparation of projects according to legislation of EU, submitting the notification of a particular project to the Managing Authority which further appraises it. This appraisal is made in compliance with procedures set in budgetary and financial legislation. The duty of the Managing Authority is to submit approved project applications to the European Commission (Ministru Kabinets, 2006).

The second section of the Reference Framework determines the strategic aim of environmental sector – based on the approach to environmental politics, current situation and conditions of the CF – to define priorities of Latvia in environmental sector for involvement of the CF resources in the 2004-2006 period. In strategy there are analysed pivot documents in environmental politics, current situation, defined priorities and feasible tasks for involvement of legislative acts (Ministru Kabinets, 2006).

The third section of CF Reference Framework relates to transport area. In this Reference the strategy of Latvia is outlined for identification and selection of transport infrastructure developmental projects (Ministru Kabinets, 2006).

On January 1, 2006 the EU legislative act regulating Project management of the CF was enforced (Saeima, 2005). The aim of this law is the elaboration of efficient and transparent CF project management in Latvia in compliance with Community legislative acts. The preparation of environmental and transport projects financed by CF as well as their implementation and monitoring are the spheres of activity for this law. The law is applicable to projects that will be approved by EC till December 31, 2006. The law regulates the institutions participating in project management and determines their functions in project realising.

On April 13, 2004 a new regulation was adopted the Cabinet of Ministers regulation No.298 – laying down rules on Procedure for preparation, approval, implementation and monitoring of the projects financed from the European Union Cohesion Fund in Latvia (Ministru Kabinets, 2004). The Regulation determines the order for usage of CF resources, which is performed in accordance with Reference Framework and requirements in legislation of Community and Latvia (Ministru Kabinets, 2004). The aforementioned Regulation transposes Regulation 1386/2002 part II (European Commission, 2002).

On September 13, 2005 the Cabinet of Ministers Regulation No.694 was adopted (Ministru Kabinets, 2005a). It determines the on-the-spot check procedure in sites of environmental and transport projects. This regulation was elaborated on the ground of Regulation 1164/99, Article 12, amendmended by Regulation 1264/99 (3) and requirements defined in Regulation 1386/2002, Article 4 (European Commission, 2002).

On March 8, 2005 there was an Instruction No.2 (Ministru Kabinets, 2005b) of the Cabinet of Ministers of Latvia elaborated on the ground of Regulation 1386/2002, part II and Article 9 (European Commission, 2002). It is an instruction for the monitoring of the CF Management and Control system. It establishes the order for managing authority of CF as follows (Ministru Kabinets, 2005b):

- the revision of Latvia's legislative acts and each institution's internal documents, which regulates the activities of CF;
- monitoring of CF Management and Control system (Ministru Kabinets, 2005b).

On July 28, 2004 the Managing authority developed a description of the Management and Control system in Latvia (Finanšu ministrija, 2004) in compliance with Article 5 of Regulation 1386/2002. This description lays out the CF Managing and Control system in Latvia, responsibilities, liabilities and rights of participating institutions (Finanšu ministrija, 2004).

3. The Usage of CF in Latvia

The CF is one of the biggest investment funds. It takes about 80 – 85% of expenses for public projects. National co–financing contributes to 15 – 20% of the total amount. However, in projects with higher potential of income there is a possibility to increase this ratio. This ratio can be reduced taking into account the incomes made by project itself, for example, payments for water supply and usage of principle 'pollutant pays' (Ministru Kabinets, 2006).

After the establishment of CF in the year 1994, resources were assigned to four EU member states – Ireland, Greece, Spain and Portuguese. Latvia in the year 2000 started to attract the resources of Instrument for Structural Policies for pre–Accession (ISPA). Since the year 2004, resources of CF became available to Latvia.

Projects, being introduced before accession of Latvia to EU, will be financed from CF resources. This means that in addition to currently assigned CF resources (in current programming period), it will be necessary to attract remaining delayed resources. For new projects the CF resources of financing period 2004–2006 are attracted. In the project approval process EC defines the deadline for implementation of project. Usually financing is granted in division into years, however in special cases after approval EU can grant all resources needed (Ministru Kabinets, 2006).

All the authorities involved in CF implementation are responsible for finance management and control according to their competences.

Payments of CF are performed in three following sections:

- liabilities of EC, grounded on the resolutions for approval of project announcements;
- payments of EC in accordance with certified declarations of expenses;
- payments to Final Beneficiaries.

Accordingly to its budgetary liabilities, EC performs payments to the authority which further is responsible for submitting of payment demands to EC.

Payment Authority is responsible for the financial and co–financial flow from CF. It is also responsible for payments to Final Beneficiaries.

The Financing of CF, Accessible from Latvia for Environmental Sector is shown in Table 1.

The Financing of CF, Accessible from Latvia for Transport Sector is shown in Table 2.

The implementation of CF projects is very resource - and time - consuming. After a comparatively fast approval of project application of ISPA in 2000–2002, it turned out that the implementation process was very complex. The implementation of ISPA projects was successful only

Table 1

The Financing of CF, Accessible from Latvia for Environmental Sector

Financing Period	Total financing from CF, EUR	Financing to the approved ISPA projects, EUR	Financing to the CF projects, EUR
2004	94 982 887	20 802 070	74 180 817
2005	78 833 832	11 598 922	67 234 910
2006	84 116 612	6 463 834	77 652 778
2004 – 2006	257 933 331	38 864 826	219 068 505

Source: data from Ministry of Finance of Latvia, 2006

Table 2

The Financing of CF, Accessible from Latvia for Transport Sector

Financing Period	Total financing from CF, EUR	Financing to the approved ISPA projects, EUR	Financing to the CF projects, EUR
2004	94 982 887	18 364 421	76 618 466
2005	78 833 832	27 578 900	51 254 932
2006	84 116 612	30 503 732	53 612 880
2004 – 2006	257 933 331	76 447 053	181 486 278

Source: data from Ministry of Finance of Latvia, 2006

partially. For several projects the head contracts were signed only in 2003. In the same year the realization of projects was started. Main progress determinants are the following: efficiency of system management, capacity of institutions, properly working personnel, well-organised procedures, cooperation with contractors in municipalities, administrative issues and limited capacity of advisory services market (Ministru Kabinets, 2006).

4. Weaknesses of the CF Management System in Latvia

To find out the weakest links in management system, investigations of these processes were performed. This made a ground for several assessments.

One of the disadvantages not being eliminated by the Managing Authority as a responsible body for the development of legislative basis is insufficient national legislation in information and publicity issues as it is stated in Regulation 621/2004 (European Commission, 2004), adopted on April 1, 2004. The lack of such a framework makes possible the recipient to interpret the EU requirements as they please. This raises doubts on possible sanctions from EC.

The Managing Authority has failed to supervise adequately the elaboration of internal legislative acts produced by Intermediary Bodies regarding the management and control systems. Intermediary Bodies do not have any guidelines for establishment of that system. It results in situation that there are different Managing and Control systems established for Intermediary Bodies and they are obstructing the objective appraisal of these systems. The slow implementation speed shows that experience of other countries in attraction of CF resources is not considered. In this case it would be possible to avoid the 'beginner's mistakes'. In the same way it points to the particular problems of systems efficiency. Large number of delayed projects will raise doubts of EC in ability of CF allocated resource attraction.

Delaying factors in attraction of CF resources are the limited competition and the insufficient capacity of the market (tenders). Managing Authority has not made any investigations of the conditions of tender market. This has caused circumstances that in purchase tenders of CF are only one participant boosts prices considerably. Often in purchase tenders the national criteria are used that are discriminative and does not encourages the competition.

When concluding contracts with contractors, both Intermediate Bodies and contractors do not provide for price increases. There is no tool to obligate contractors to finish the tasks being delegated. So the increase of project expenses should be covered by EC or Government of Latvia or municipality.

Permitted faults in resource attraction of current programming period are not systematically appraised. Also no appraisal of resource attraction process has been done – how the committed finances promote the equalization of social differences; no fault–search process in resource attraction system has been performed yet.

The monitoring of projects is provided five years after they are completed, but there are no rules made for the procedures of project quality checks.

Conclusions

The Management and Control system of CF is appropriate to comply to the main requirements of the EC. The documents are subordinated in compliance with hierarchy of normative documents of EC – mainly the Treaty and, as a second, Regulation 1164/99, as well as Regulation 1386/2002.

The Cohesion Fund Reference Framework 2004–2006 is elaborated in compliance with the purpose of the Treaty. The institutional system described in the Reference Framework works in accordance to the Regulation 1164/99. The Management and Control system is elaborated in conformity with Regulation 1386/2002.

Improvements in publicity arrangements should be made in the regulatory documents. The publicity procedures should comply to the Regulation 621/2004.

Favourable conditions for incoming international enterprises in supply market of Latvia should be ensured, thus increasing competition and reducing the term of project establishment. The Intermediate Bodies should introduce the guidelines of the purchase management. Market research should be conducted and the tendencies of development should be considered in the evaluation of tenders.

Supplements about the technical quality of project's accomplishment should be added to the Management and Control system. As well as shortages in realisation of inspections should be eliminated.

Investigation should be performed over the influence of committed finances to the equalization of social differences.

References

1. European Community (1997) Consolidate version of the Treaty establishing the European Community,Available at: http://europa.eu.int/eur-lex/lex/lv/treaties/dat/12002E/htm/C_2002325EN.003301.html, 15.03.2006.
2. European Commission (1999a) Council Regulation (EC) No 1164/94 of 16 May 1994 establishing a Cohesion Fund. Available at: http://europa.eu.int/eur-lex/lex/Result.do?idReq=3&page=1&refinecode=, 15.03.2006.
3. European Commision (1999b) Council Regulation No 1264/1999 of 21 June 1999 amending Regulation No 1164/94 establishing a Cohesion Fund. Available: http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:31999R1264:EN:HTML, 15.03.2006.
4. European Commission (2002) Commission Regulation No 1386/2002 of 29 July 2002 laying down detailed rules for the implementation

of Council Regulation No 1164/94 as regards the management and control systems for assistance granted from the Cohesion Fund and the procedure for making financial corrections. Available at: http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:32002R1386:LV:HTML, 15.03.2006.

5. European Commission (2004) Commission Regulation (EC) No 621/2004 of 1 April 2004 laying down rules for implementing Council Regulation (EC) No 1164/94 as regards information and publicity measures concerning the activities of the Cohesion Fund Available at: http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:32004R0621:EN:HTML, 15.03.2006.
6. Finanšu Ministrija (2004), Vadības un kontroles sistēmas Latvijā apraksts (Description of Management and Control system in Latvia), nepublicētie materiāli (in Latvian).
7. Ministru Kabinets (2006) Noteikumi par Kohēzijas fonda ietvara dokumentu Nr.120 (About the Reference Framework for assistance from the Cohesion Fund established), Latvijas Vēstnesis Nr.30, 21.02.2006. (in Latvian).
8. Ministru Kabinets (2004) Noteikumi par kārtību, kādā sagatavo, apstiprina, īsteno un uzrauga no Eiropas Savienības Kohēzijas fonda līdzekļiem finansētos projektus Nr.298 (Laying down rules on Procedure for preparation, approval, implementation and monitoring of the projects financed from the European Union Cohesion Fund in Latvia), Latvijas Vēstnesis Nr.66, 28.04.2004. (in Latvian).
9. Ministru Kabinets (2005a) Noteikumi Nr.694 Kārtība, kādā veicamas pārbaudes no Kohēzijas fonda līdzekļiem finansēto projektu īstenošanas vietā (The order of inspection procedures in locations where the environmental and traffic projects have been realised), Latvijas Vēstnesis Nr.147, 15.09.2005. (in Latvian).
10. Ministru Kabinets (2005b) Kohēzijas fonda vadības un kontroles sistēmas uzraudzības instrukcija Nr.2, (An instruction for the monitoring of the CF Management and Control system), Latvijas Vēstnesis Nr.43, 15.03.2005. (in Latvian).
11. Saeima (2005), Eiropas Savienības Kohēzijas fonda projektu vadības likums (EU Cohesion fund Projects Management law), Latvijas Vēstnesis Nr.205, 22.12.2005. (in Latvian).

FINNISH EXPERIENCE OF ECONOMIC CLUSTERING AND POSSIBILITIES OF ITS USE IN LATVIA

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Abstract

This article analyzes the experience of economic clustering of Finnish industry. This experience is described in the report of the fundamental investigation which was carried out by the Research Institute of the Finnish Economy (ETLA) - Advantage Finland – The Future of the Finnish Industries. The study deals with the competitiveness and future growth prospects of the Finnish industry on the basis of Michael E. Porter's theory of the competitive advantage of nations. The comparative advantage of Finnish industries has been moving from capital- and resource- intensive branches to those driven by know-how and technology. The author recommends to study this experience and to use it in Latvia. The finding of the real and potential business-groups in the economy of Latvia may be realized with the algorithm of clustering described by the professor of Colombian University (USA) David Stark on the base of Lursoft data of the Latvian enterprises.

Key words: competitive advantages, industrial cluster, regional economics.

Introduction

According to the results of the investigations carried out during World Economic Forum, 2003 (102 countries were studied), Finland once again won the first place in a rating of perspective competitiveness of the states (Growth Competitiveness Index) and the first place in a rating of current competitiveness of the states (Business Competitiveness Index), having bypassed such industrially developed countries as the USA, Japan and the Great Britain. The cluster approach to the analysis of the structure of economy became especially popular in Finland after it had been used during elaboration of the state industrial policy in 1991-1993. Development of clusters has been discussed earlier after M. Porter's work 'Competitive advantages of the nations' was published in 1990 for the first time. On the basis of the theory of Porter the fundamental research in Finland has been initiated, the final report on which was published in 1995 under the title 'Advantage Finland - The Future of Finnish Industries' (research was carried out by the Research Institute of the Finnish Economy (ETLA)). In this research the cluster structure of economy of Finland was analysed, tendencies of the development were described, and prospects of competitiveness were evaluated. Preliminary versions of this research, which were published earlier in the Finnish language, were included in the syllabus of universities of economics, courses of improvement of professional qualification of managers and state officials, thus, having made the cluster approach for officials and managers of all levels the main analytical tool of interpretation of micro – and mezzo – economic processes. Many evaluations and prospects, which were made during this research, became prophetical, and today the Finnish industrial policy (on the basis of which alongside with creation of national innovative system the understanding of the essence of clusters of competitive producers is present) has reached brilliant results, and, in opinion of the author of this article, the Finnish experience should be thoroughly studied and used for the realization of industrial policy in Latvia.

Materials and Methods

The information compiled by the Central Statistical Bureau of Latvia, information of the Commercial Register of the Republic of Latvia, materials of the fundamental research Advantage Finland – The Future of Finnish industries, which was carried out by the ETLA (Research Institute of the Finnish Economy), scientific publications related to this research.

The following scientific research methods have been applied – monographic method, analysis, synthesis, intercorrelation's graph (product of Lursoft) on the base of property relations, statistical research method.

Results and Discussion

Way of identification of an industrial cluster -view of Finnish scientists

The concept of a cluster can help us to understand the evolution and current structure of an industry without establishing artificial sectoral boundaries. Sharp distinctions between branches are not made; the focus is made on uncovering mutual connections and interaction among firms and industries. Clusters are defined on the basis of these product and information flows between firms and industries. Thus industrial agglomeration of producers, customers, and competitors promotes throughout efficiency and increases specialization. Geographical proximity is typical of clusters – although it is not absolutely necessary. The agglomeration of many participants creates positive externalities: specialized factors of production are more readily available, new innovations are easier to come due to active interaction, and technological spillovers are virtually unavoidable. The main idea is that a cluster is considered to be better equipped to succeed in the market place than an individual company (Hernesniemi, 1996).

Under a cluster a network of independent industrial and/or service firms (including their suppliers) is understood, as well as founders of technologies and know-how (universities, scientific research institutes, engineering companies), which join market institutes (brokers, advisers) and consumers, who cooperate with each other within the limits of a uniform chain of making a price.

Usually the theoretical background of investigations of industrial clusters is Porter's diamond model which incorporates forces influencing the firm's ability to sustain and upgrade its competitive advantage. The four main determinants of the diamond are:

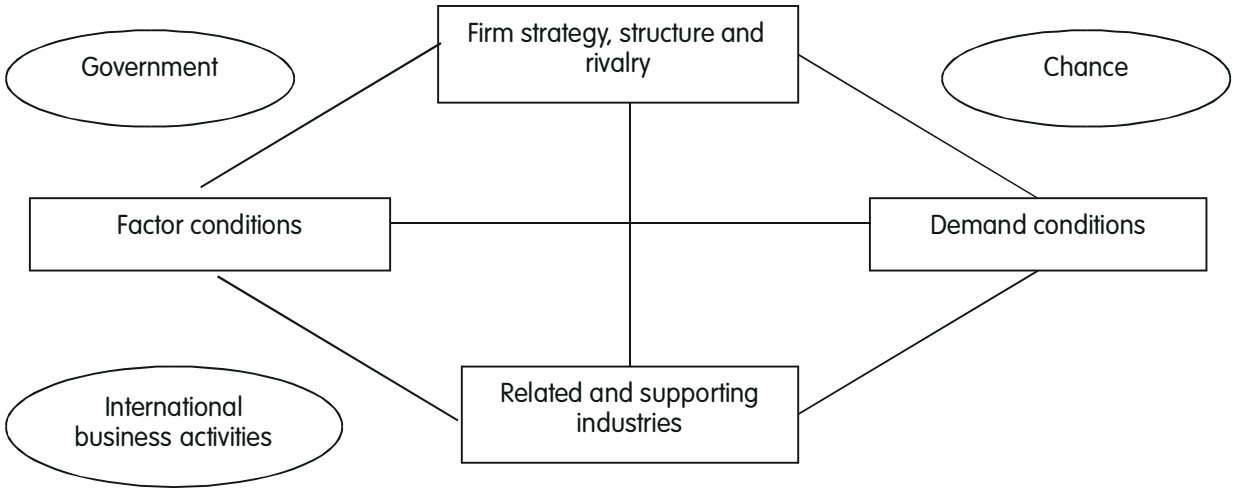
1) factor conditions;
2) demand conditions;
3) related and supporting industries, and
4) firm strategy, structure and rivalry. Besides these there are three outside forces shaping the operating environment namely;
5) government;
6) chance;
7) international business activities (added by Finnish scientists).

The starting point of a cluster analysis is the identification of network relations. Among these are relationships with competing producers, R&D cooperation, and user-producer relations. After identifying these key relationships an agglomeration can be found, where interaction is particularly intense. This concentration is taken as a starting point for a cluster analysis. When potential clusters are identified, they are studied with the help of Porter's diamond model (Figure 1). If clear internal synergies are found within this concentration, it is indeed justified to refer to the group as a cluster.

Clusters, which exist in economy, can be identified according to Porter's methodology. The source of information is the state official statistics. The identification of clusters takes place in 4 stages:

1. It is necessary to define a branch, which is successful in the world, taking into consideration the share of its export. The share of the branch in the total amount of state export is chosen as an empirical criterion.
2. When the successful product is defined, it is necessary to find enterprises, which produce it. The enterprises are grouped according to their functional relationships.[1] These relationships form the skeleton of the clusters. Actually, clusters are formed on the basis of a definite key product.
3. Experts evaluate and decide whether the clusters have been combined in a compact way, and if it is necessary some corrections are made.
4. After all these actions the research of clusters begins.

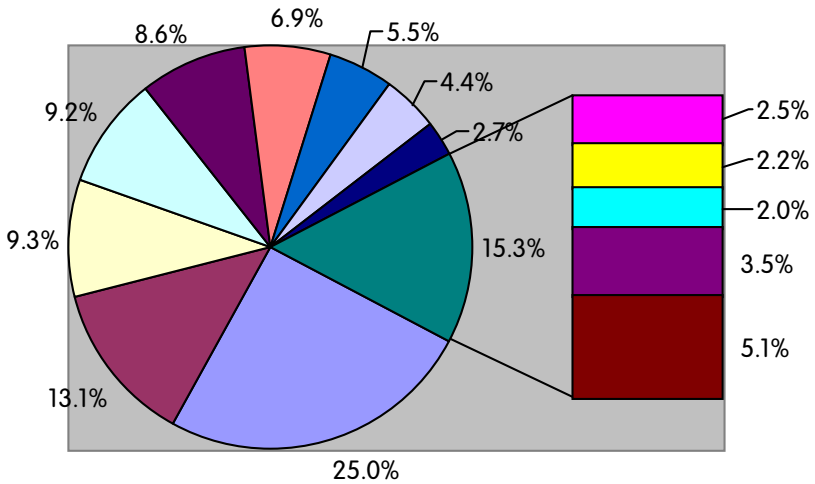
David Stark, professor of Columbia University (USA), uses an algorithm in order to identify the business groups, which are formed according to relationships among companies. The essence of this algorithm is the following: taking into consideration two variables (shareholders of the



Source: The original diamond model is in Porter1990a, International business activities (IBA) added by Finnish scientists due to discussion inspired by John Dunning (Dunning, 1993).

Figure 1. The diamond model of sources of local competitive advantages.

[1] Finnish researchers do not mention how to identify these functional relationships among enterprises, which form the basis of the existing clusters in economy. D. Stark suggests a good solution to this problem.



- wood and wood products
- base metals and base metal products
- machinery; mechanical and electrical equipment
- mineral products
- textiles and textile products
- foodstuff
- chemicals and chemical products
- other products
- plants and vegetable products
- animals and animal products
- pulp of wood; paper and paperboard
- articles of stone, plaster, cement, glass; ceramic products
- mathematical addition
- difference between "total" and included classes of products

Figure 2. The most significant groups of export products in Latvia[2] in 2005, (in %, significance is evaluated by thousands of lats).

company and shares of other enterprises that belong to this company) and using KrackPlot programme, business groups, i.e. clusters, which currently exist in economy and form its core, are shown in a graphical mode (Stark, 2002).

As to identification of clusters existing in Latvian economy, it is possible due to the unique product – graph of relationships, created by Lursoft. The graph shows property relationships of enterprises.

Thus, experience of Finnish researchers and the algorithm of D. Stark, which compensates flaws of Finnish system, allow to find and identify existing clusters in the economy of Latvia.

The identification of economic clusters in Latvia:

1. step. Searching for successful export product

As it is seen on the diagram, wood industry has been the export leader of Latvia for recent 3 years, although a decreasing tendency can be noticed.

2.step. Searching for the most successful enterprise, which produces the export product.

The biggest producer of wood products in Latvia is 'Latvijas finieris'.

[2] The figure was formed by the author with the help of data of Central Statistical Bureau of Latvia (www.csb.lv (http://test.csb.gov.lv:8080/Dialog/Saveshow.asp)).

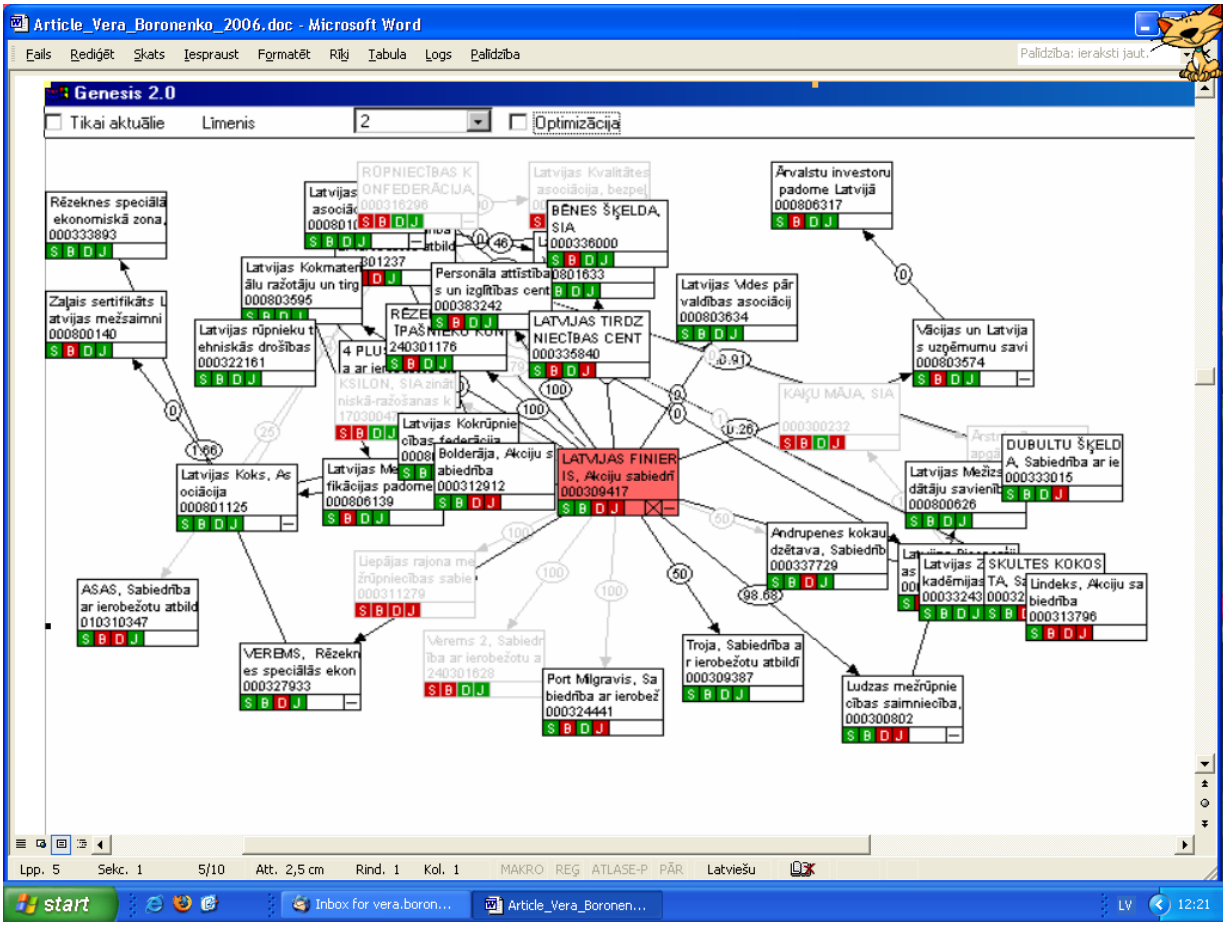


Figure 3. Graph that shows property relationships of the enterprise 'Latvijas finieris', which form the wood cluster in economy of Latvia[3] .

3.step. Searching for functional economic relationships of participants of the cluster with the help of Lursoft graph.

4.step. Identification of the cluster structure.

As a result of the previous step, the structure of the wood cluster in the economy of Latvia has been identified. The key product of the existing and well functioning cluster is wood. In order to continue the analysis, it is necessary to tabulate all the participants of the cluster.

Out of 24 basic participants of the wood cluster in Latvia, which has been identified on the basis of functional relationships of its leader – 'Latvijas finieris', only 13 companies have a commercial status, either limited liability company, or stock company. The rest 11 participants are either social organizations or associations, which are oriented on teaching and management of personnel, solution of problems related to quality and certification of products, as well as solution of various problems connected with wood industry of both Latvian producers and foreign investors. As to the location of the participants of the wood cluster, it is possible to say that the majority of them (16) are registered in Riga, 3 in Riga region and only 5 in Latgale region, which seems to be the main raw-material base of the wood cluster in Latvia.

The Finnish experience of the regional economy clustering

For Finland, the beginning of 1990s of the last century became a crucial period of going out of a deep economic crisis and the beginning of a way to today's economic welfare of the country. While studying the experience of structural transformations of the Finnish economy of the beginning of 1990s, it is necessary to study the political background of these transformations as well, in order to show that Finland solved its crisis problems by introducing the cluster approach not only in the economy, but also in the control system of the state.

Experience of voluntary cooperation of municipalities of Finland (Vanags, 2005). The autonomy of local governments is guaranteed by the Constitution of Finland. In the new Constitution of 1999 it is said that Finland is

[3] Lursoft data

Table 1

Structure of the wood cluster of Latvia, which was identified on the basis of functional relationships of its leader – 'Latvijas finieris'

Companies and enterprises – participants of the wood cluster of Latvia	Institutional status of the participants of the wood cluster of Latvia	Location of the participants of the wood cluster of Latvia
Latvijas finieris	Stock company	Riga
Skultes kokosta	Limited liability company	Riga region
Verems 2 (reorganizēts)	Limited liability company	Rezekne region
Port Milgravis	Limited liability company	Riga
ASAS	Limited liability company	Riga region
Lindeks	Stock company	Riga
Latvijas Vides pārvaldības asociācija	Association	Riga
Troja	Limited liability company	Riga
Lūdzas mežrūpniecības saimniecība	Stock company	Rezekne region
Latvijas Zinātņu akadēmijas Ekonomikas institūts	Limited liability company	Riga
Latvijas Mežizstrādātāju savienība	Association	Riga
Vācijas un Latvijas uzņēmumu savienība	Social organization	Riga
Ārvalstu investoru padome Latvijā	Association	Riga
Latvijas koks	Association	Riga
Latvijas Kokrūpniecības federācija	Association	Riga
Latvijas Mežu sertifikācijas padome	Association	Riga
VEREMS	Rezekne SEZ Limited liability company	Rezekne region
Rēzeknes Meža Īpašnieku Konsultāciju Centrs	Limited liability company	Rezekne
Rēzeknes speciālā ekonomiskā zona	Stock company	Rezekne
Zaļais sertifikāts Latvijas mežsaimniecībā	Social organization	Riga region
Latvijas Kvalitātes asociācija	Association	Riga
Latvijas Kokmateriālu ražotāju un tirgotāju asociācija	Association	Riga
Personāla attīstības un izglītības centrs	Limited liability company	Riga
Latvijas Personāla vadīšanas asociācija	Association	Riga

divided into municipalities, which are administered with the help of local governments that consist of local residents. The Constitution gives local governments the right to levy local taxes. In spite of the fact that the Constitution insufficiently explains the idea of regions, it is clear that regional local governments can exist, because it is specified that administrative territories, which are bigger than municipalities, can have local governments.

Today development of government in Finland is connected with regionalization. Up to the middle of 1990s of the last century there were practically no regions in Finland, if only administration of government in provinces is not understood under the notion 'region'. Today there are 19 regions and an autonomous region of Aland Islands in Finland. According to the 'Law on regions' of 1998, it is the central authority who defines the borders of regions after having consulted with municipalities.

The administration of regions is formed of representa-

tives of municipalities, i.e. 'from below upwards'. Municipalities finance activity of a region as well. The primary goal of the board of a region is regional development and planning. As examples of voluntary functions of a region it is possible to mention such functions as development of tourism, cultural events, education and studying of local history. Functions are delegated to regions both by the central authority and by municipalities. Significance of regions increases because of getting money from structural funds of EU and their rational use.

Regions have executive functions, as well as political ones. The basic one is the political function. The highest institution of a region is an assembly, elected by municipalities, which belong to the region, observing proportionality of political parties in these municipalities. The executive authority belongs to the board, which is subordinated to the assembly and can be dismissed by it.

Municipalities can voluntarily cooperate, thus, forming subregional territories. Cooperation mainly occurs in such spheres as the industrial policy, planning of the use of the land, transport, and building of houses. For 3 years there has been an experiment in Finland, which strengthens administration of a subregional level and expands its functions: such spheres as public health services, education and social services are being included in the list.

Municipalities have a right to create municipal alliances for performance of concrete functions. Sometimes creation of such alliances is obligatory. An institution, which makes decisions at the level of these associations, is a council formed by municipalities, which are a part of the alliance. The executive authority belongs to the board of the alliance. The alliance has its own budget financed by municipalities, which are members of the alliance. Associations are accountable to municipalities, which have created them.

Municipalities in Finland are traditionally strong structures. The law on local governments gives municipalities a relative freedom to define their organizational structure and functions. Municipalities have a right to define rates of taxes.

The state controls activity of municipalities by means of regulation and special grants. Starting with the end of 1980 the number of documents of the central authority, which regulate activity of municipalities, has considerably decreased. In the period of time from 1989 till 1993, Finland has conducted an experiment of free municipalities, which gave certain local governments a greater freedom, e.g. they lowered requirements to agree decisions of municipalities with the state institutions and formed internal organizational structures. The experiment has justified itself. The results of it were used in the realization of the reform of local governments.

The same as in Denmark and in Latvia, in Finland during already several years there have been negotiations between the central and local governments. The central government is represented by the Ministry of Internal Affairs and the Ministry of Finance, local government – by an alliance of local governments. Negotiations deal mainly with financial issues of local governments, such as rates of local taxes, operational and investment costs, distribution of costs between the central authority and local governments, as well as development of the services provided by local governments.

Experience of the development of Finnish industrial clusters (Hernesniemi, 1996). After having investigated history of formation, as well as the major tendencies of the development of Finnish clusters, it is possible to reveal some characteristic features. In all cases the major factor of modern competitiveness of clusters is high level of development of the system of joined institutes and branches. On the one hand, it has grown out of market relationships and effective competition, and, as to formation of national innovative system and inflow of qualified personnel, it is undoubted merit of the state policy.

It is possible to note an interesting paradox: effective development of production with high added value and active innovations occurred in the sectors, which lacked in natural resources. Lack of own resources has generated a demand for energoeffective technologies, relative lack of wood resources (for manufactures that are oriented to export), metals and chemicals stimulated a deepening of processes of raw material processing; enterprise calculation and competent industrial policy have ensured the correct choice of promising market niches and investment priorities.

It is possible to expect that in the near future the basic role in the continuation of steady competitiveness for the majority of clusters will be played by the factor of quality of corporate strategy. Particularly, the key aspect of strategic development of such clusters as information and telecommunication, wood, power and machine-building will be globalization of operations, orientation to consumers of the concrete regional markets, increase in the service component of production and export of engineering services while preserving leadership in new technologies.

The essential moment of the global strategy, on which inevitably companies of wood, machine-building and power clusters will count, remains ecological compatibility of finished goods and used technologies. For metallurgical cluster the basic direction of corporate strategy, most likely, will become increase of flexibility of manufacture, growth due to investments, mergers and acquisitions, as well as corporate alliances. For a building cluster, as well as clusters of public health services and business services the major element of the future competitiveness will become

Table 2

Economic characteristic of clusters in Finland*

Cluster	Volume of production in 1999, in billion FIM	Employment in 1999, thousands of person	Average growth rates per year, 2001 – 2015 (prognosis), %	
			Production	Employment
Wood	8.1	68.2	2.4	-1.5
Information and telecommunication	11.2	163.5	8.1	-0.4
Metallurgical	2.6	55.7	3.1	-0.6
Power	3.0	36.4	3.2	-1.8
Machine-building	3.7	82.9	2.8	-0.2
Food	2.0	44.0	1.4	-0.8
Business services	6.6	157.7	3.3	2.8
Building	8.4	179.9	2.3	1.1
Public health services	8.9	313.4	2.2	1.5

* Data on volume of production and employment include only basic trends of business in a cluster. The machine-building sectors of wood, energetic, metallurgical and building clusters are included in a machine-building cluster. All business services are included in the cluster of business services.

Source: ETLA

continuous innovations, as well as growing internal and external demand.

What industrial clusters of Finland, from the point of view of the Finnish researchers, possess obvious or potential competitiveness? Experts of the Institute of economy research of Finland (ETLA) with the help of methods of the analysis of tables 'expense-release' have identified nine core clusters: wood, information and telecommunication, metallurgical, power, business services, public health services, machine-building, food, and building clusters.

During the research there were the following indicators of the international competitiveness of finished production of the branches incorporated in clusters: excess of a share of production of the given branch in the world market above the total share of the country in the common world trade; excess of branch export over import. At the same time potential competitiveness was fixed in case if rates of growth of sales volume, profit and investments, as well as the labour productivity level in the given branch were above average within the branch in the world.

In modern economy, especially in conditions of the globalization, the traditional division of economy on sectors or branches is not topical anymore. The first place is taken by clusters – the system of interrelations of firms and organizations. As classical examples of it a technological cluster in Silicon Valley or a footwear cluster in Italy can be mentioned.

The cluster approach can change the realization of the state industrial policy in the most crucial way. In this case efforts of the government should be directed not on the support of separate enterprises and branches, but on development of mutual relations between suppliers and consumers, between end users and manufacturers, between manufacturers and the governmental institutes, etc.

Final conclusions look absolutely liberal: it is necessary to develop all clusters because all of them can appear promising for the increase of competitiveness. It is obvious that not all clusters will be successful, but it will be defined by the market, not by the decision of the government. At an early stage, the main task of the government is to improve the infrastructure and eliminate unfavourable conditions, and then it should concentrate on elimination of restrictions, which hinder the development of innovations.

In end it is necessary to note that in the National Development Plan of Latvia for 2007-2013, which is being discussed at the moment, a lot of attention is paid to industrial clusters and the Finnish experience is taken as a basis for planning the development of practice of knowledge use in order to create competitive advantages for commercial enterprises. It is necessary to mention one dangerous inaccuracy in the formulation of the development tasks, which says that it is necessary to create a cluster on the basis of spheres of creative activity (industries). In fact this is utopia, because a cluster cannot be created 'from above', it is created only on the initiative of entrepreneurs, whereas the government creates only favourable conditions for the creation of a cluster. Social and commercial activities of Latvian entrepreneurs (actions of LITTA in order to create IS cluster; LIDA seminar 'On Innovative Food Cluster Experience in Finland' for local government specialists, researchers, entrepreneurs, representatives of NGOs, ministries, municipalities and regions, the aim of which was to learn experi-

ences and best practices of Finnish food cluster and discuss opportunities and need for similar initiatives to catalyse local and interregional collaboration and co-operation as new support instruments and their implementation mechanisms) prove that in business circles of Latvia ideas of clustering are seen in a constructive way, and entrepreneurs have clear vision about what is an industrial cluster.

Conclusions

- The study of the Finnish practical research experience of the sphere of industrial clustering and the analysis of the current situation in Latvia lead to the conclusion that it is rather difficult to apply Finnish experience of clustering in Latvia.
- First of all, Finland has great experience in cooperation not only on economic level, but on political regional level – level of local governments – as well. It creates political basis for clustering of Finnish economy. Local governments in Latvia do not have such experience.
- Secondly, the crisis in the beginning of 1990s in Finland was absolutely different from the crisis in Latvia, because Finland is on a qualitatively different stage of economic development. Consequently, creation of clusters, which helped Finland to survive the crisis, can be not so efficient in Latvia.
- Thirdly, for the time being, it is not possible to say for sure what hinders creation and development of clusters in Latvia. It is most likely that societal culture of Latvia is very different form the societal culture of Finland. In order to create clusters and let them function properly, there should be cooperative spirit in societal culture, not a collectivist one. In collectivist societies, the process of clustering does not have corresponding cultural basis.
- At the moment, Finnish experience can be successfully used by scientists and researchers, i.e. they can use methodological basis and research techniques of Finland in the sphere of identification and studies of clusters of enterprises in Latvia.

References

1. Dunning J. (1993) Internationalizing Porter's Diamond. Management International Review, Special Issue, vol. 33, 1993^2, pp. 7-15.
2. Home page of the Research Institute of the Finnish Economy, Available at: www.etla.fi, 25.04.2006.
3. Hernesniemi H., (1996) Lammi M., Yla-Anttila P. Advantage Finland – The Future of Finnish Industries. (ETLA (the Research Institute of the Finnish Economy) report of the Finnish clusters' study) – Helsinki, Taloustieto Oy, pp. 76-77.
4. Porter M. (1990a) The Competitive Advantage of Nations. The Free Press, New York, and Collier MacMillan, Toronto, 1990, 127 pp.
5. Web-site of the Central Statistical Bureau of Latvia, Available at: www.csb.lv., 08.06.2006.
6. Nacionālais attīstības plāns (National Development Plan) 2007-2013. 1. redakcija. Available at: www.nap.lv, 28.03.2006. (in Latvian).
7. Vanags E., Vilka I. (2005) Pašvaldību darbība un attīstība. (The Activity and Development of Municipalities) – Rīga: LU Akadēmiskais apgāds, Latvijas Pašvaldību savienība, pp. 104-105. (in Latvian).
8. Портер М. (2000) Конкуренция. (Competition) - Издательский дом «Вильямс». Санкт-Петербург, Москва, Киев, 220 с. (in Russian).
9. Старк Д. (2002) Гетерархия: неоднозначность активов и организация разнообразия в постсоциалистических странах. (Heterarchy: Ambiguity of Assets and Organizing Diversity in Postsocialist Countries) – From the book: Экономическая социология. Новые подходы к институциональному и сетевому анализу. М.: РОССПЭН, 68-70 с. (in Russian).

ENVIRONMENT ESTIMATION IN AGRICULTURE OF LATVIA

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Abstract

The efficiency of solving of the state environmental protection policy and implementation of the environmental problems are closely related to identification of the existing problems of the environmental protection in a definite territory. In the rural territories this process depends on the process of agricultural production. In the society, alongside with the opinion about necessity of sustainable development there is also an opinion that the primary goal is to attain total economic increase even if it can damage the environment itself.
Analyzing definite indices of the effect of agriculture on the environment, it is possible to evaluate changes in the development of the branch and the environmental condition as well as their mutual interrelation.
Key words: the environment, effect on the environment, sustainable development.

Introduction

The objectives of the program in the policy of the state environmental protection in agriculture envisage to develop a sustainable, environmentally friendly agriculture. A sustainable development creates harmony between the human and nature, nature and environmental protection and enables economics, subjected to the environmental requirements, meeting the contemporary requirements without endangering opportunities of the future generations to meet their ones.

Agriculture must provide two contradictory conditions - it has to be cost-effective and at the same time it has to preserve natural resources.

In the territory of Latvia, the primary problem of the environmental protection in agriculture is that agriculture is not the manager of the environment. The problems related to the environment are degradation of soils and infestation of agricultural lands. Huge agricultural resources are not used, which threatens preservation of the landscape and the biological diversity.

Objective of the research – to state tendencies of development of the effect of agriculture on the environment in Latvia in order to evaluate opportunities of its sustainable development.

The **assignments of the research** are as follows:

- to identify indices which characterize the effect of agriculture on the environment;
- to evaluate their amount and tendencies of development in the context of sustainable development

Materials and Methods

For the needs of the research, data from the LR Central Statistics Board (The Yearbook of Latvian Statistics, 1995, 2005), data of the Latvian State Institute of Agrarian Economics (Latvian agriculture and the countryside, 2003, 2004), the economic total evaluation of agriculture in Latvia 2004-2005 and data of LR Ministry of Agriculture (Latvian agriculture and the countryside, 2005) are used.

Methods applied in the research are as follows: monographic, descriptive, economic, and statistical analyses (the timeline analysis, correlation analysis).

Results and Discussion

Conditions of sustainable development relate to all the branches of economics including agriculture. Not always indices of the agricultural production, which are favorably characterized from the point of view of the environmental protection, tell about the positive tendencies of development of agriculture as an economic sector because manufacturing of the agricultural produce goes together with a high economic and environmental risk. Globally, agriculture and development of rural regions are related with numerous ecological problems - increase of degradation, desertification of lands, and deforestation. These facts cause decrease in the density of population, increase of poverty, irrational use of lands, faulty methods of economic management, and lack of corresponding technology.

Agriculture is usually considered as activity which degrades the environment. In the process of production, soil becomes more acid, organic substances and feedstuffs decrease, use of the mineral matter and pesticides leaves its impact. As a result of inefficient management of the melioration systems, soils bog up and it is always associated with strong contamination of the environment. The possible problems for the future are soil erosion, degradation of water resources, and considerable decrease of the biological diversity. However, as scientists consider, it is possible to channel the agricultural activity in relation to nature and environment in a positive direction (Fischer, 2002).

To redeem the errors, in many European countries the agricultural policy of the state is radically changed and great attention is paid to developing the ecologic agriculture. To make correct decisions, for evaluation of the rural development and sustainable development of the branch of

agriculture, it is necessary to use a definite system of indices-indicators. As it is specified by the FAO (Food and Agriculture Organization of the United Nations), the traditional indices of the economic development provide a deformed picture of the branch development. That's why they have to be considered together with the indices describing the environment and the social development (FAO, 1997).

Together with integration of Latvia into the joint EU space, state institutions use reports which are developed using descriptive entities (indicators) incorporated in a definite analytical model created by the OECD (Organization for Economic Co-operation and Development). It is based on a five-phase model - the moving force, load, condition, effect, and action. These indicators are connected in a joint line of causal relationships showing what causes a problem, why it is created, what effect it creates, and how or by what means to solve it.

The quantitative indices of agriculture and the sustainable development of entrepreneurship related to it are defined in the guidelines of the Latvian sustainable development. As the quantitative factors affecting agriculture and the environmental condition can be mentioned indices describing use of the agricultural lands, economic indices of development of production of the agricultural produce, density of the rural population, the demographic load, etc. (The guidelines of sustainable development, 2002).

The evaluation factors included in the five-phase model of the OECD enable to evaluate quality of the environment and changes according to the national and international environmental standards, analyzing components of the environment, but they do not reflect the total effect of a definite branch on the environment taking into account processes related to its operation and development.

Therefore, the descriptive quantitative indices of the agricultural effect on the environment can be united according to their content into 4 groups - economic, social, environmental, and institutional ones:

- the group of economic indices includes entities describing manufacturing, consumption and management;
- social indices - describe the community connected with the branch, life conditions and relations;
- environmental indices - quantitative use of nature;
- institutional indices - the unity of social and legal norms which determine activities of the state administration and/or promote protecting nature of the agricultural production.

Table 1 includes indices that are divided into groups and describe agriculture. It is possible to widen or to change the indices included in every group depending on the effect of a definite branch of agriculture on the environment.

The environmental indices. In the agricultural production, the principal resource is land. The land consists not only of the physical area and the surface topography, but it also includes the natural resources of soil, mineral deposits, water, plant and animal kingdom.

The rapid tendency of urbanization brings corrections in the land utilization both in the urban and rural areas, and urbanization changes division of the use among the scale of production in different branches. By increasing the scale of production in one branch, income opportunities of the people employed in the branch also increase.

A balanced use of land is connected with the following priorities:

- elimination of low fertility of land;
- access to land and safe property rights to it;

Table 1

Indices describing the impact of agriculture on the environment

Group	Indices
Environmental	Amount of the utilized land and its bowels in the branch. Areas of agricultural land and the percentage of the managed agricultural lands, utilization of the natural and artificial fertilizers, areas used for biological agriculture, productiveness of domestic animals and cultivated plants, the biological diversity.
Economic	The percentage of agriculture in the GDP structure, the net VAT in agriculture, income of farm households, the number of rural inhabitants/farms engaged in non-agricultural activities, value and the amount of the produced goods, level of self-provision of the produce
Social	The number of people engaged in agriculture, level of unemployment, the forecasted length of life of inhabitants, size of the living space, demographic load.
Institutional	Support of the state to agricultural production, legal restrictions for the size of means for plant protection, use of fertilizers and development of the branch.

Source: research carried out by the author

- renewal of the critical sectors and ecological problems including forests, dry land, mineral deposits;
- management of land use;
- possession of information of the interested parts and access to information;
- international cooperation to raise productiveness, to exchange information and introducing technologies (Indicators of Sustainable Development, guidelines and methodologies, 2001).

Many of the priorities are related to agriculture and taking decisions related to agricultural development. It is important to eliminate the low level of income using biotechnologies, preserving and protecting the genetic resources, eliminating balanced pests, feeding balanced species, by being ready to emergency situations and protecting water resources. With agricultural land it is important to increase fertility, at the same time protecting natural resources related to it. Decreasing the agricultural areas which are evaluated as being negative from the point of view of the biological diversity, preservation of the landscape, the impact on the environment decreases.

In Figure 1, the descriptive indices of the management of the agricultural land are summarized. A factor, which eliminates analysis of dynamics, is that data of the State Land Service about lands and areas which cannot be used in agriculture and which are weed-infested and overgrown with bushes are available only to the year 2002, so it is impossible to evaluate if the negative tendency of the management of the agricultural land remains.

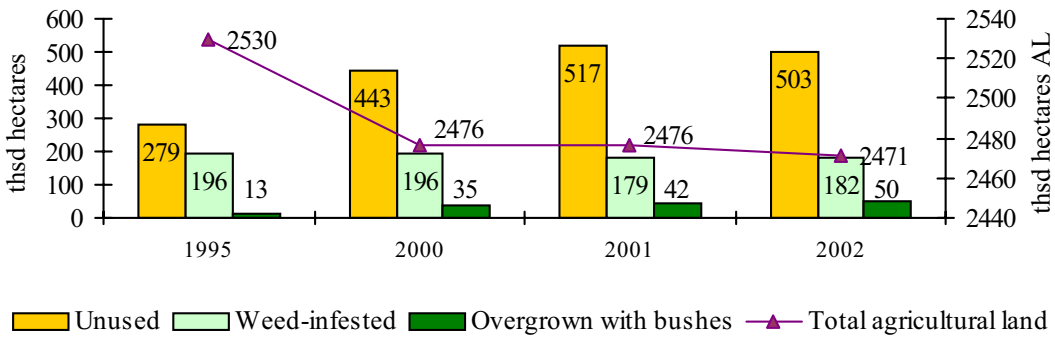
The area of agricultural lands in Latvia in the period from 1995 to 2004 decreased averagely by 1 %, the area of the unused land increased averagely by 21.7 %, and areas which overgrow with bushes increased by 56.7 %. The unused lands are excluded from the process of agricultural production, thus degrading rural landscape and the environment. In the perspective of production of the agricultural produce, weed - infested lands can be returned for production, in turn, lands which are overgrown with bushes need larger investments for the use in production. In such processes it is important to choose methods which less degrade the environment.

In the peasant farms, indices of the agricultural, arable and average total areas of farms in Latvia for the years 2000-2004 have not essentially changed. The average arable land totals to 10.7 ha, the total area of the farm - 23.98 ha, the area for the agricultural land - 14.02 ha (LVAEI, 2004). It gives evidence that the tiny areas available for land managers delay ensuring effectiveness of agricultural production, creating uneven division of the production load on the environment.

Use of unsustainable lands endangers the use of land resources. Land can become an insufficient resource to produce the required production and to ensure social requirements (recreation and tourism) of the man. In order to avoid the problems, it is necessary to increase agricultural lands and their fertility together with the protection of natural resources. Effectiveness of land utilization is described by the amount of the manufactured produce and productiveness of the cultivated plants.

As it is reflected in Table 2, in the period of time under the research, areas for cereals, sugar-beets and rape increase. The sharpest jump (averagely by 118.1 % per year) is in the areas sowed with rape. There the increase is related to a stable demand for rape seeds also in the outer market where the price reaches the world level. The increase in productiveness for other cultivated plants is slower, which from the point of view of the effect on the environment is valuated as being positive.

Carrying out the correlation analysis, it can be concluded that between the total sown areas, there are different levels of closeness of correlation depending on the cultivated crop. From the point of view of analysis of the effect of agriculture on the environment, the increase of productiveness at the cost of decreasing the amount of sowing areas for potatoes is valuated as being negative (r=-0.55). Productiveness of sugar-beets and rape increases



Source: data of State Land Service

Figure 1. Using of agricultural land in Latvia, 1995 – 2002.

Table 2

Field crop sown area and yield in farms of Latvia, 1995-2004

Years	Area, ha					Yield, t per ha				
	Cereal	Sugar beets	Rape	Potatoes	Fodder roots	Cereal	Sugar beets	Rape	Potatoes	Fodder roots
1995	408.4	9.5	1.1	75.3	17.5	1.69	26.4	0.81	11.5	12.2
2000	420.0	12.7	6.9	51.3	9.7	2.20	32.1	1.46	14.6	10.0
2001	443.7	14.1	8.4	55.1	...	2.09	34.9	1.54	11.2	11.1
2002	415.0	15.9	18.4	53.6	12.3	2.48	39.1	1.78	14.3	10.8
2003	428.5	14.4	25.9	54.6	14.3	2.18	37.0	1.44	13.5	14.0
2004	436.7	13.8	54.3	48.9	13.5	2.43	36.7	1.90	12.8	12.2
Average Increment Rate, %	13.5	7.75	118.1	-8.3	-5.1	7.5	6.8	18.6	2.2	0

Source: data of Central Statistical Bureau and calculations made by the author

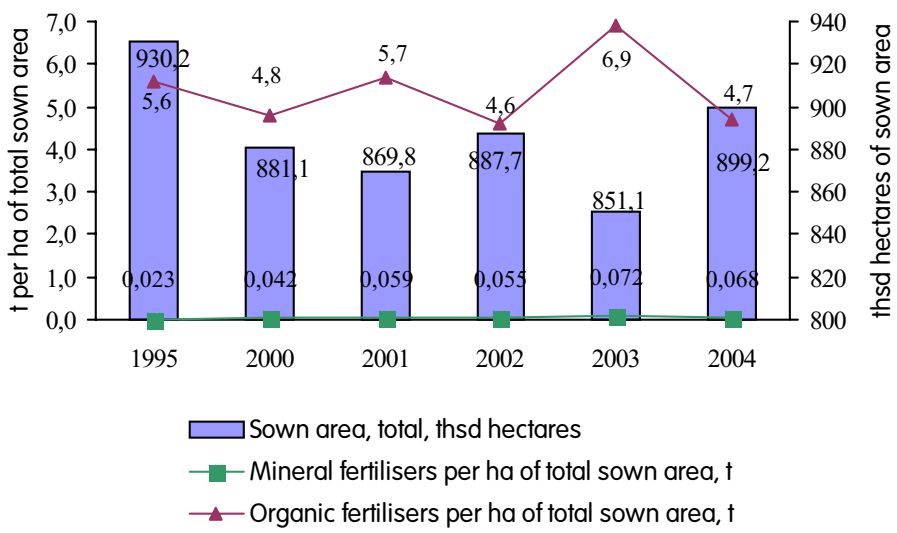
by the increase of sown areas (respectively r=0.98 and r=0.71). Areas meant for vegetables decrease, but the average productiveness in the period is stable (r=0.65). These coherencies allow to conclude that preservation of the productiveness of the cultivated plants is also affected by other factors.

As A. Riekstiņš (2003) points out in his article, productiveness of cultivated plants depends on:

- quality of the agricultural land;
- meteorological conditions;
- agro-technology;
- management method;
- ecological factors (Riekstiņš, 2003).

However, in evaluating the increase in productivity, use of fertilizers should be taken into account. Increase in productivity at the cost of application of mineral fertilizers is a factor which endangers environmental protection.

In the period from 1995 to 2004, the total sown area and the utilized amount of organic fertilizers averagely decreases by 3.5 % per year. After analysis of data summarized in Figure 2, carrying out the correlation analysis, it can be concluded that utilization of organic fertilizers has a medium close negative functional and linear coherency (r=-0.75) – by decreasing the sown area, the amount of the utilized fertilizers increases. The amount of utilization of the mineral fertilizers increases averagely by 24.2 % per year.



Source: data of Central Statistical Bureau

Figure 2. Use of mineral and organic fertilizers in Latvia, 1995–2004.

The amount of the organic fertilizers is closely related with development of the livestock breeding branch and the amount of methane and nitrogen which is excreted as a result of the management of animal manure, the amount of methane emissions due to the processes of animal fermentation as well as emission of nitrogen from the agricultural lands. The increase of these indices decreases the impact of the environment. As L. Melece (2006) points out, taking into account the fact that there is inconsistent information about utilization of manure or the organic fertilizers for fertilizing cultivated crops, because the amount of the utilized manure on 1 ha of sowings is given, it is impossible to determine from which domestic animal it comes from and what changes in the amount of the fertilizers and the content of nitrogen might be within a shorter and longer period of time.

The factors which describe the condition of agriculture and the environment are density of domestic animals as well as proper management of manure. Decreasing the number of livestock in the state territory, problems related to the environment remain. Disproportionate development of cultivation of plants and livestock breeding in the state territory determines a high density of domestic animals in several farms. Recession of livestock breeding is also a reason for not maintaining meadows and pastures and not using agricultural land which is less useful.

The amount of the utilized manure is connected with changes in the number of animals in the livestock branch. According to the data of the SUDAT (the data network for registering Latvian farms) in 2003, increase in the number of the average respective livestock units has restarted: if it was 15.8 respective livestock units (LLV) in 2001 and in 2002 15.7 LLV, then in 2003 it increased to 17.1 LLV or by 4 % per year. The density of the pasture livestock on a unit of the fodder area has not essentially changed (LVAEI, 2004).

The effect created by the livestock breeding branch on the environment depends on the time of keeping animals in the cattle-shed and outside it. Making calculations, coherency is observed: by decreasing the length of the pasture period, increases the emission value of the ammonia coefficient. The largest amounts of the ammonia emission in the year 2004 were due to manure handling - 73 % from the total emissions, due to not fertilizing the land areas with mineral fertilizers - 7 % (Melece, 2006).

According to the conditions of a good agricultural practice (Bušmanis, 1999), in order to provide creation of sustainable agriculture, it is necessary to utilize the organic fertilizers to provide soil fertility together with the mineral fertilizers as being only supplementary, it is not allowed to set high fertilization norms which are not ecologically grounded. The means of fertilizing must provide high yields without contamination of the environment.

Taking into account division of the sector of manufacturing the agricultural produce according to the scale of manufacturing where the largest percentage belongs to farms with a smallscale manufacturing and taking into account indices of the land utilization (Figure 1), a huge part of fields stay uncultivated, and turn into infested meadows which slowly overgrow with bushes and become boggy. Huge areas of land, which are not managed and for many years are waste lands, leave a better impact on the environment than if they are utilized intensively. However, not all the processes in theses areas are favorable for the human. That's why a minimum, but reasonable, participation of the human is required and it needs investment of human and financial resources.

The economic indices. Describing Latvian agriculture (in the statistical data hunting and forestry are also included), as one of the primary factors which affects the quantitative changes of the primary resource of the

Table 3

The economic indices describing agriculture in Latvia

Indices	Years					Changes in 2004/2000, %
	2000	2001	2002	2003	2004	
The percentage of agriculture in the GDP structure, %	4.2	4.2	4.4	4.1	4.0	- 4.8
The percentage of people employed in agriculture, %	12.22	12.47	11.32	9.92	6.33	- 48.2
Income (on 1 man) employed in agriculture, LVL	542	658	674	629	...	16.1*
The average monthly gross payment to people employed in agriculture, LVL	115.0	119.0	134.0	154.0	179.0	55.7
The average gross payment to people employed in Latvian national economy, LVL	150.0	159.0	172.8	192.5	211.0	40.7

Source: data of Central Statistical Bureau and calculations made by the author

* Changes in 2003/2000, %

agricultural production land and its bowels is the change of the number of inhabitants.

At the start of 2000, in the territories of the Latvian countryside there lived 760 thousand inhabitants, but at the start of 2004 746 thousand inhabitants. The number of inhabitants in the villages and rural areas has decreased by 14 thousand or 1.8 %. The tempo of the decrease is slower, because in the period 1995-1999, the number of inhabitants in the countryside of Latvia decreased by 2.5 % (Latvian agriculture and the countryside, 2005).

With the decrease of the number of inhabitants and increase of the demographic load, the number of people employed in the branches of agriculture decreases (see Table 3). By decreasing the number of inhabitants, the areas of land per one inhabitant increase, which determines that the load on the environment becomes smaller.

For the economic indices of people employed in Latvian agriculture in comparison with the indices of 2004 with the guiding period being the year 2000, the tendency of development is determined:

- the branch percentage GDP decreases by 4.8 %;
- the percentage of the people employed in agriculture decreases by 48.2 %, which shows that the number of inhabitants in the rural territories and updating of manufacturing decreases;
- but, by increasing the average payment by 55.7 %, the income of the people employed in agriculture per 1 employed has increased by 16 %.

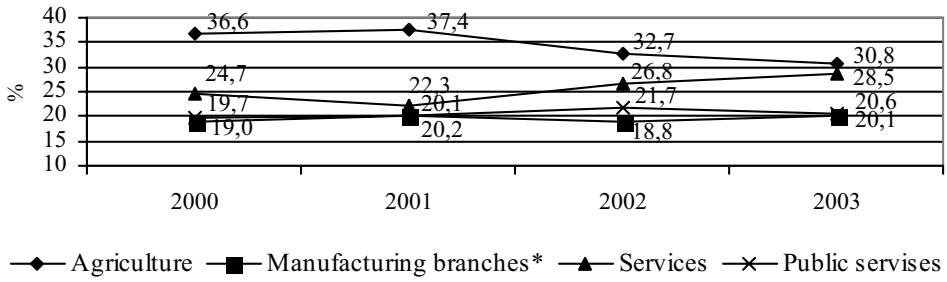
From this it can be concluded that by decreasing the intensity of agricultural action, the effect of the action of the branch on the environment and the contamination caused by it decreases, but it is necessary to evaluate which one is created by the human and that is analyzed in the next group of indices.

The social indices. The effect created on the environment by the inhabitants depends on their number, level of welfare, and the stage of degradation of the surrounding environment. By increasing any of the factors, the created effect on the environment increases, any of the indices decreases, and the effect on the environment caused by the inhabitants decreases. The level of welfare to people employed in agriculture is described by the average payment which in the period from 2000-2004 forms averagely 81 % of the average gross payment for the people employed in agriculture. The average payment to people employed in agriculture increases sharper than to people employed in the national economy. It shows that in respect to payment, the branch of agriculture gradually becomes equivalent to other branches of the national economy. So, the income of rural inhabitants increases and also the level of welfare increases. Wherewith, for inhabitants of rural territories there are better opportunities to purchase and to utilize goods, manufacturing technologies and methods which not always are environmentally safe. With every year the scope of collecting the household waste, processing and disposal increases. The contamination also depends on the activity branch of the people employed in the rural territory.

As it is seen from Figure 3, there is mutual correlative connection between the employment changes in agriculture and other manufacturing branches in Latvia (r=-0.96): by decreasing the number of the employed in agriculture, the number of the employed in other manufacturing branches increases.

The number of the employed in the public services and in the service sector is fluctuating: it has a little tendency to increase; the percentage of employed in the total structure is within the limits of 19-20 %. Wherewith, if the effect caused by the employed people in agriculture decreases, the effect caused by other manufacturing branches on the environment increases, which allows to conclude that the evaluation of the environmental condition in preserving the rural landscape and in evaluating sustainable development is also required in other branches of the national economy.

The institutional indices. By analyzing descriptive indices of the institutional condition of the environment, it is



Source: data of Central Statistical Bureau and calculations made by the author
* excluding agriculture and hunting

Figure 3. Structure of the employed people in rural area according to the kinds of activity, 2000-2004.

essential to determine the effect of the state measures: of support on the development of the branch of agriculture.

For the support of agriculture, there are two forms of the support measures- support by the market prices, and the direct support of income.

In the case of the market price support, higher income is provided to the manufacturers by keeping comparatively higher prices in the market. Implementation of such measures is provided by adjustment of the outer trade and implementation of several related measures which adjust the demand and the supply, for example intervention, measures for supporting exports. These measures are financially supported by the consumer when he purchases the definite product.

Since 2001, the program of favoring the market of agricultural and food products is implemented and within its framework operates the trademark 'Kvalitatīvs produkts' (A high-grade product). To favor export measures of the food products, the concept „Growing green in Latvia" is used, which gives proof of the quality of the product as well as of the uncontaminated environment in the process of manufacturing.

The direct income support from the state budget is implemented by paying directly to the manufacturers in the order approved by the state. The amount of the support in agriculture is determined basing on the criteria which are directly connected with manufacturing. The government has to favor manufacturing of the agricultural produce by such methods which provide poison-free produce, safety, protection of the environment, and development of the countryside by including these issues in the national strategies of sustainable development.

With the moment when Latvia joined the EU in 2004, there is opportunity for the Latvian farmers to qualify for the EU direct support payment. The payment is done for the agricultural land which is kept in a good agricultural and environmental condition irrespective whether the process of the economic manufacturing is performed on it as well as supplementary payments is done to promote manufacturing directions of products.

Despite the increasing amount of measures for supporting agriculture from LVL 25 883 2000 per year to LVL 125 101 2004 per year or by 383 %, the intensity of agricultural manufacturing in recent years has decreased in Latvia and stability of the branch is preserved.

Conclusions

1. The descriptive indices of the environment according to their content can be divided into economic, social, environmental, and institutional groups of indices, including the descriptive indices of the branch of the national economy in every of them which enables to evaluate the effect caused by the branch on the natural environment.

2. Opportunities of sustainable development for the branch of agriculture depend on the indices of land utilization. Therefore it is required to carry out structural analysis of the unmanaged agricultural lands not allowing decrease of the rural landscape and the branch by intensifying the areas used in manufacturing.

3. Medium close and close linear and functional coherence exists between changes in the amount of the sown areas and the level of productivity. Changes in the amount of the sugar-beet, rape and vegetable areas when the productiveness increases allow to conclude that other factors affect preservation and increase of the level of manufacturing.

4. In the period from 1995 to 2004, the total sown area and the amount of the utilized organic fertilizers averagely decreased by 3.5 % per year. By decreasing the sown area, the amount of the utilized fertilizers increases. The amount of utilization of mineral fertilizers increases averagely by 24.2 % per year which is the factor endangering environmental protection.

5. The decrease of the number of rural population by 1.9 % in Latvia and the percentage of the employed by 48.2 % changes the effect on the environment created by them, because the income of the population increases and opportunity arises to use manufacturing technologies and methods which not always are environmentally safe.

6. The total VAT in agriculture decreases, but application of pesticides and mineral fertilizers increases, which shows that fertility of soil is increased artificially.

7. Despite the increasing amount of measures for the support of agriculture, the intensity of agricultural manufacturing in recent years has decreased in Latvia preserving stability of the branch and providing sustainable development of the branch.

References

1. Bušmanis P. (1999) Labas lauksaimniecības prakses nosacījumi (Conditions for a good agricultural practice). Jelgava, 103 pp., 81 pp. (in Latvian).
2. Fischer G. (2002) The Economics of Land Use Change: Interim Report Available at: www.iiasa.ac.at/Publications/Documents/, 10.03.2005.
3. Indicators of Sustainable Development: framework and methodologies (2001). Available at: www.un.org/esa/sustdev/csd, 10.02.2005.
4. Land quality indicators and their use it sustainable agriculture and rural development (1997). FAO Land and water bulletin 207 pp.
5. Latvijas ilgtspējīgas attīstības pamatnostādnes (2002) (Guidelines for sustainable development in Latvia), LR MK Available at: ppd.mk.gov.lv/ui (in Latvian).

6. Latvijas lauksaimniecība un lauki 2003: politika un attīstība (2004) (Latvian agriculture and the countryside 2003: policy and development). LVAEI, Rīga, 264 pp. (in Latvian).
7. Latvijas lauksaimniecība un lauki 2004: politika un attīstība (2005) (Latvian agriculture and the countryside 2003: policy and development). LVAEI, Rīga, 156 pp. (in Latvian).
8. Latvijas lauksaimniecība un lauki (2005) (Agriculture and Rural Area of Latvia). LR ZM. 142 pp. (in Latvian).
9. Melece L. (2006) Lauksaimniecības sektora radītās siltumnīcefekta gāzu emisijas, (The hothouse effect gas emissions created in the agricultural sector). In: Latvijas lauksaimniecība, lauki un pārtika – ekonomikas attīstības procesi: publikācijas Latvian agriculture, countryside and food- processes of the economic development: publications. LVAEI 11.krājums pp. 46-63. (in Latvian).
10. Riekstiņš A. (2003) No kā atkarīga raža (On what the yield depends). Agropols, pielikums Ražība Nr.3 2003.gada septembris pp. 22 - 24. (in Latvian).
11. Statictic Yearbook of Latvia (2005) LR CSB Rīga 302 pp. (in Latvian).
12. Statictic Yearbook of Latvia (1995) LR CSB Rīga 265 pp. (in Latvian).

INTRAZONAL AGRICULTURAL RESOURCES IN KURZEME PENINSULA

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Abstract

The paper focuses on the exposition of the research results on agricultural resources in Kurzeme peninsula–climatic resources, qualitative evaluation of the land, condition of land amelioration, topographic resources, and structural breakdown of farm land by types of use.

It is concluded that extremely various climatic and soil conditions govern in the region. The Southeast part of Kurzeme peninsula is displayed very favourably by the aggregate value of agricultural resources.

Labour productivity in Kurzeme has been analysed as well.

Key words: agriculture, factor, peninsula, resources.

Introduction

Encyclopaedical publication 'Pasaules zemes un tautas' (Lands and Peoples of the World, 1978) defines Kurzeme peninsula as the Northwest part of Latvia lying between the Baltic Sea in the West and the Riga Gulf in the East.

Latvian geographers (Latvijas ģeogrāfija, 1975) characterise Kurzeme peninsula and its intrazonal differences from climatic (Temņikova, 1958), relief, soil, and other aspects essential for agriculture (Brīvkalns et al., 1968).

The total length of the sea and gulf borderline is twice longer than its land borderline, where it verges on Dobele and Riga districts.

It is generally known that factors forming or determining agricultural production capability can be classified into six groups:

- climatic factors – quantity of solar energy, heat, moisture, length of the vegetation period, etc.;
- edaphic or soil-related factors – type of soil, mechanic content, amount and content of humus, reaction, content of plant nutrients, etc.;
- topographic or orthographic factors – relief, slope of hillsides, erosion, rockiness, configuration of fields, size of outlines, etc.;
- anthropogenic factors formed by humans due to ameliorative, culture-technical, technological, and other methods;
- social factors – education, professionalism, general intellectual development, social and public positions, and traditions;
- economic factors – energy resources (capacities of tractors, combines, and truck engines), premises, constructions, equipment, etc.

The study of nature, soil, anthropogenic, social, economic, and other factors, as well as general provisional study of conditions of Kurzeme region show that the intrazonal factors determining or forming agricultural production capability and structure of this region might be different and even extremely different. These aspects have stimulated more profound or profound complex research on each intrazone or micro-region, or sub-district of natural conditions.

K. Brīvkalns (1959), a researcher of soil and natural conditions, has displayed five sub-districts or intrazones of natural conditions (soils) in Kurzeme:

- coastal sandy lowland (1a) stretching along the coasts of the Baltic Sea and the Riga Gulf and covers the Northern part of the region;
- Western Kurzeme plain and hill land (2a) – parts of Liepāja and Kuldīga districts;
- Venta lowland (2 b) – a small zone in the territory of Kuldīga district;
- Eastern Kurzeme moraine plain (2c) – the most important and spacious agricultural zone covering the whole districts of Saldus and a large part of Tukums district;
- Northern Kurzeme hill land (2d) ending in a sandy lowland in Talsi district, and also stretching into Tukums district.

The borders of these intrazones do not coincide with the borders of districts, thus the agro-economic studies are made complicated, since statistical data are usually given by districts, while some data are available also by parishes.

Therefore also other internal classification of regions was searched for.

A. Boruks (Boruks et al., 2000) has split the parishes of Kurzeme into four sub-regions according to the suitability of their soils and natural conditions for agricultural production.

Other scientists (Špoģis et al., 2003) include Eastern Kurzeme into the region of commercial agriculture.

Geographers (Latvijas ģeogrāfija, 1975) separate several agricultural and economic districts in Kurzeme peninsula.

The comparison of scientific breakdowns revealed

both coherences and significant differences.

The aim of the paper is to study agricultural resources in edaphic, topographic, and climatic zones of Kurzeme peninsula and to assess the possibilities of primary sectors.

The objectives for the achievement of the set aim:

- to analyse the qualitative differences of climatic resources and soils in the districts of Kurzeme;
- to assess the structure of agricultural areas in the districts of the region;
- to study the resources created by anthropogenic factors;
- to analyse some of the labour productivity aspects;
- to evaluate the possibilities of agriculture by the total value of resources.

Other research objectives related to agricultural resources are not studied due to the limited scope of the paper.

Materials and Methods

The research comprises the use of two main sources – scientific literature and statistical data.

The methods of calculations, analysis and synthesis are used for the purpose of the research, while the methods of induction and deduction are applied for the interpretation of data and calculations.

Results and Discussion

1. Climatic resources

The capacity of climatic resources in Kurzeme is evaluated in two sections:

1) total especial resources of the peninsula;

2) differences of intrazonal climatic resources of the peninsula.

The most essential peculiarities and differences of the total climatic resources of the peninsula are well known not only by Latvian farmers. Many professionals have to accommodate themselves to and make a targeted use of these peculiarities and differences. However internal zonal differences are also of great importance.

The segmented relief of Kurzeme greatly affects the weather conditions, and the processes of climate formation as well. The significantly increased amount of precipitation, lower temperatures, shorter frost free period and shorter vegetation period are observed in hilly lands.

Relatively heavier rainfalls are observed in Western Kurzeme highland (650 - 750 mm), while quite opposite situation is observed in Venta lowland, where there are few extra rainfalls, as Western Kurzeme highland mainly experiences more rainfalls. However, the amount of precipitation in Kurzeme hilly land is by 200 mm lower than in Vidzeme highland and by 100 mm lower than in Latgale (Справочник по климату, 1966).

On average the frost free period in Latvia fluctuates between 150 and 180 days in Kurzeme region and up to 125 - 140 days in the Eastern districts. Due to the analysis of the frost free period it is concluded that the shortest period is observed in the central parishes of Kurzeme peninsula, mainly in the parishes of Saldus district. Yet the longest frost free period is in the coastal zone.

However, the analysis of the number of sunny days affecting agricultural production leads to the conclusion that the sowings of the coastal parishes may accrue more solar energy, since sunny days govern in this zone. The smallest number of sunny days is observed in Kurzeme midland and its Northern part.

2. Land quality and value as the main edaphic resources

The study comprises the analysis of the data on the qualitative and cadastral values of soils in the districts of Kurzeme peninsula.

As it is seen from the data arranged in Table 1, regularities have been determined in the qualitative evaluation

Table 1

The qualitative and cadastral value of soils in the districts of Kurzeme peninsula

District	Assessment of field quality in points	Assessment of the quality of UAA in points	Coefficient of place location	Relative cadastral evaluation of UAA (Ludza district = 100%)
Saldus	43	41	1.00	152
Tukums	42	39	1.10	156
Talsi	41	37	1.00	137
Ventspils	41	37	0.97	133
Liepāja	40	38	1.00	143
Kuldīga	39	35	1.00	130
The lowest – Ludza	34	31	0.87	100
The highest – Jelgava	55	53	1.26	238

Source: A. Boruks (Boruks, 2003) and the arrangement done by the author

of soils: the best soils are in the Southeast part, while the evaluation decreases in hilly lands and sandy areas, especially in Kuldīga district.

Different results are obtained if soil indicators in parishes are compared. The analysis of the assessment of the utilized agricultural area (UAA) promotes the conclusion that the quality of fields reaches and exceeds 50 points in several parishes of Saldus and Tukums districts.

To give the idea on the presence of edaphic resources in Kurzeme, the data on districts of Ludza and Jelgava, having the most polarised evaluation of the soil quality, were included into Table 1.

The comparative analysis of the evaluation of UAA on the districts of Kurzeme region and Ludza district leads to the conclusion that the quality of part of soils in Kuldīga district is similar to Ludza district.

The soil quality level is consistent in Jelgava and only some parishes of Saldus and Tukums, yet in general the UAA in Jelgava district is by one third or 29.3 % higher than in Saldus district.

Tukums district shows better conditions for location, however the coefficient of location is by 0.16 units lower in comparison with Jelgava district.

3. Impact of topographic factors

The use of high-power, highly productive machinery, and modern technologies is a characteristic development feature of contemporary agricultural production. Such a tendency is economically impossible in hilly, segmented, small outlined, and stony areas, as well as in areas subjected to erosion.

This regularity proves that hilly lands of Northern Kurzeme and Western Kurzeme are more suitable for non-agricultural activities.

4. Structure of types for the use of agricultural areas

After the evaluation of soil, and the study of climatic and topographic resources the author's intention was to analyse the structure of types for the use of land, by means of calculation of the percentage of UAA, forests, bushes and other types of use out of total agricultural areas in the districts (see Table 2).

The data included into Table 2 leads to the conclusions that:

- the proportion of UAA is very diverse in the districts of Kurzeme;
- the largest proportion of UAA is located in the Southeast of the region, namely, in Saldus district, also in the parishes of Tukums district this indicator is only by 2 percentage points lower;
- only half of total land area is used for agricultural production in Talsi and Kuldīga districts;
- the most forested territories are located in Kuldīga district, where they together with brushwood cover 33 per cent of total agricultural area. Similar results are also seen in Talsi district, where the corresponding proportion reaches 34.5%;
- an original situation is observed in Liepāja district: although the proportion of forests is the smallest here, brushwood, swamps, and water cover a large part of the territory.

5. Anthropogenic factors

Land amelioration is the most important resource in this group.

Kurzeme, as well the other districts of natural conditions in Latvia, has a negative hydrothermal coefficient, since the average annual precipitation considerably exceeds evaporation.

Under the following circumstances, as it is generally known, land amelioration is needed for an efficient agricultural production. According to the statistics, land areas were extensively ameliorated in the 1970s and 1980s, but since 1990 land amelioration has been stopped.

Neglected amelioration systems cease functioning and thus local small swamps occur in the fields. Similar swamps occur also when branches or sections of drainage pipes become blocked and crash.

The data analysis has been performed considering

Table 2

The structure of types for the use of agricultural areas in Kurzeme in 2002

Districts	UAA, %	Forests, %	Bushes, %	Other, %
Saldus	69.7	21.6	1.6	7.1
Tukums	67.5	22.5	1.4	8.6
Liepāja	65.3	20.4	3.4	10.9
Ventspils	62.6	27.9	1.6	7.9
Kuldīga	55.9	33.1	2.0	9.0
Talsi	55.4	32.6	1.9	10.1

Source: table made by the author according to the data of the State Land Service

Table 3

The situation in land amelioration in the districts of Kurzeme

Districts	% of total UAA		
	ameliorated UAA	of which the reconstruction, or repair of amelioration systems is needed	new amelioration needed
Saldus	71.5	3.6	4.7
Liepāja	66.6	5.2	45
Talsi	57.0	6.2	3.2
Tukums	53.6	3.9	4.2
Kuldīga	46.3	2.5	3.4

Source: results of Agricultural Census of 2001 in Latvia (2001)

the especial importance of this resource. The results of the analysis are included into Table 3.

Several conclusions may be drawn according to the data grouped in Table 3:

- the activity of Kurzeme districts has been very diverse, as the proportion of ameliorated areas in Saldus districts almost twice exceeds the respective proportion in Kuldīga;
- the planners of that time have used recommendations expressed by scientists and specialists, who proposed that land first of all had to be ameliorated in the best soils, like in Saldus district;
- according to the assessment of land owners, the reconstruction and improvement of amelioration systems is needed in large areas.

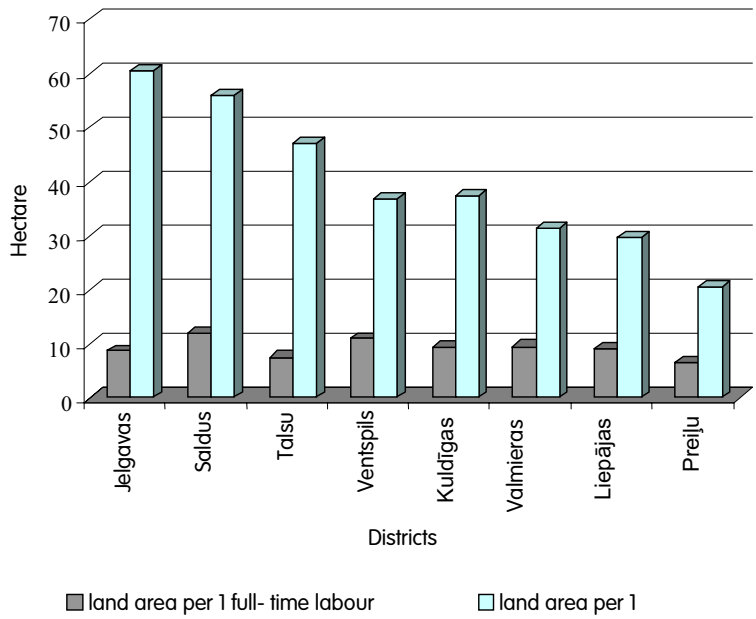
6. Labour force resources and labour productivity

Labour resources and labour productivity are formed due to the interaction of social and economic factors.

The analysis of the structure of employed persons shows that the number of employed has a coherence with the structure of areas.

However, these data do not disclose labour productivity.

Therefore further special calculations were done, and results are depicted in Figure 1. The assessment of calculations presented in Figure 1 is done due to the concept that differences in labour productivity greatly describe various used land areas per each full-time employed person and per each person employed in general. Total work regime is characterised by the figure how many farm land areas are cultivated by one person employed in agriculture.



Source: calculations and construction done by the author (Structure of Rural Farms in Latvia, 2004)

(Legend: hectares, land area per 1 full-time labour unit; land area per 1 employed)

Figure 1. Agricultural land area per 1 employed person and 1 full-time labour unit in 2003.

The research includes also one the most characteristic district from the other regions for the purpose of comparison and evaluation of labour productivity of Kurzeme inhabitants.

Several conclusions have been drawn according to Figure 1.

- The area of UAA per 1 person employed in agriculture varies extremely by the districts analysed: in Jelgava district it is 3 times larger than in Preiļi district. A slightly smaller difference is seen between Saldus and Preiļi districts. The farm size, the level of their commercialisation, technologies applied, and content of sectors are the factors creating the mentioned differences.
- All the districts experience diverse difference between the land area per one employed and per 1 full-time labour unit.
- The highest general labour productivity is seen in Jelgava district, but in Kurzeme region it is seen in Saldus district, where each employed person manages the largest land areas which amount to 56 hectares here.
- Talsi district, where this area is only by 16 % smaller than in Saldus district, comes right after Saldus district by the total number of employed persons. Though the area managed by one full-time unit is much lower in Talsi district.
- The lowest total labour productivity out of all Kurzeme districts is observed in Liepāja district, and the difference from Saldus district is large.
- Jelgava district is a leader in bench districts, while Preiļi district has the smallest amount of land per one employed person. The large number of employed in agriculture and many small-scale farms might be the cause for the mentioned result in this district.

7. Total assessment of agricultural resources

Summarising several main agricultural resources, A. Boruks (2003, 2004), an economist and scientist of soils, has determined total evaluation of agricultural conditions for each parish.

Additionally land areas are analysed in order to draw conclusions. These calculations show even larger differences among districts, since land areas favourable for agriculture in Kuldīga district amount only to 18%, while in Saldus district – already to 78%.

The mentioned author has divided all parishes into four groups: the most favourable conditions for agriculture, good, average, and unfavourable conditions for agriculture.

Assuming that the assessment of A. Boruks (2004) is scientifically well based and correct, it was used also for the clarification of intrazonal differences in Kurzeme. The data are arranged in Table 4.

According to A. Boruks' assessment there are no single parish in Kurzeme, where agricultural conditions are the most favourable as they are in Jelgava, Dobele and Bauska districts, where almost the majority of parishes being most favourable for agriculture are located.

This breakdown is disputable. K. Špoģis (2003) considers that in the Southeast part of Kurzeme soil and nature conditions are well suitable for intense commercial activities in agriculture and includes them into the main commercial and agricultural region – Zemgale.

Several conclusions have been drawn due to the data summarised in Table 4:

- parishes with conditions favourable for agriculture cover three fourths of Saldus district, and half of Tukums district, while good agricultural territories can be found also in Liepāja and Talsi districts (ca. 40%);

Table 4

The breakdown of Kurzeme parishes by the capacity of agricultural resources

Districts	Favourable conditions for agriculture		Average conditions for agriculture		Unfavourable conditions for agriculture	
	number of parishes	their land area, ha	number of parishes	their land area, ha	number of parishes	their land area, ha
Saldus	14	97,415	4	27,196	0	0
Liepāja	12	92,580	12	103,828	1	11,347
Tukums	9	79,009	7	63,086	0	0
Talsi	7	46,779	8	59,747	2	21,260
Kuldīga	4	28,305	14	126,726	0	0
Ventspils	3	24,232	7	43,386	2	8528
Total number	49	368,320	52	423,969	5	41,135
%	44	x	51	x	5	x

Source: calculations done by the author (Boruks, 2004)

- the soil district 2c greatly coincides with 2-4 micro-region, which has soils and the most important soil features suitable for efficient agriculture;
- the sub-district of Venta lowland is agriculturally heterogeneous: its Southern part includes Saldus district with the characteristic good soils, while the conditions in the Northern part are just average, in micro-regions 3–14 with Gleyed soils;
- the highland of Northern is divided into three parts: its Northern part is unsuitable for efficient commercial agriculture, while its Southwest part is adjacent to a micro-region with good conditions for agriculture, which is the continuation of good conditions for agriculture of Saldus and Tukums districts, and its end –Northern borderline;
- the areas of eroded soils in Kurzeme districts vary a lot: in Liepāja district these areas amount to 13.5 thousand ha, in some parishes of Tukums district – to 7.4 thousand ha, while in Saldus district, especially in its Northern part, they amount to only 1200 ha;
- the assessment of intrazonal differences leads to the statement that they are large or even extreme, since the proportion of Group 2 parishes (with good conditions for agriculture) fluctuates between 22% in Kuldīga district and 78% in Saldus district;
- half of the parishes of the spacious Liepāja district is included into Group 3 or group with average conditions for agriculture;
- the land areas of parishes are very diverse, thus convincing;

Conclusions

1. Total climatic resources of Kurzeme region are favourable for agriculture, but they greatly vary among the interzones of the region.

2. The qualitative land assessment in Kurzeme interregions differs and fluctuates from the South to North of the peninsula. The most valuable soils can be found in the Southeast part of the region.

3. Topographic conditions are obstructive in the hilly lands of Kurzeme.

4. The proportion of utilised agricultural areas in Kurzeme fluctuates between 55 per cent in the most forested district of Talsi and 70 per cent in Saldus district.

5. The number of persons employed in agriculture varies within the region. The highest indicator of labour productivity is observed in Saldus district, which has the largest number of parishes favourable for agriculture.

6. The condition of land amelioration is different by districts, though amelioration systems are not functioning any more in large scales, as since 1990 amelioration in Latvia has been stopped.

References

1. Boruks A., Krūzmētra M. et al. (2000) Dabas un sociāli ekonomisko apstākļu mijiedarbība un ietekme uz Latvijas lauku attīstību (Interaction of Natural and Socio-economic Conditions and Impact on the Development of Latvia Countryside), Jelgava, pp. 27–47. (in Latvian).
2. Boruks A. (2003) Zemnieks, zeme un zemkopība Latvijā no seniem laikiem līdz mūsdienām (Farmer, Land and Farming in Latvia from Ancient Times till Nowadays), LLU, Jelgava, 717 pp. (in Latvian).
3. Boruks A., Vītola Ī. (2004) Dabas apstākļi un to ietekme uz agrovidi Latvijā (Land Conditions and its influence on agroenviroment in Latvia), LR VZD, Rīga, 163 pp. (in Latvian).
4. Brīvkalns K. (1959) Latvijas PSR augsnes (Soils in Latvia SSR), LVI, Rīga, 69 pp. (in Latvian).
5. Brīvkalns K., Boruks A., Stablovs R. (1968) Zemju kategoriju izmantošana lauksaimniecības ražošanas organizēšanā (Use of Land Categories for Organisation of Agricultural Production), ZTIR, Rīgā, 35 pp. (in Latvian).
6. Galvenā ekciklopēdiju redakcija (1978) Kurzemes pussala / Pasaules zemes un tautas (Kurzeme Peninsula /Lands and Peoples of the World). Zvaigzne, Rīga, 401 pp. (in Latvian).
7. Centrālā statistikas pārvalde Latvijas 2001.gada lauksaimniecības skaitīšanas rezultāti (2003) (Results of Agricultural Census of 2001 in Latvia). CSP, 220 pp. (in Latvian).
8. Latvijas ģeogrāfija (1975) (Geography of Latvia) Zinātne, Rīga, pp. 150–163., pp. 434–436., pp. 605–609. (in Latvian).
9. Centrālā statistikas pārvalde (2004) Lauku saimniecību struktūra 2003.gada jūnijā (Structure of Rural Farms of 2003 in Latvia). CSP, 86 pp. (in Latvian).
10. Temņikova N. (1958) Latvijas PSR agroklimatiskais raksturojums (Agro-climatic Description of Latvia SSR), LVI, Rīga, 39 pp. (in Latvian).
11. Špoģis K., Zaharova Ž. (2003) Zemgale kā lauksaimniecības reģionos (Zemgale as a Region for Agriculture). In Economic Science for Rural Development, Jelgava, pp. 198-206. (in Latvian).
12. Справочник по климату. 5 выпуск (1966) гидрометеоиздательство. (Hydrometereology publisher) Ленинград, 86 с. (in Russian).

DIVERSIFICATION TYPES OF AGRICULTURAL BUSINESS ORGANIZATIONS ACTIVITY AND FACTORS DETERMINING THEM

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Abstract

The article analyzes the diversification types, forms and their choice conditioned by the inner and outer environment factors in agriculture business organizations. The analysis of the agriculture census data showed that external diversification of agriculture business organizations is more popular compared to internal diversification. The former diversification ensures extra incomes and higher employment of human resources without additional investment and with minimal risk. Wage labor is the main form of the external diversification. The internal diversification implements 5.9% of agriculture business organizations. Mostly these organizations choose closely related forms of internal diversification (non-traditional agriculture, ecological agriculture). Above mentioned agriculture business organizations are aimed at the synergy in more rational usage of available inner resources and less activity risk. The diversification of agricultural business organizations activity (when applying unrelated forms, e.g., wood reprocess and trade of wood ware, crafts, rural tourism) prevails in unfavorable for farming localities and is characteristic to organizations with higher intellectual and management potential.
Key words: diversification, agriculture business organization, types of diversification.

Introduction

In these latter years, the conditions of agricultural development, as the main activity of rural economy, are changing substantially. At present, one of the main ways of the adaptability to the changing conditions is the diversification of agricultural business organizations activity, which is associated with the creation of new products/services directly unconnected to the production of traditional agricultural products. Although in the literature of management the strategy of diversification is named as one of the most complicated business organizations development strategies (Thiele, 2002), with existing various diversification manifestation forms a possibility appears to implement this strategy under permanent external environmental conditions of business organizations and limited internal resources.

In most cases, the theoretical implementation of the diversification strategy of business organizations is associated with the dynamic change of external environment of business organizations. In the case of agricultural business organizations, the factors and motives of external environment have big impact upon the self-determination on the activity diversification as well as upon the choice of diversification types.

The research relevance is conditioned by the fact that diversification of agriculture business organizations activity is marked out as one of the main tendencies of the rural economics strengthening. In Lithuania, no research has been carried out concerning deeper application of the diversification strategy weighted according to the particularity of agriculture business organizations activity and conditions.

This research allows identifying the main forms of diversification strategy, which could be implemented in the agriculture business organizations, and also the factors and problems, which determine the choice of types and forms. The research results can be used in preparing the recommendations, forming the trends of support, etc.

The aim of the present research is to investigate diversification types and forms (as well as the factors of their external and internal environment determining such choice) of agricultural business organizations activity.

Materials and Methods

The evaluation of the spreading of the diversification types and forms of agricultural business organizations was carried out using the Agricultural census 2003 data carried out by the Department of Statistics under the Government of the Republic of Lithuania (Visuotinio, 2005). The investigation of the factors determining the choice of diversification types and forms was carried out according to the results of special empiric investigation.

Very different farms have been recorded during the agricultural census and only part of them can be attached to agricultural business organizations. The evaluation of the spreading of diversification types and forms was carried out according to the data of marketable farmers' farms, which appear to be the closest to business organizations in their aims and economical bases. From 271.5 thousand recorded farms, only 89,5 thousand, i.e. 33%, were marketable.

In the literature of management, several classifications of diversification types are presented (Ansoff, 1958; Jucevicius, 1998; Ginevicius, 2005). For the investigation of the diversification types of agricultural business organizations, the most acceptable, from the methodical point of view, is the classification of these types according to the ways of diversification strategy implementation and according to the interrelation of the 'old' and 'new' activities carried out in business organizations (Bowler, 1996).

Usually two implementation ways of diversification strategy are singled out, they are as follows: internal and

external. The essence of the internal diversification is the development of business organization activity while using their inner resources within the limits of the organization itself. The external diversification is associated with the 'withdrawal' of the activity or 'human resources' beyond the limits of business organization.

According to the connection of the 'old' and 'new' activities carried out in business organizations it is possible to single out related and unrelated diversification. The essence of the related diversification is when new products/services have interconnection with up-to-date products/services of business organizations. This connection can manifest not only in production but in realization stages as well (Berneiser, 2000). Unrelated diversification is based upon the expansion of business organization activity (with unconnected products/services) (Ginevicius, 2005).

Diversification forms of agricultural business organizations are singled out by applying the type of internal diversification. During the investigation such agricultural business organizations were analysed. They (plus to traditional farming (Zemes, 2005)) are engaged in the following activities:

1) forms of related diversification:
- untraditional agriculture (untraditional plant-growing – growing of medicinal plants, potherbs, decorative plants, flowers, mushrooms, osiers and other plants; untraditional animal-breeding – breeding of ostrichs, quails, grape snails, earthworms, leeches, sport horses, furry animals, deers, fallow-deers, and other domestic animals and wild animals);
- ecological agriculture;
- service rendering for agriculture (soil cultivation, harvesting, fodder supply, etc.);

2) forms of unrelated diversification:
- rural tourism (settlement, relaxation, and other related services);
- handicrafts (palm weaving, blacksmiths, ceramics, willow weaving, leather and glass production, etc.);
- wood processing and wood handicrafts making;
- aqua culture (fish breeding, fishing, etc.).

When carrying out empiric investigations, the methods of gathering of quantitative and qualitative information were coordinated (Tidikis, 2003). The gathering of quantitative information was carried out by the method of questionnaire poll when posting and e-mailing questionnaires. The gathering of qualitative information was carried out by the method of structuralized interview.

The general whole was determined according to the Agricultural census 2003 data carried out by the Department of statistics, when the size of general whole is known; the analysed grip was determined by the Schwarze method (1993). According to this method it was determined that the number of the investigatives is 381. The investigation was carried out in 2005, during which 252 respondents were questioned. The reciprocity of questionnaires was 54.7%.

For the evaluation, the methods of statistical grouping,

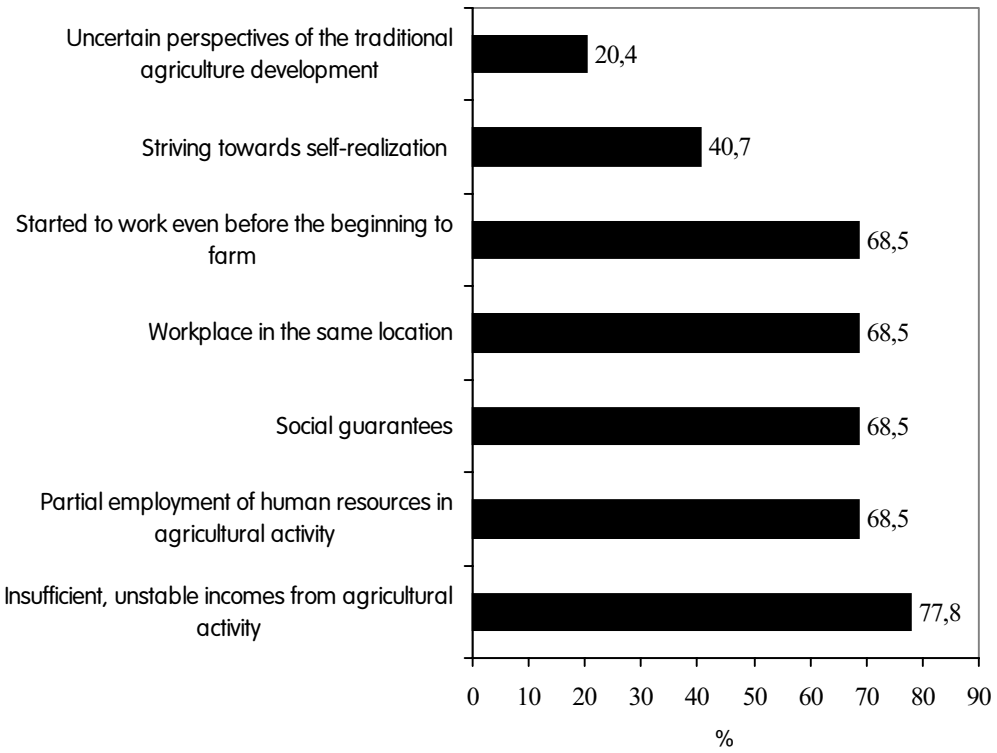

Figure 1. Respondents' opinion on the factors that influenced external diversification.

comparison and logical analysis, graphical viewing and summing were used.

Results and Discussion

The spreading and factors of external and internal diversification

The Agricultural census data analysis showed that the external diversification of agricultural business organizations activity is more popular than the internal one. Almost 25% of all farming persons and their family members were occupied with additional hired jobs. Therefore, it is possible to maintain that the similar part of agricultural business organizations carries out the external diversification of the activity, while only 5.9% declared the internal diversification of the activity. It means that the diversification of agricultural business organizations activity in most cases appeal to the redistribution of human resources by coordinating traditional agriculture with hired job of farming persons and their family members.

According to the results of the empiric investigation (Fig.1), two main unconnected among themselves groups of factors determine a major spread of external diversification.

They are as follows:

- insurance of farming persons with the help of hired jobs against insufficient and unstable incomes from agriculture. The hired job wage is a secure and stable source of revenue increasing home budgets of those farming and ensuring higher stability. Besides, a farmer or his family members working as hired workers do not experience additional expenses for the insurance of old-age pension and other social guarantees. Even 78% of the respondents indicated insufficient and unstable incomes from agricultural activity as the self-determination activity factor for internal diversification;
- un-coordination of farm's (as one of agricultural business organizations) size and structure with existing human resources and their professional education. In majority of agricultural business organizations, the existing human resources are used only partially, therefore, when rationalizing distribution and use of human resources their larger or smaller part is directed towards other business or public organizations. Farming persons' and especially their family members' professional education has large impact as well. Very often those without professional education employ themselves beyond the limits of business organizations, and for agricultural works workers from the outside are usually hired. Almost 69% of the respondents indicated the unreasonable use of human resources as the factor that influenced external diversification.

Similar factors in most cases condition agricultural business organizations to choose the internal diversification of the activity (Fig. 2). These are insufficient, unstable incomes from agricultural activity and unreasonable use of human resources in agricultural activity.

Insufficient incomes and rationality of human resources depend directly upon the size of business organization (in the case of this investigation – farm). It is obvious from the distribution of farms according to their size (Table 1).

The largest demands for activity diversification are in

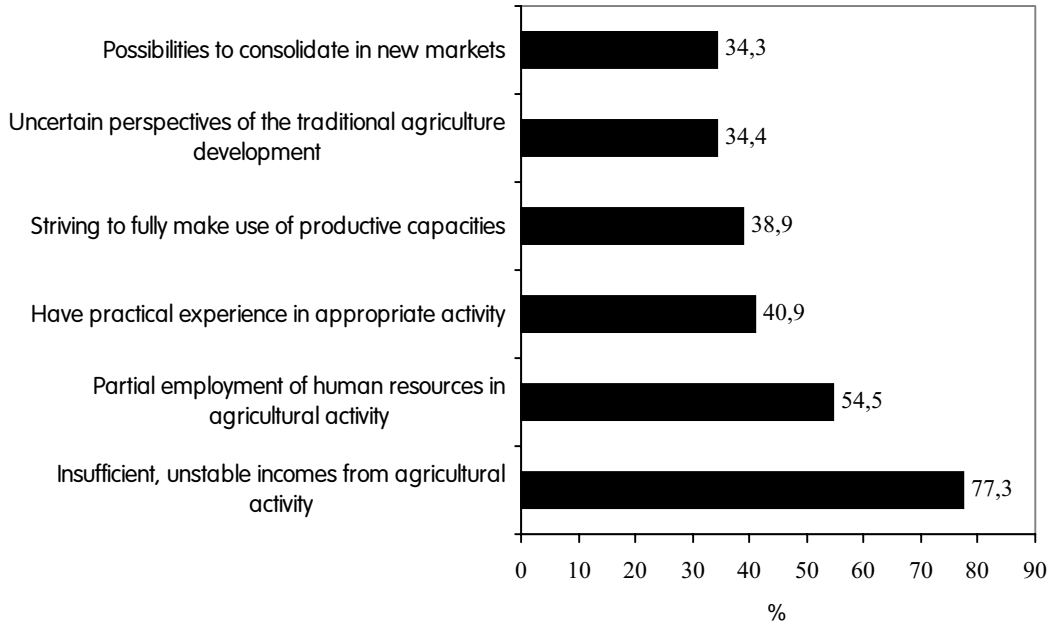

Figure 2. Respondents' opinion on the factors that influenced internal diversification.

Table 1

Respondents' structure according to their farm size, %

Groups of farms, ha	Distribution of farms in groups, %
up to 5	12.3
5-10	23.0
10-20	21.0
20-30	9.9
30-50	12.7
50-100	7.9
100 and more	13.2

small farms. A total of 56.3% of all farms diversifying their activity (from which farmers took part in the empiric investigation) were up to 20 ha in size, while 50 ha and larger farms made up only 21%.

Farm size and insufficient incomes connected with this as well as unreasonable use of human resources are common factors to both external and internal diversification, while other, less visible factors determine the choice of diversification type (according to the ways of strategy implementation). They are as follows:

- demand for investments when implementing diversification strategy and their appeasement possibilities. It is possible to maintain without additional scientific evidence that larger or smaller investments and means for that are necessary when applying internal diversification. The owner of other organization creates the place for hired jobs necessary for external diversification. Therefore, such farmers, who have no investment possibilities choose external diversification. External diversification is characteristic to the beginning of farming, when the flow of incomes from farming is small and the flow of investments must be large. Consequently, investment into the farm and especially means assigned to the consumption needs of the farmer and his family, are strengthened by the incomes from hired labour;
- potential of internal resources in agricultural business organization, necessary for the activity diversification. These are material (buildings, machinery, etc.) and intellectual (professional and practical abilities, enterprise, innovation, etc.) resources, underused in agricultural activity and having inconsiderable significance for the mastering of new business activities. Internal diversification is an additional possibility to use these resources more rationally as well as for the creation of additional surplus value. Approximately 40% of the respondents connected directly their self-determination to carry out internal diversification with the striving to better use of the accumulated practical experience and existing productive capacities. Without or with insufficient internal resources and with limited possibilities for means investments the priority should be given to external diversification;
- new possibilities in goods and service markets influencing the choice of particular diversification form. It is possible to state that respondents evaluate insufficiently seriously the importance of markets and opportunities afforded by these markets when carrying out activity diversification. Only 34% of the respondents (carrying out internal diversification) stated that this factor was an important one. A big possibility for the unsuccessful choice of diversification trends and new business fields appears when underestimating afforded possibilities. In the case of market instability and undeveloped marketing, with the shortage of enterprising and means for investments, external diversification is less risky;
- other factors, directly unconnected with business aims as well as with the distribution of resources and use rationalization; however, they are important in the private lives of those farming and their family members. One of such factors is the strategically unplanned purchase of the land suitable for agricultural activity (by way of inheritance or by way of land return from the state fund) conditioning the self-determination of how to dispose of this land and how to coordinate this disposal with other activities including and the hired labour career. Unformed land and agricultural products markets, rapid changes in all economic sectors conditioned large uncertainty and hesitation among people when choosing farming or continuing the hired labour. In this situation the medium solution was chosen, i.e. to continue the hired labour while contiguously farming. Very often this solution turned into the one to apply the external diversification strategy, especially when not long distances between farming and hired labour places allow doing this.

The spreading and factors of related and unrelated diversifications

Two vivid subtypes can be singled out in the internal

diversification of the agricultural business organization activity according to the interrelationship between traditional agriculture and the newly started development of activities in organizations. It is related and unrelated diversification.

In Lithuania, according to the Agricultural census data, from 5248 marketable farmers' farms (that had diversified their activity) 69.9% implement related diversification and 30.1% implement unrelated diversification. Calculating from the number of all registered marketable farms, 41% implement related diversification and 1.8% implement unrelated diversification. It means that related diversification is more close and attractive for the country's agricultural business organizations.

The majority of those implementing internal diversification of the activity choose a narrow combination of activities, i.e. they adjust one new activity to the traditional agriculture. However, during the empiric investigation, many wide internal diversification cases of the activity have been noticed, when not one, but two or even more new activities were engaged in (in parallel with agriculture). Altogether 16.7% of the respondents implemented wide diversification, and 0.8% of the respondents coordinated 3 and more new activities to the traditional agriculture. From the management point of view, it is very difficult for the small business to successfully master many activities while ensuring the long lasting competitive ability of goods and services. Wide diversification justifies only during short periods under especially unstable market conditions, when it is difficult to make long lasting decisions on strategic activity directions. Therefore, the phenomenon of the wide internal diversification of agricultural business organizations can be considered not as purposeful striving but as a temporal phenomenon determined by the toss of farmers when choosing the rational combination of activities under unstable market conditions as well as by the uncertainty of some other factors of external environment.

Internal diversification is concurrent with diversification form, i.e. with 'new' activities, which are brought into the structure of business organization. According to the agricultural census data, in Lithuania the main diversification forms of agricultural organizations activity are not characteristic in diversity (Table 2).

Untraditional agriculture is the most popular among the related diversification forms, especially the growing of medicinal plants and potherbs, the growing of rare vegetables as well as the ecological agriculture. The larger diversity is when choosing unrelated diversification. Mostly it is wood processing, wood handicrafts making, handicrafts, aqua culture, and rural tourism.

When estimating the choice of the internal diversification forms and the factors determining it, it is possible to envisage the common tendency characteristic to both related and unrelated diversification. It is the coordination of traditional agriculture with the following activities:

- which need natural resources: forest – as resource necessary for wood processing; lake or pond – as resource necessary for aqua culture; exclusive landscape – as resource determining rural tourism is in the next rural environment or even in the agricultural business organization diversifying its activity;
- to which products and services market conditions are favourable: high demand; worked off realization channels, long-termed selling agreements. It is service rendering for agriculture, wood processing, rural tourism, ecological agriculture, and some other

Table 2

The structure of the internal diversification of agricultural business organizations activity (according to the agricultural census data)

Diversification type	Diversification form	Number of agricultural business organizations	Structure, %
Related	Untraditional agriculture	743	14.1
	Ecological agriculture*	72	1.4
	Service rendering for agriculture	2,855	54.4
	Total	3,670	69.9
Unrelated	Rural tourism	134	2.6
	Handicrafts	161	3.1
	Wood processing and wood handicrafts making	783	14.9
	Aqua culture	152	2.9
	Other	348	6.6
	Total	1,578	30.1

* only such agricultural business organizations were registered, in which ecological production was carried out by covering only part of agricultural farming lands used by agricultural business organizations

branches of untraditional agriculture;

- which development coincide with the directions of European Union's general agricultural policy and rural development policy as well as with supported activities. In the documents programming rural development and regulating this policy, rural tourism, ecological agriculture, handicrafts, aqua culture, and development of services for agriculture are named as the most perspective diversification trends of rural economic activity.

These diversification forms are connected with the choice of such activities, which are mostly popularised and are less risky. Such choice is conditioned by low enterprising and innovation of agricultural activity subjects as well as by significant influence of agricultural and rural policy. The low diversity of diversification forms can have negative impact in the future due to the direct competition between agricultural business organizations diversifying their activity.

The main factor conditioning the wider development of related diversification (in comparison with unrelated diversification) is the possibility to decrease the demand for investment means when compensating it by the synergy achieved from coordination of activities.

Coordination of activities can be achieved when using the same technological equipment and machinery, the same human resources, their qualification preparation and practical experience not in one but in several activities. When coordinating activities, general volumes of investments, qualification preparation of human resources as well as marketing costs are decreasing. One of the most obvious examples of the related diversification providing large synergy possibilities is service rendering for agriculture. The use of agricultural machinery, made up for personal needs, is increased while rendering services of mechanized farm works externally. Here the large synergy is achieved through one investment while purchasing the same machinery necessary for two activities, the common maintenance and exploitation of this machinery and qualification requirements for the exploitation of this machinery. The similar synergy is achieved and in other cases of related diversification, i.e. when coordinating the traditional agriculture with ecological or untraditional agriculture.

The popularity of related diversification is increased by its less risky degree as well (in comparison with unrelated diversification). When choosing related diversification forms is obvious more clearness concerning future, simpler and less damaging is the withdrawal from 'old' activities. When implementing the related diversification it is unnecessary to thoroughly reorganize the internal structures of business organizations.

Many factors determine the less popular unrelated diversifications. The factors are as follows: the necessity to penetrate into new markets, large investments, demand for new qualification abilities, reorganization of internal structures in business organizations, and finally – larger risk. Therefore, in major cases, the diversification of agricultural business organizations (when choosing its unrelated forms) is determined by choosing restrictions of the development of traditional agriculture and related diversification, by the sensation for new opportunities on market and state support as well as by special abilities and high motivation. The impact of these factors can be interpreted according to the empiric investigation results presented in Table 3.

Traditional agriculture and diversification forms related to it are directly connected with natural factors which differences best of all are reflected by favourable and less favourable for farming localities. According to the empiric investigation results the related diversification is more extended in favourable for farming localities, and the unrelated one – in less favourable for farming localities. In the localities, where conditions for traditional agriculture are limited, conditions for service rendering for agriculture, even for the ecological agriculture, are limited as well. The growth of organization itself as well as income growth can be achieved only by the forms of unrelated diversification. In these localities, natural conditions are suitable for this purpose. Landscapes, lakes, forests and other items, conditioning the development of such diversification forms as rural tourism, aqua culture, and handicraft, prevail.

The unrelated diversification is kind of innovative and requires special abilities, markets cognition, and active marketing. Therefore, more educated persons, highly estimating the meaning of progressive science and engineering, assume its putting into practice risks. It is very difficult to evaluate this all in the empiric investigation. That is why it was connected (in generalization) with education. From Table 3 it is possible to see that the farmers with higher education usually put into practice unrelated diversification forms (characteristic in innovation). For example, from all farmers – respondents, who have chosen rural tourism for the activity diversification, 58.3% had higher education. The shortage of education and enterprising impede the choice of even more innovative forms of diversification.

Conclusions

1. The diversification of agricultural business organizations activity is conditioned by the insufficiency of agricultural business development determined by existing tendencies on world's food market and by contemporary agrarian policy. The necessity to diversify their activities, agricultural business organizations understand as possibility to get additional incomes and to more rationally use existing human and material resources.
2. The type of external diversification best of all corresponds to the intellectual and investment capability of Lithuanian agricultural business organizations, because additional incomes and better employment of human resources are

Table 3

Distribution of respondents applying internal diversification according to the forms of diversification and according to some factors determining them

Diversification types	Diversification forms	Number of agricultural business organizations	Of these, situated in unfavourable for farming localities*	Part of the respondents with higher education, %
Related	Untraditional agriculture	59	49.2	35.6
	Ecological agriculture	18	55.6	61.1
	Service rendering for agriculture	25	20.0	28.0
Unrelated	Rural tourism	12	91.7	58.3
	Handicrafts	11	54.5	45.5
	Wood processing and wood handicrafts making	13	46.1	15.4
	Other	27	66.7	40.7
Mixed (related and unrelated)	Diverse	33	33.3	48.5

* Unfavourable for farming localities are passed by the order (by the Minister of Agriculture of the Republic of Lithuania on February 27, 2004) 'Regarding less favourable for farming localities'. This order is replaced by the order No. 3D-278 of May 3, 2004 'Regarding the replacement of Agricultural minister's order No. 3D-72 'Regarding less favourable for farming localities".

ensured without additional investments and with minimal risk.

3. With the lack of experience for agricultural business organizations in the field of marketing, in major cases internal diversification is developed when choosing its related forms and seeking for synergy from the more rational use of existing inner resources by coordinating 'new' activities with traditional agriculture.

4. The diversification of agricultural business organizations activity (when applying unrelated forms) prevails in unfavourable for farming localities and is characteristic to organizations with higher intellectual and management potential.

References

1. Ansoff H.J. (1958) A Model for Diversification. Management Science, 4, pp. 392-414.
2. Berneiser M. (2000) Zur Entwicklung der Diversifikationssparten in ländlichen Warengenossenschaften der Primär- und Sekundärstufe (For the development of the diversification sections in rural goods co-operatives of the primary step and secondary step). Available at: www. http://ch.expasy.org/cgi-bin/get-entries?RA=Berneiser%20S , 12.10.2004. (in German).
3. Bowler I., Clark G., Crockett A., Ilbery B. and Shaw A. (1996) The Development of Alternative Farm Enterprises: A Study of Family Labour Farm in the Northern Pennines of England. Journal of Rural Studies, 3, pp. 285 – 295.
4. Ginevičius R., Sūdžius V. (2005) Organizacijų teorija (Theory of Organizations), Vilnius, Technika, 279 pp. (in Lithuanian).
5. Jucevičius R. (1998) Strateginis organizacijų vystymas (Strategic Development of Organizations), Kaunas, Pasaulio lietuvių kultūros, mokslo ir švietimo centras, 454 pp. (in Lithuanian).
6. Schwarze J. (1993) Grundlagen der Statistik 2.5th (Bases of the 2,5th statistics), Herne/Berlin, Neue Wirtschaftsbriefe, 150 pp. (in German).
7. Thiele H.D., Weiss C.R. (2002) Diversifikation und Wachstum landwirtschaftlichen Unternehmen (Diversification and growth of agricultural enterprises). Available at: http://www.agrimanager.de/agrarwirtschaft/aktuell/beitraege/pages/showmsg.prl?params=recent%3D1%, 16.04.2005. (in German).
8. Tidikis R. (2003) Socialinių tyrimų metodologija (Methodology of Social Research), Vilnius, Lietuvos teisės universiteto leidybos centras, 626 pp. (in Lithuanian).
9. Žemės ūkio respondentinių įmonių duomenys (2005) (Data about Agriculture Enterprises), Vilnius, Lietuvos agrarinės ekonomikos institutas. Parengė R.Būdvytienė, R.Daunytė, J.Grigalienė, V.Kučas, A.Kuodys, J.Misiuvienė, 107 pp. (in Lithuanian).
10. Visuotinio 2003 m. surašymo rezultatai (2005) (Results of the 2003 Agricultural Census in Lithuania), Statistikos departamentas prie LRV, 273 pp. (in Lithuanian).

METHODOLOGICAL ATTITUDES OF THE RESEARCH OF EMPLOYEE MOTIVATION

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Abstract

The article is meant to analyze the methodological qualitative characteristics of the creation of employees' motivation model. These characteristics help to measure the reliability of research instruments. In accordance with Kendal ranking correlation (Henning, 1997) there are identified motivation indicators of managing employees and executives.
The main attention is paid to the importance of motivation models' shaping and the essential principles by giving the results of model shaping and their interpretations.
Key words: motivation, models, instruments of research, methodics.

Introduction

The opinion is prevailing that research methods in the field of management are not being formed yet.

Researches carried out in the management can be modelled by interpretative (phenomenological) models, therefore it is needful to decide on the strategy formation (at methodological level).

When analysing the experience of the leaders from Lithuanian enterprises in the field of the employee motivation model construction, one should acknowledge that this problem hasn't been investigated enough and elucidated in literature sources. When intercepting experience from other countries, leaders start to use elements of motivation models borrowed from foreign countries' employees, however, not everyone succeeds, because of the lack of theoretical knowledge and practice implementation of motivation models without the comprehensive analysis is being mechanically or entirely ignored by Lithuanian employees.

Having evaluated motivation elements of the employees from Lithuanian enterprises beforehand, it is possible to economically ground the decisions made, to form rational program on motivation means, to align operations in such way as to use every enterprise's advantages at its maximum.

The necessity to choose the best choice of the implementation of motivation solutions, actions as well as means conditions the expediency to carry out the integrated investigation of employees' (from Lithuanian enterprises) motivation means and ways.

Novelty of the research. Referring to the research methods of Kendal's rank correlation, collision (imaginary) situations and triangulation, the following items are analysed in the space for motivation: activity motives and behaviour sources of a particular person or society, motives of leaders - autocrats and democrats - as well as motives of subordinates - particular persons and work groups.

Research object: employee motivation.

The aim of the research: to prepare the methodics of the creation of employee motivation model.

Materials and Methods

Scientific and publicist literature was analysed while investigating motivation, behaviour and motivation methods of separate periods of time; primary and secondary sources were analysed while clearing out the influence of separate factors for motivation and efficiency of measures offered; the method of quantitative investigation was applied while carrying out the main practical investigation; the method of collision situations was used while creating investigation instruments and their projects.

Correlation of motivation forms with work satisfaction and its results has been defined. The impact of the main factors such as qualification, delegation of power, continuing training and material as well as psychological means on motivation of employees is analysed in the paper. With the help of triangulation investigation method, Lithuanian enterprise employees' motivation and behaviour at work has been evaluated in the three aspects. The main aspects are as follows: interests of leading workers, interests of executive workers and neutral attitude towards the compatibility of these interests. It is a new attitude towards employees' motivation models. With reference theoretical and practical investigations, Lithuanian enterprise employees' motivation model has been prepared.

Results and Discussion

Verification of the reliability of the data and the employee motivation model's creation instruments

The aim of this research is to confirm the correctness of methodological presumptions (that had been reached during the theoretical analysis) as well as presumptions (model implications) of conceptual problem solution formed in their base (Fig.1).

When analysing the motivation of employees from Lithuanian enterprises, activity motives (aims of the society), information addressees (leading and executing employees) were determined. Every one of these components was qualitatively evaluated and differentiated. The whole motivation process is being analysed in the three-dimensional space.

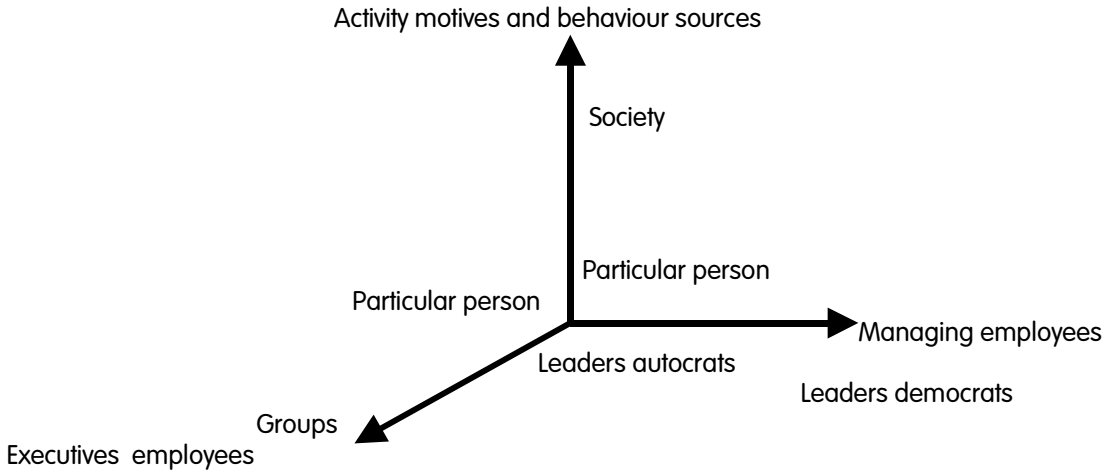

Figure 1. The space for motivation (Marcinkevičiūtė, 2003).

The analysis of employees' activity motives and behaviour very often appeal to presumption that people are improving during all their life, therefore, during every stage of the age the motives and behaviour of their activity can be different (Steers, 1981; Stogdill, 1999).

During the investigation period, variants of answers should be singled out from respondents' propositions. Those variants should provide information on qualities desirable. In the investigation by metrological construct, the phenomenon measured not less than by two questions of the research instrument (questionnaire) was approached.

Particular empiric indicators as well as specific measurement scale are chosen for the measurement of metrological constructs and subconstructs. Significances of metrological constructs (leaders and executives) are measured directly. Questions created for the direct measurement of every construct made up subconstructs of the direct measurement. The summary of the should-to-be-used (in questionnaires) constructs and subconstructs as well as measurement peculiarities are presented in Table 1.

All constructs and subconstructs are thoroughly singled out and compared with measurement models suggested in the scientific (Marcinkeviciute, 1998). When creating the research instrument it is necessary to avoid mistakes, which should impede to ensure validity and reliability criteria. From the literature analysis it turned out that the research of phenomena is rather complicated, especially through questionnaire. It is necessary to note that questionnaire questions must be formulated as opinion questions, because the aim of questions is to thoroughly analyse the employees' activity motives and get the more comprehensive information on the character of the behaviour of those being researched. The questions in this research are kind of indicators defining the indicated (the researched feature, i.e. employees' motives) directly (opinions of those researched on the motivation in their enterprises) and indi-

Table 1

The summary of metrology constructs, subconstructs and measurement peculiarities used in questionnaire (2003-2005)

Importance of subconstructs	Numbers of questions
Metrological constructs LEADERS	
Application of professional abilities	7
Information and warrant delegation	13
Work salary	6
Appropriate leadership	6
Valuable orientations	4
Metrological constructs EXECUTIVES	
Work salary	8
Application of professional abilities	5
Professional training	12
Socio-cultural cooperation	10
Information and decision-making	10

rectly (when employees' behaviour at work was being researched).

In scientific literature, the 5-point scale is usually suggested for the evaluation of employee motivation, in which every question has its number meaning respondents' opinions: 1 point – absolutely not important, 5 – very important.

In the authors' opinion, variant answers expressed only by numbers, insufficiently comprehensively name the structure of employees' motives and behaviour, therefore the method of collision (imaginary) situations is being chosen.

Majority (80 per cent) of the questions on the employee activity motives and behaviour at work were with the fan of answers, where every variant of the answer meant different proposition. When coordinating private, semi-public and public questions it is possible to receive more detailed, more comprehensive and more reliable information. When receiving semi-public questions, respondents were given the opportunity to express their opinion and to additionally comment and express their remarks on the especially important questions of the research.

According to the author Davis (1995), the most important attribute of the characteristic (when analysing the object) is that it must be measured. If conception of measurement would be connected only with the routine measurement procedures of physical bodies' characteristics, the measurement of sociological phenomena would be impossible. In the XXth century, especially in its second part, conception of characteristics measurement was generalized and was applied for the characteristics of the objects of any nature (Hinrichs, 1994; Hofstade, 1999). Today, the procedure of measurement means the attribution of numbered meaning to the objects (when keeping to special regulations). Regulations can vary, therefore three different scales can be constructed.

In the research of Lithuanian enterprises' employee motivation, a rank scale has been created, because the value of constructs and subconstructs is received by interest-bearing expression. In order to avoid complications, the interest-bearing expression can be transformed into ranks from 1 to 10. In order to correctly attribute respondents' answer variants to one of the rank levels, all answers' meanings in the measurement scale can be distributed into the following intervals: the 1st rank (the highest level) involves answer meanings from 90 to 100 per cent, the 10th rank (the lowest level) involves answer meanings from 0 to 10 per cent (Fig. 2).

By the rank scale, only one rank is attributed to every answer variant, therefore there are no problems with the indentification of the number of ranks with the number of measured characteristics. The entire measurement scale can be divided into ten intervals every one of which would cover by 10 per cent of the whole scale. This criterization (when singling out ranks) is needful when trying to unanimously classify the research data.

Practice shows that the appliance of methods of statistics is needful for the grounding of the reliability of research instruments (statistics are treated as means, not as aim). The possible ways of the appliance of the methods of statistics are as follows: the assurance of methodological quality characteristics of the research (the measurement of questionnaire reliability), the measurement of the internal compatibility of questions (Kendall's coefficient of concordance), and the measurement of the relationship between the answers to questionnaires (the modified Kendall's coefficient of concordance).

One can find affirmation in the scientific literature that the reliability of research instruments can be proved by the two following stages: when measuring the internal com-

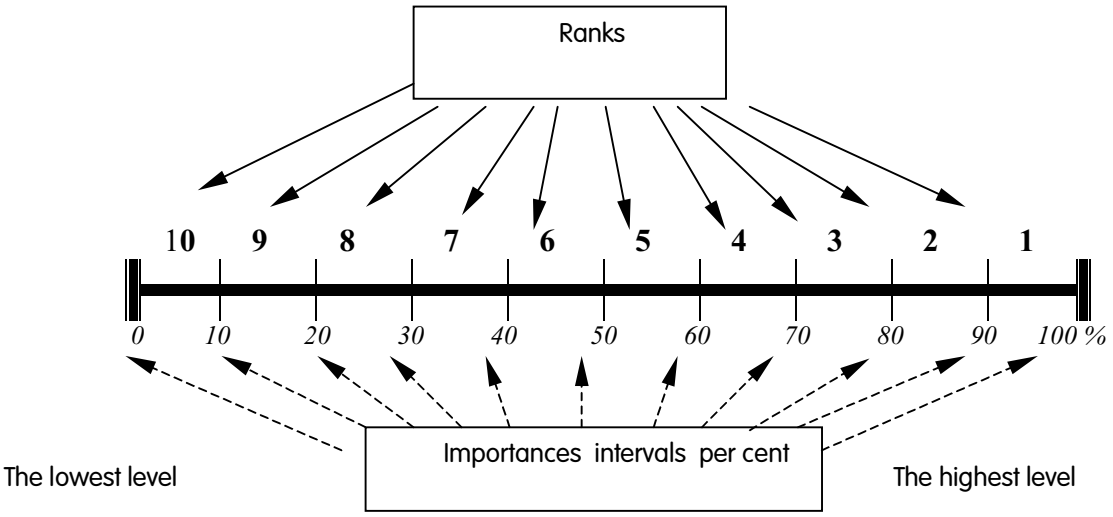

Figure 2. The criterization of answers assignment to the ranks (Marcinkevičiūtė, 2003).

Table 2

Inner compatibility of questions in the questionnaires of the managing employees and executives (2003-2005)

Subconstructs	W(m) meaning	λ^2 meaning
LEADERS		
Application of professional abilities	0.83	149.4
Information and warrant delegation	0.13	67.6
Work salary	0.33	99
Appropriate leadership	0.51	122.4
Valuable orientations	0.88	167.2
EXECUTIVES		
Work salary	0.36	115.2
Application of professional abilities	0.22	39.6
Professional training	0.13	67.6
Socio-cultural cooperation	0.21	88.2
Information and decision-making	0.43	129

patibility of questions in the questionnaires of the leading and performing employees.

The measurement of the internal compatibility of questions. The modified Kendall's coefficient of concordance (W(m) – Kendall's rank coefficient) should be used for the internal compatibility of the questionnaire questions. It allows determining the relationship between two rank series. Since the relation between more than two rank series should be determined during this research, Kendall's coefficient of concordance (compatibility) is used. Since in the series compared combined ranks exist, the following modified equation for the calculation of the coefficient of concordance is used:

$$W(m)=12\cdot S/\ m^2\cdot(n^3-n)\cdot m\cdot \Sigma\, T^{(i)}, \qquad (1)$$

where:

S – the sum of squares of declinations from mean;

$\Sigma\, T^{(i)}$ – i series correction coefficient;

m – the number of rank series analysed;

n – the number of variables characterizing series.

The values of Kendall's coefficient of concordance (compatibility) are presented in Table 2.

On the basis of research data of econometrics theorists (Hofstade, 1999; Hinrichs, 1994) in reality this coefficient varies between the limits from 0 to 1. When n>7, λ^2 is used, if the following condition is valid:

$$m\cdot(n-1)\cdot W(m)>\lambda^2(\alpha_{(n-1)}), \qquad (2)$$

where the calculated coefficient of concordance W(m) was meaningful;

$$\lambda^2=m\cdot(n-1)\cdot W(m). \qquad (2.1)$$

In all cases the calculated λ^2 value is larger than the theoretical one, therefore the coefficient of concordance W(m) gains meaningfulness showing the coincidence of respondents' opinions (theoretical values of λ^2 can be find in the statistical tables (Hinrichs, 1994)).

With reference to the statements of people, who took part in the opinion poll, the main motivation elements of the leading and executing employees were determined.

Motivation elements of the leading employees are as follows: improvement of the appliance of potential opportunities, motivation on consulting, information and delegation of warrants, valuable orientations, intercourse between leaders and subordinates, reasons for marriage and work ethic violations, and attitudes towards salary.

Motivation elements of the executive employees are as follows: socio-cultural intercourse and peculiarities of the national character, improvement of career education policy, professional skills and safety at work policy, attitudes towards information transmission, responsibility and decision-making, attitudes towards work salary and the analysis of the reasons of dissatisfaction with work (demotivation).

After the evaluation (by the values of the Kendall's rank correlation coefficients) of the importance of the questions and the significance of the answers, designed questionnaire variants can be prepared. They could be useful for the research of the motivation of the leading and executive employees. It is necessary to emphasize that after the appliance of the methods of statistics for the assurance of the quality of methodological characteristics (questionnaires), the number of primary questionnaire questions decreases significantly.

In this research the management practice of existing enterprises is taken into account. Such practice says that when reacting to the internal and environmental changes, the main passport to success in the rapidly changing envi-

ronment is the ability to envisage the forthcoming changes when they aren't noticeable yet. Having evaluated the importance of the chosen subconstructs (in both leaders' and executers' constructs), the most effective elements of the models of employee motivation subconstructs were determined and motivation models of the leading and executive employees were created.

The basis for the motivation model of leading employees – an appropriate appliance of professional abilities of employees. Formation of the abilities in the enterprises could be conditioned by the creative approach of the employees towards the work, competence to look for novelties, enthusiasm, creative courage, the maintenance of continuous relation with the collective, belief in one's efforts and possibilities, and competence to critically look upon one's work. When applying this motivation model, the leaders of enterprises should know which activity motive is seen as an advantage (in the system of remuneration) by their subordinates, because over time activity motives vary and motivation means which played once, could be ineffective next time.

The information of employees and the feedback in the enterprises should ensure the more circumstantial objective information. The constant continued training in the enterprises should be not only formal, but practical as well grounded by individual, motivated initiative of the employees, their active position and responsibility. Therefore, progressive learning methods should prevail in the process of training. Professional improvement should become individual. The choice of forms, methods and ways of learning should depend on the individual position of those learning. The timely renewal of progressive technologies should enable training to be organized in various forms not depending upon training program, place, time of training as well as other parameters.

The basis for the motivation model of executive employees – economical demands and maximization of enterprise profit. Employees should be motivated by work salary, awards, premiums, etc. When applying the abovementioned model, the constantly varying part of the work salary would become as stimulant, and premiums would be paid only for the anticipatory and qualitative fulfilment of the named tasks. Employees' productivity, work quality or polite service of clients could be as particular criteria when evaluating work salary. Preferred stock purchase of the enterprise would give employees partial business ownership enabling them to a share in the profits of the company. Employees would work better, because they would feel as enterprise owners. The model would evaluate the work efficiency and appropriate results of the whole company or its industrial subdivision. The variety of tasks would enable employees to evaluate their efforts and the appliance of their professional abilities at work.

Having analysed the composition of constructs of the leaders and executors, the author of this paper has defined that there are common links between the motivation models of leading and executive employees. In such case, the coordination of positions of the leaders' and performers' constructs was carried out (Fig. 3).

Having intercoordinated the constituents (elements) of the subconstructs of the leading and executive employees, the common motivation model of the employees (for both leading and executive) is being prepared. The structural elements of the model are as follows: appliance of professional abilities, work salary, information, warrant delegation and decision-making, professional training, socio-cultural cooperation and valuable orientations.

Alternatives of the means suggested by the motivation model strengthen the inward and outward activity

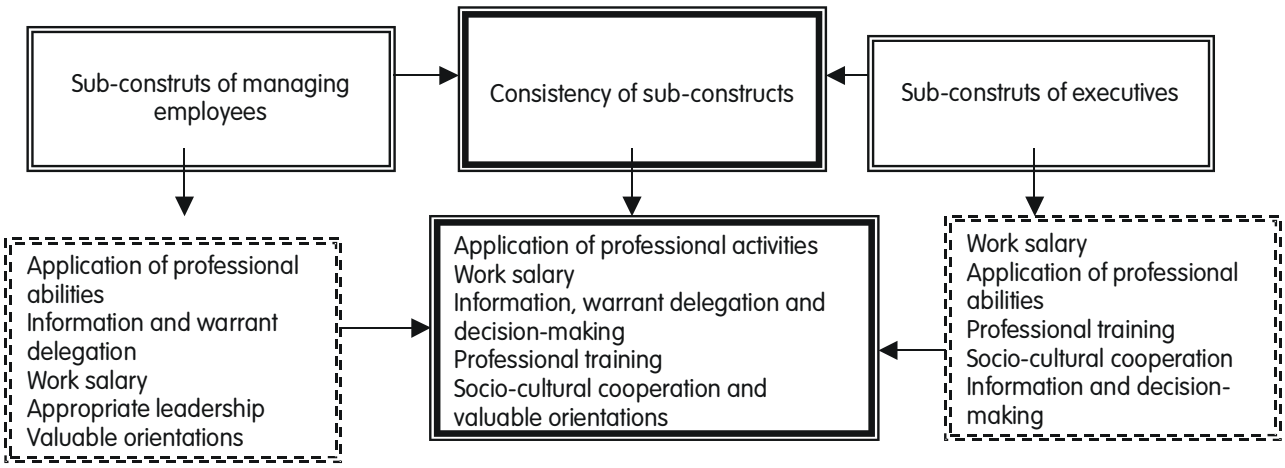

Figure 3. Consistency of the managing employees' and executives' sub-constructs.

motivation, positively affect the employees' wish and disposition to work qualitatively, because good rates can be achieved only when leaders mind the welfare of their employees, use social, economical and psychological means in the motivation when coordinating the interests of employees and the enterprise.

The suggested adaptation of the motivation model as well as the effectiveness in practice is grounded by the examples of alternative motivation model formation and choice (in USA, Japan, Finland, Great Britain, Germany and other countries), which have already proved the growth of the potential of the satisfaction level of the employees' activity motives. The suggested means would decrease the risk of the decision making of the nonqualitative management by 15 per cent and would anticipate the implementation of theoretical attitudes of motivation into practice.

Conclusions

1. In order to create rational employee motivation models one must keep to some kind of logical analysis and consistency, because the creation of models requires big preparatory work, i.e. the evaluation of the present condition of the employee motivation and the determination of the constructs of the research instruments.
2. Leaders of the companies should carry out practical investigations of the employee motivation in their own companies in order to determine activity and behaviour motives as well as motivation means prevailing between employees. Having diagnosed the employees' motives as well as their development level and variation tendencies, leaders should choose the most appropriate motivation ways by determining their priority.
3. The following structural elements could make up the employees' motivation model: professional abilities, work salary, information, warrant delegation and decision-making, professional training and socio-cultural cooperation as well as valuable orientations.
4. The means suggested by the motivation model would decrease the risk of the decision-making of the nonqualitative management by 15 per cent and would anticipate the implementation of theoretical attitudes of motivation into practice.

References

1. Davis K., Newstrom J. (1995) Human Behavior at work: Organizational Behavior, New York, McGrawHill Book Company, USA, 253 pp.
2. Henning M. (1997) Psychology: The Science of Mental Life, New York, McGrawHill Book Company, USA, 65 pp.
3. Hinrichs J. (1994) The Motivation Crisis, New York, Megraw-Hill, USA, 320 pp.
4. Hofstade G. (1999) The Cultural Relativity of Organizational Practices and Theories, Limberg, West Publishing, UK, 321 pp.
5. Marcinkevičiūtė L. (1998) Behaviour, Work Motivation and Motivation Methods of the Enterprise: master theses, Kaunas, Academy, LT, 75 pp.
6. Marcinkevičiūtė L. (2003) Peculiarities of Workers' Motivation Models of Lithuanian Enterprises under the Changing Market Conditions. Doctoral theses, Kaunas, Academy, LT, 150 pp.
7. Steers M. (1981) Employee Turnover and Post – decision Accomodation Processes, Greenwich, Jal Press, UK, 236 pp.
8. Stogdill R. (1999) Personal Factors Associated With Leadership, Boston, Public Personnel Management, USA, 71 pp.

THE REAL EXCHANGE RATE AND COMPETITIVENESS IN LATVIA

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Abstract

The main aim of the paper is to analyse influence of the real exchange rate on competitiveness of Latvia. Using fundamental equilibrium exchange rate methodology the equilibrium real exchange rate for Latvia is estimated. According to the model's results the real exchange rate was overvalued almost during all the reporting period and therefore it could be used as one of the factors influencing competitiveness of Latvia.

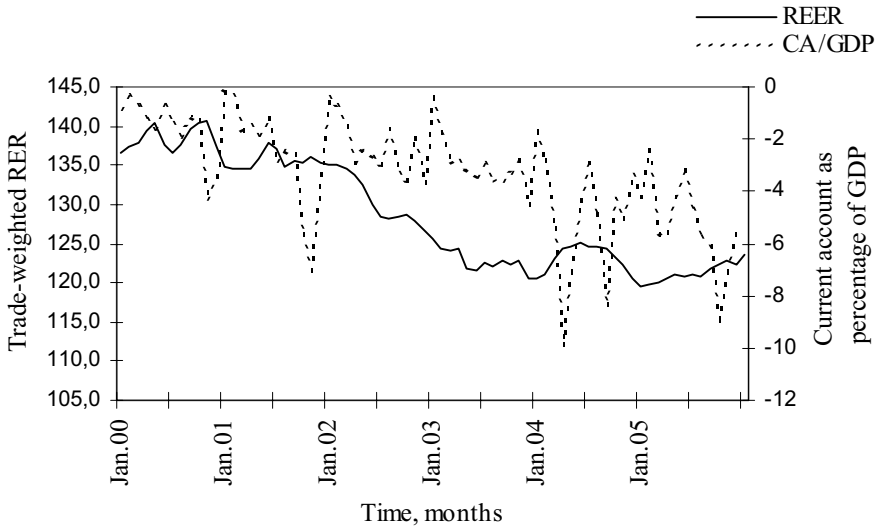
Key words: equilibrium real exchange rate, competitiveness, fundamental equilibrium exchange rate methodology.

Introduction

There are many indicators that can be used to capture the changes in external competitiveness of a country. The concept of the real exchange rate (RER) is used most commonly. The RER is recognized in economic theory and policy as one of the key macroeconomic variables, in particular in the case of a small open economy. It determines the relative price of domestic and foreign goods and therefore impacts their demand and price behaviour. If the RER is below its equilibrium, this stimulates the demand through increased exports but produces inflationary pressures especially as the aggregate demand reaches its supply potential. An appreciated RER conversely decreases the demand for domestically produced goods, depresses the domestic output growth and generates downward pressures on inflation. This output and inflation trade-off related to the RER is particularly relevant to the recent discussions in our society about the decision of the Bank of Latvia authorities to choose the central parity at the ERM II entry and the euro adoption later on. If a country has participated in the ERM II and adopts the euro with an overvalued currency, it is likely to find it has lost competitiveness and subsequently will experience a slower convergence of real incomes toward the EU level. The basic assumption of claims for devaluation is that real exchange rate appreciation has directly translated into loss of competitiveness of Latvian economy. Has it really been so? How it could be detected?

Statistical data shows that the important problem that Latvian monetary authorities should take into particular consideration as potential risk is a current account deficit (Fig. 1), which is considered to be a potential risk factor for the macroeconomic stability. After visual examination we can see (at least in short-run) some relationship between trade-weighted (effective) real (taking into account prices) exchange rate and current account deficit as percentage of GDP.

Overvaluation of the exchange rate can have a negative impact on exports and can cause a sharp decrease in the pace of export growth. But it is difficult to estimate correctly the value of the real exchange rate in the developed countries. It is even harder to trace this process in transition economies, where the programs of macroeconomic



Source: Bank of Latvia.

Figure 1. Current account deficit and real effective exchange rate (Index, Dec.1996=100) in Latvia (2000 – 2005).

stabilization start with undervaluation of the exchange rate and sharp increase in productivity due to reforms and structural changes. In this paper the author operates with trade-weighted real exchange rate, calculated by the Bank of Latvia.

Since exchange rate is a substantial factor in the scope of external competitiveness, the first step of the analysis is the estimation of equilibrium exchange rate of Latvian lat to see whether the exchange rate of lat is over-valued, undervalued or is about to be optimal. From theory, a significant departure of the RER implied by the central parity from its equilibrium value may indeed either exacerbate the inflation pressures and demand if the RER is too depreciated or contract the economic activity and prices if the RER is too appreciated (Edwards, 1989). This motivates evaluating how the actual RER compares to its equilibrium and how this relationship may evolve in the future.

Previous studies related to similar questions about RER and competitiveness in Latvia covered the period till 2001. Articles by Krajnyak and Zettelmeyer (1997) and Begg (1999) imply that RER of the Latvian lat was overvalued between 1993 and 1999, but they also conclude that ever lasting current account deficit is not so much due to exchange rate policy but rather because of a too slow/ insufficient structural adjustment on a micro level. In this case macro adjustment (devaluation) will be short-lived and possibly even damaging. One of the later publications concerned the real exchange rate dynamics in Latvia is the paper by Bitans (2002), a researcher in the Bank of Latvia. He concluded that in 2001 the exchange rate in Latvia generally corresponded to the stage of economic development at that moment. The real appreciation of the exchange rate with respect to the countries of Western Europe was in line with the appreciation of the trend exchange rate, which was driven mainly by raising productivity in tradable sector. Therefore, the appreciation of the RER from 1994 to 2001 had not generally harmed foreign trade, because underlying fundamental variables in the economy supported real appreciation and it did not endanger macroeconomic stability and growth. As common conclusion from the previous studies is observable RER trend appreciation during transition period and overvalued (in comparison with equilibrium) exchange rate later.

Hence, it is necessary to analyse if the continuous appreciation of the real exchange rate of Latvian lat has been an equilibrium process and what the impact of the changes in real exchange rate on the competitiveness of the Latvian economy has been. The main purpose of this paper is to estimate the Fundamental Equilibrium Exchange Rate (FEER) in the case of the Latvian economy and to analyse behaviour of the equilibrium exchange rate of the Latvian lat.

Choice of FEER methodology in this paper is only the first step of deeper analysis in the future. A review of the theoretical foundations and some applications of the FEER is provided for example in Williamson (1994). Sustainability indicators used for modelling in this paper were chosen the same as in Paiva (2001).

The concept of 'equilibrium exchange rate' is still quite controversial. A number of possible definitions exist and there is already a vast of literature discussing them. Given the timing of monetary policy pass-through, the most relevant definition for policy discussions is perhaps the exchange rate, which would prevail if the economy were at its medium term equilibrium. An additional reason for why only medium term movements should be considered, when looking at a fundamentals based explanation of exchange rate movements, is that in the short run exchange markets participants are believed to base their decisions on short run trends rather than fundamentals. Again, there are various possible definitions of medium term equilibrium.

The terminology 'fundamental equilibrium exchange rate' (FEER) introduced by Williamson (1985) to designate the concept that the equilibrium exchange rate is driven by economic fundamentals and can therefore deviate substantially from the path of purchasing power parity (PPP). Among others, Driver et al. (1998) recalled a medium run equilibrium is essentially flow equilibrium. As consumption and investment decisions tend to be implemented over long periods of time, assets dynamics tend to be much longer lived than price dynamics. Therefore while nominal rigidities can be ruled out in the medium run, assets accumulation cannot. The long run equilibrium is thus stock-flow equilibrium with the medium run equilibrium pictured as evolving towards it.

Edwards (1989) defines the equilibrium exchange rate as the one that 'for given sustainable values of other variables such as taxes, international terms of trade, commercial policy and aid flows and technology, results in simultaneous attainment of internal and external equilibrium'. Simultaneous internal and external equilibrium refers to the situation in which present and future current account balances at full employment are compatible with the level of long-term sustainable capital flows.

There are a number of theoretical models and empirical applications originated from the concept of equilibrium.

Materials and Methods

In this paper, the further analysis is based on approach or the procedure developed by Elbadawi (1994), and the behaviour of FEER in Latvia is evaluated in two steps:

1) estimate the cointegrating equation of the explanatory variables, thus obtaining a series, which represents the estimated long-term path of the FEER;

2) using the model estimated in the previous step, evaluate an error–correction model for the real exchange rate for describing behaviour of RER in short-term.

As it was said before, two steps procedure is used. The first model uses fundamentals or variables that influence trade-weighted real exchange rate in the long run.

$$REER_t = \beta F_t + \varepsilon_t, \quad (1)$$

where

F_t - long-term explanatory variables;

β - vector of coefficients;

ε - residual.

After checking properties of the long-run model, the following short-term dynamic specification of the equation is estimated:

$$\Delta REER_t = \gamma \Delta F_t + \delta \Delta Short_t + \varphi \varepsilon_{t-1} + \zeta_t, \quad (2)$$

where

Δ - first difference from the variable behind the sign;

Short - short-term explanatory variables;

ε_{t-1} - residual from long term model in previous period;

ζ_t - residual.

If estimated coefficient j is significant and negative, in absolute value less than one, it can be interpreted as graduate convergence of the system to long-term equilibrium value.

One of the problems connected with use of this approach is that there is no common clear definition of fundamentals or factors that influence real effective exchange rate in the long run. Various authors have used different variables. The most commonly used variables are productivity differentials, a country's openness to foreign trade, terms of trade, government expenditures as a share of GDP, real interest rates, investment rate, trade balance, foreign direct investment, and government debt (Paiva, 2001; Bitans, 2002). Choice of variables in our model was based on results that most of mentioned variables appeared to be insignificant in the case of Latvia, probably because of comparatively short reference period in which it is hard to talk about long-term equilibrium.

Variables for further modelling were used with the aim to capture fundamentals such as the fiscal stance, degree of economic openness, and international terms of trade and net capital flows. Period of the analysis is chosen taking into account data availability: quarterly data for the period from 1995 to 2005.

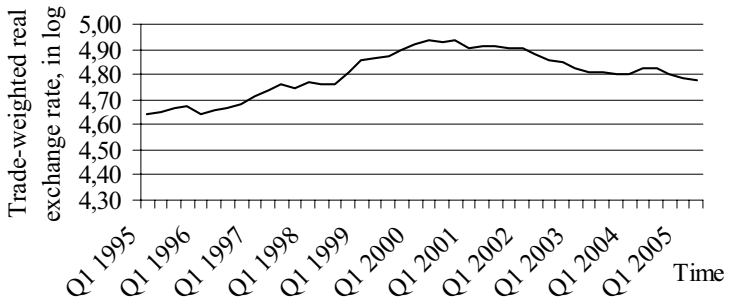
In model (1) dependent variable is *REER* - an index of the real effective (i.e. trade weighted) exchange rate of the lats against a basket of foreign currencies; in logs. For the period since 1996 the REER series are calculated and available in statistics provided by the central bank of Latvia. Missing values for 1995 were calculated for this paper choosing the basket of currencies that accounts for the largest share (about 90%) of Latvia's foreign trade. Quarterly values are calculated from average monthly exchange rates, which are the price of the domestic currency unit in foreign currency.

REER for ten major trade partners instead of frequently used bilateral (usually against USD or Euro) real exchange rate was chosen because it is richer measure of competitiveness. Western trade partners: Germany, Denmark, Sweden, Finland, the UK, and the Netherlands. Eastern partners: Russia, Ukraine, Lithuania, and Estonia.

One of the factors selected for modelling the long run behaviour of the real effective exchange rate in Latvia is government expenditures (GE) as percentage of GDP.

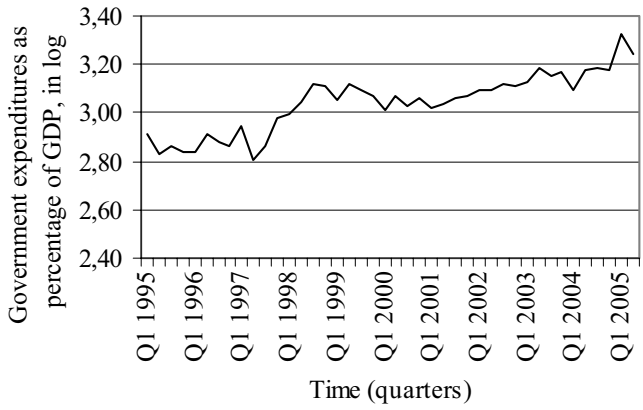
Hypothesis about government consumption effects on REER is: higher consumption by the government leads to an appreciation of the real exchange rate through an increase in the price of non-tradable goods.

Second variable, which is used in model (1) is an index of international terms of trade (the price of Latvia's exports divided by the price of its imports); the basis for the index of international terms of trade is January 1995, in log.



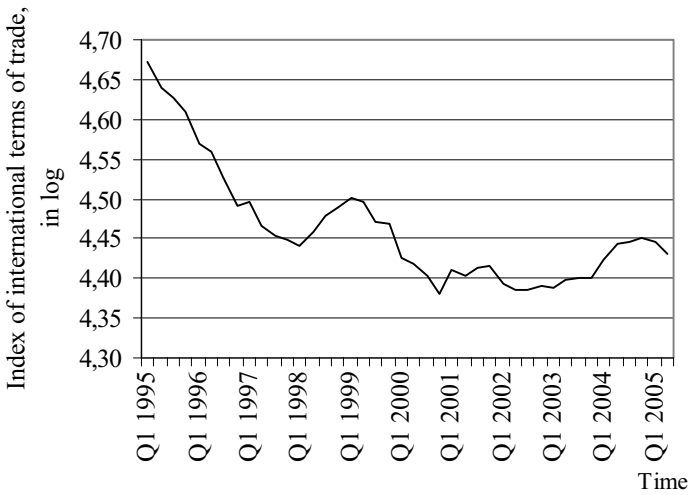
Source: for 1995 Q1-Q4 – author's calculations, for the rest of the sample calculated as average from data published in the Bank of Latvia.

Figure 2. Index of the real effective exchange rate, (logarithms).



Source: International Monetary Fond.

Figure 3. Government expenditures as percentage of GDP (seasonally adjusted, in log).



Source Central Statistical Bureau of Latvia, IMF.

Figure 4. Index of international terms of trade; (logarithms, seasonally adjusted).

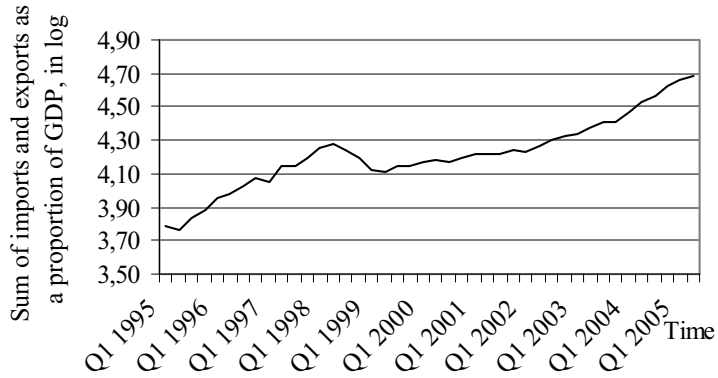
Relationship between the real exchange rate and TOT can be described as follows: deteriorating terms of trade and trade liberalization call for compensating depreciation of the exchange rate (Paiva, 2001).

While the impact of changes in the government consumption and terms of trade on the equilibrium exchange rate cannot be determined by theoretical models *a priori*, empirical studies usually indicate that higher government consumption leads to an appreciation of the exchange rate (probably reflecting a higher ratio of non-tradable goods to tradable goods in the government consumption bundle) and that an improvement in the terms of trade also leads to an appreciation of the exchange rate, implying that the income effect of the change in relative prices dominates the substitution effect (Elbadawi, 1994).

Third factor is variable which describe openness: sum of imports and exports as a proportion of GDP. In model it is denoted as OPEN. A similar variable was used by Elbadawi (1994) to proxy the degree of economic openness.

Higher degree of openness of Latvian economy is associated with real depreciation of the Latvian lat. Probably through the increase in foreign competition on the Latvian market, which, in turn, results in downward pressure on the domestic prices. In general, the degree of openness of the economy determines responsiveness of the REER to monetary and real shocks, for example, in a closed economy the productivity driven appreciation of the REER will be larger than in an open one.

As additional variable for several models real interest rate differential (INT_DIF) in Latvia and world economy was used. Term "real" means that here author takes



Source: Central Statistical Bureau of Latvia

Figure 5. Total trade as a percentage of GDP (logarithms, seasonally adjusted).

Table 1

Augmented Dickey Fuller (ADF) unit-root tests (author's calculations)

		REER	GE	Int_dif	TOT	OPEN	PROD	Critical values	
								5%	1%
Level	Intercept	-1.98	- 2.35	-2.05	-2.21	-2.11	-0.03	-2.94	-3.61
	Intercept and trend	-2.61	-1.93	-1.18	-1.38	-1.96	-2.07	-2.94	-3.60
First differences		-9.31	-4.10	-4.12	-4.15	-5.65	-3.71	-2.94	-3.62

differences between the nominal interest rates paid on long term loans in domestic currency and domestic annual inflation. Inflation is defined in terms of CPI annual percentage change. As the proxy for the world real interest rate the corresponding data for Germany was used.

To gauge the Ballassa-Samuelson effect (Ballassa, 1964; Samuelsson, 1964), productivity differential was included into the model too. Again, there is no common law how to measure productivity impact on trade-weighted real exchange rate. In this case quite simple variable was used: PROD – based on overall productivity of Latvian economy and productivity in its major foreign trade partners.

Investment to GDP ratio in Latvia was dropped out of the model because it appeared to be insignificant.

Results and Discussion

All variables listed in previous section at first were checked for stationarity. As can be seen from the figures above, the behaviour of used variables is not common. Looking at these time series one can get an impression that these are not stationary time series, because visually the mean, variance and autocovariances of the individual series do not seem to be time-invariant.

Augmented Dickey Fuller (ADF) unit–root tests confirm that one cannot reject the hypothesis that individual variable is stationary against the stationary hypothesis.

The results of unit-root tests also suggest that the original series are integrated with the same order 1(~I (1)), i.e. the series are stationary in their firsts differences.

Regression analysis: long- run model

Using the mentioned above variables, the following model was estimated (value under each coefficient is it's standard error (se)):

$$REER_t = -0.58 \cdot OPEN_t + 1.14 \cdot TOT_t + 0.49 \cdot PROD + \\ + 0.01 \cdot INT_DIF + 0.02 \cdot GE + u_t \quad (3)$$

(se) 0.09 0.045 0.155 0.0003 0.005

$$R^2 = 0.854$$

All coefficients of the estimated mode are statistically significant at 5% significance level and they have correct signs (as expected). The main results from the regression can be seen in Figure 6: the model gives quite good fit.

During the further testing procedures test of residuals will be made.

Checking for cointegration and tests of residuals

Estimating regressions involving time series data, one should remember about the possibility of obtaining spurious results in a sense that the results look good but on further analysis their behaviour is bizarre and suspicious. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series might be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegration

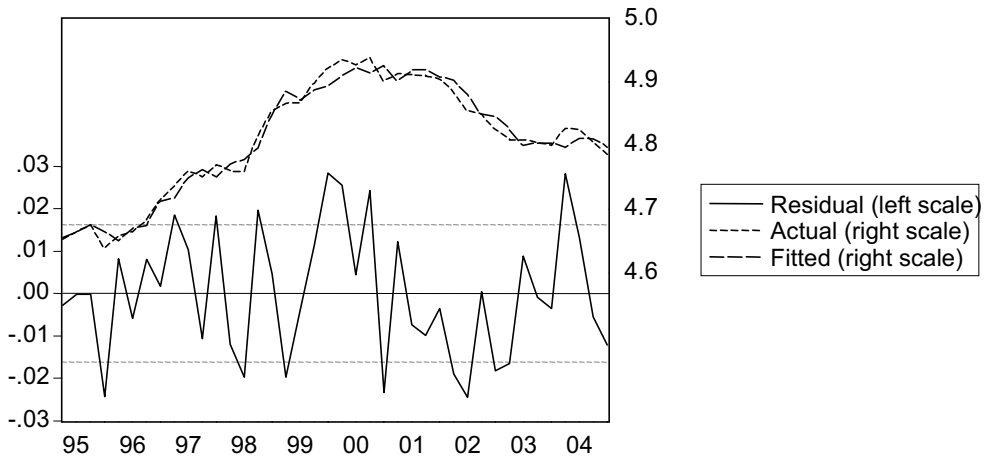


Figure 6. Graphical analysis of the regression output: actual, fitted, and residual values of the model (3).

equation and may be interpreted as a long-run equilibrium relationship among the variables.

In previous section it was found out that the time series of variables are integrated of order one. In general, it is known that if series are integrated of the same order, the series can be cointegrated. If that is the case, the regression (3) is meaningful, i.e. not spurious; and any valuable long-term information is not lost, which could be the result if the first differences were used instead.

The residuals obtained from model (3) satisfy the standard design criteria. In order to assess if a stationary process can approximate the residual series, the ADF test is applied. The test rejects the hypothesis of nonstationarity at 5 % level of significance. Thus, the equation (3) can be interpreted as a cointegrating relationship.

The Johansen's cointegration test also was applied and shows that the selected variables are cointegrated. Although they are individually non-stationary, there seems to be a stable long-run relationship between them.

Previous results allow to formulate an error (equilibrium) correction model for analysis of the short-run dynamics of the REER.

Error Correction Mechanism (short-run model)

While the relations above drive the behaviour of the real exchange rate in the long run (thus being considered the equilibrium REER), the short-run dynamics of the system is given by the error-correction specification:

$$\Delta REER_t = -0.3421 \cdot \Delta GE_t + 0.169 \cdot \Delta INV_t - $$
$$- 0.26 \cdot \Delta OPEN_t - 0.259 \cdot \varepsilon_{t-1} \quad (4)$$
$$R^2 = 0.439$$

(se) (0.141) (0.04) (0.07) (0.082)

The term $\varepsilon_{t-1 \text{ in model (4)}}$ represents the first lag of the residuals estimated in the equation (3). The model specification performed well in the tests for autocorrelation, normality of residuals and parameter stability. The coefficient of determination is not big, while the model in general is statistically significant. All the coefficients are significant.

The coefficient of the error-correction term ε_{t-1} is negative, and has an absolute value smaller than one, indicating the gradual convergence of the system toward long-run equilibrium values. The speed of adjustment for Latvia's REER is determined by the value of the coefficient on ε_{t-1}. The coefficients of the government expenditures, investments and the degree of openness, are significant, suggesting that public consumption, relative price changes and capital flows have an immediate impact on the real exchange rate.

Equilibrium REER and REER Misalignments

The equilibrium REER can be obtained by inputting the equilibrium values of the fundamentals in the cointegrating relationship estimated above. In order to derive the equilibrium values of the fundamentals here the time series approach is used. The time series approach rests on the assumption that the fundamentals should be in equilibrium on average over time. In particular, simple time series smothering techniques can be applied when deriving the equilibrium values of the fundamentals (Vetlov, 2002). In this article, the Hodrick-Prescott filter of order 1600 is applied.

Figure 7 shows that the real exchange rate was overvalued almost during all the reporting period. Analysing misalignments, special interest is for the end of 2004 when Latvian lat was re-pegged from SDR currencies basket to euro: lat was overvalued in comparison with the equilibrium.

Conclusions

The real exchange rate is recognized in economic theory and policy as one of the key macroeconomic variables, in particular in the case of a small open economy. It

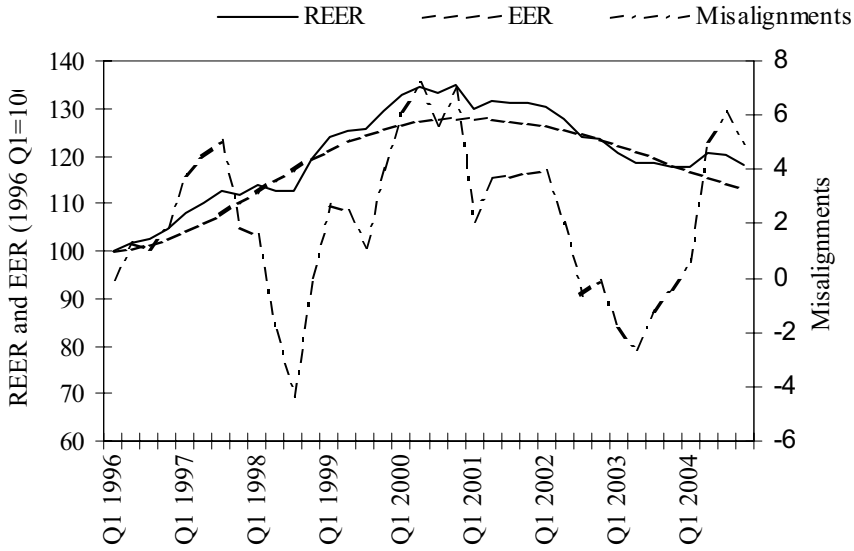


Figure 7. Exchange rate developments in Latvia (1996 Q1=100). Left scale: real effective exchange rate of Latvian lat and from the model (3) with detrended variables obtained equilibrium exchange rate EER. Right scale: Misalignments.

determines the relative price of domestic and foreign goods and therefore impacts their demand and price behaviour. If the RER is below its equilibrium, this stimulates the demand through increased exports but produces inflationary pressures especially as the aggregate demand reaches its supply potential.

There is no certain possibility to evaluate whether the selected exchange rate level is optimal and sustainable since pegging of the nominal exchange rate, being important for reaching the monetary targets, cannot always solve the real exchange rate problem.

The FEER methodology explains the long-run equilibrium behaviour of the exchange rate by the evolution of economic fundamentals such as the fiscal stance, net capital flows, the degree of economic openness, and the terms of trade. This model showed that the real exchange rate was overvalued almost during all the reporting period.

Taking into account that Latvia was an economy of transition, the use of FEER methodology can be discussable and further analysis should include the use of other methods for checking robustness of results.

References

1. Ballassa B. (1964) The Purchasing Power Parity Doctrine: A Reappraisal, Journal of Political Economy 72 (December), pp. 586-596.
2. Begg D., Halpern L., Wyplosz C. (1999) Monetary and exchange rate policies, EMU and Central and Eastern Europe, Forum Report of the Economic Policy Initiative No. 5. CEPR, 122 pp.
3. Bitans M. (2002) Analysis of the Real Exchange Rate in Latvia: 1994-2001, Bank of Estonia Research Paper Series 'Relationship between Real Exchange Rate and Competitiveness in the Baltic States', 52 pp.
4. Driver R.L., Westaway P.F. (2001) Concepts of Equilibrium Real Exchange Rates, Bank of England, 54 pp.
5. Edwards (1989) Real Exchange Rates, Devaluation, and Adjustment, MIT Press, 383 pp.
6. Elbadawi I. (1994) Estimating Long-Run Equilibrium Real Exchange Rates, in Estimating Equilibrium Exchange Rates J. Williamson ed., Washington; Institute for International Economics, pp. 93-131.
7. Engle R.F. and Granger C.W.J. (1987) Co-integration and error-correction: Representation, estimation and testing, Econometrica 55, pp. 251-276.
8. Krajnyak K., Zettelmeyer J. (1997) Competitiveness in transition economies: what scope for real appreciation?, IMF Staff Papers, pp. 309-362.
9. Paiva C. (2001) Competitiveness and the Equilibrium Exchange Rate in Costa Rica, IMF Working Paper, February 2001, 29 pp.
10. Samuelsson P. (1964) Theoretical Notes or Trade Problems, Review of Economics and Statistics 46 (May), pp. 145-154.
11. Vetlov I. (2002) Analysis of the Real Exchange Rate and Competitiveness in Lithuania, Bank of Estonia Research Paper Series 'Relationship between Real Exchange Rate and Competitiveness in the Baltic States', 49 pp.
12. Williamson J. (1985) The Exchange Rate System, Policy Analyses in International Economics, 5. Washington: Institute of International Economics, 152 pp.
13. Williamson J. (editor) (1994) Estimating Equilibrium Exchange Rates, Institute for International Economics, Washington, DC, 300 pp.

CHANGES OF LEGAL AND SOCIAL FAMILY RELATIONSHIPS IN LITHUANIAN RURAL AREAS

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Abstract

Family relations have always played and still play an important role in the system of social relations. The family is a primary social cell; it executes the fundamental functions of prolongation of relation, upbringing of young generation, and mutual moral and material support of family members. One of the main stages of family creation from both legal and social points of view is contracting a marriage.

The form of entering into a marriage and the definition of family legal relations have been changing in the run of history depending on the culture, church and state relationship, and general philosophy of the particular period of time. The Old Testament of Holy Writ gives information about the marriage. In the ancient times marriage and family were more of a religious institution managed by the church, but as marriage is the root of every legal establishment - family, relations, church, and state - it attracted a wider mass attention.

The social and legal relations and aspects of Lithuanian rural family setting and its existence at different periods were really original and interesting. Researching the conception and development of the legal and social family relations and comparing them to the modern law, essential differences can be observed, but at the same time some similarities, which have not changed till our times, can be found. At all times the prevailing family model in Lithuania was the traditional family model and the main differences in comparison to the modern family model are the forms of marriage registration and its stability. This family model was predominant in the rural areas of late XIX century Lithuania.

Key words: family, marriage, rural areas, adoption, divorce.

Introduction

The family is the closest and the most stable form of human relations (Leonas, 1931). It is the union of a man and a woman bound by conjugal, relative, adoption and maintenance relations, living together and having a common household. The family makes a primary social cell, i.e. the foundation. It is not the result of human intellect, will or decision. The family institution takes origin in human nature. This is proved by the birth and existence of the human being himself (Čižiūnas, 1971).

The classic family definition by G. P. Murdock defines the family as "a social group having a common place of residence, economic relations and reproduction. It consists of adult people of both sexes and at least two of them are involved in socially acceptable intimate relations and there is one or several genuine or adopted children" (Murdock, 1993). When we speak about the family in general, we mean the traditional family. According to the sociological family definition (T. Parsons, W. Good and other), the traditional patriarchal family is understood as a social unit having the man – father (breadwinner), the woman – wife, mother (housewife), and economically and socially dependent children. The family relations are based on a certain role hierarchy with the man at the top of it. The modern life style has slightly changed this conception; still the man remains predominant in the family though the woman is also equally expected to contribute to the family budget.

Family life is not just an act; it is a continuous homogenous process. Very often it depends on the parents' living conditions, their intellect, education, culture, willpower, pedagogical wisdom, creativity, and ambitions (Bajoriūnas, 1998).

The family is considered to be real, when the man and the woman have registered their marriage. The family starts with marriage registered in accordance with established procedure. The further step is the birth of children (Bajoriūnas, 1998).

According to M. Carpel and E. Strauss, the family can be defined as:

- biological family, i.e. association enabling the individual to have descendants;
- legal family, i.e. legal agreement, providing the family members' rights and duties;
- functioning family, i.e. association, organizing its members' day-to-day life, intercourse, housekeeping, and leisure activities;
- long-term social pledge, i.e. agreement to ensure the children's socialisation and support to the elderly people;
- the family may be understood as a relation structure, the peculiarities and importance of which can be interpreted individually by the family members (Karpel M., Strauss E. 1983).

In psychologist N. Solovjov's opinion, people creating a family hope that family will help in meeting their needs. When these expectations falsify, the family relations lose stability. Family needs in scientific literature are often equated to family functions.

N. Solovjov maintains that: "There are as many family

functions as kinds of needs to be repeatedly met" (Solovjov, 1977).

Peters J. F. indicates that the family meets the needs of social and economic standing, self-expression, meaning fullness of sexual relations, reproduction and intercourse stability (Peters, 1991).

In different periods of human history the understanding and development of family establishment, divorce, adoption, and other legal and social family relations varied, but the family has retained its importance and has remained the foundation of society and state.

Purpose of the research is to evaluate the legal and social changes in the regulation of family relations in Lithuanian rural areas.

Object of the research is the legal and social regulation of rural family relations.

Methods of the research – the analysis of scientific literature, the analysis of legal regulations, comparative and historical methods, the detailing and generalization as well as the logical abstracting.

Materials and Methods

The fundamental approach of this work is to use analysis and comparative methods. The intention is to analyze not only the fundamental statutes, laws, and dogmas, but also to identify and interpret the philosophical, traditional and theological aspects that society identifies with marriage and family. The historical and comparative method explains the genesis of the marriage institution and sense of law norms, because each norm of law is historically predetermined and only can be understood by analyzing history.

Logical – analytical method was applied together with other methods. Systematic - analysis method helped to establish various decisive questions of the work, which facilitated solutions to the problems.

Results and Discussion

Marriage as the beginning of family legal relations is very important establishment regulated by laws and other social norms. It exists for many centuries and in all societies. It is an important human right. Though, both social and legal importance is not the same in different countries and it varies in the course of history. This change depends on the social, cultural and economic development determining the change in values and philosophy.

Marriage is understood in two ways: as a marriage act and a family that forms between the man and the woman as the result of the act. These two concepts are different: the wedding means an action which gives the start to the family (Trauung, Eheschliessung, бракосочетание, la celebration du mariage). The consequence of this act is called matrimony (брак, брачный союз, matrimonium, le mariage). The marriage is an agreement between the man and the woman for their permanent life and right alliance.

The societal books provide many descriptions of family. It is difficult to point out the authorship of some definitions; for example, family could be defined like the main cell of a community as a group of relatives living together and having common ground and corporate property intimately related and protecting and safeguarding each other.

Family can be defined as "married couple or other group of adult kinsfolk who cooperate economically and in the upbringing of children, and all or most of whom share a common dwelling"(Skolnick et al, 1993).

According to Anthony Giddens, a family is a group of persons directly linked by kin connections, the adult members of which assume responsibility for caring for children (Giddens, 1997).

A family is similar to a guardian of humanistic and cultural values. This microstructure of society communicates to future generation's ethnic mentality, cultural values and shared descent from a common ancestor; thus it helps to uphold national identity, ethics and prosperity (Lithuanian Family..., 1995).

The marriage and family institution is old as a mankind itself. Even the primitive society family had family background. St. Jeremy and St. August proclaimed that sex is less valuable then celibacy; nevertheless family was a tolerant virtue. Basil, Virgin, Izidor Sevilietis and others considered family life to be the best way. Family ratio was the reason why dynasties appear in the Middle Ages. Family was always connected with politics; the honorable married other honorable people, making relationship stronger. Family relationship existed between the king and his servants. Almost until the middle of the XX century servants were called family. This determination is used today for example, the 'Kremlin family'. For that reason family must be strong and unbreakable as it is the bases for religion and social community (Masiulis, 1963).

Getting married in the Middle Ages of Lithuania was a relatively simple process. The man and woman joined hands and spoke specific words that made the vows. Mutual consent was required, and the woman had to be twelve years old and the man fourteen. Until the late 16th century, no priest was required. In fact, even witnesses were not necessary, although a sensible person would have them lest words spoken in the heat of passion be conveniently forgotten the next day (Dičius, 1974).

Most nations including Lithuania kept to the opinion that marriage is an agreement between a man and a woman to live married life, which manifested itself in the sharing of table and bed. In the old times this agreement was concluded without witnesses: the couple used to have

a meal and drink from one dish and go to bed. This form of entering into marriage was known in the ancient India but some clear features of the form could be also found in Lithuania (Masiulis, 1963).

In the early feudal times in Lithuania the marriage was concluded by buying or kidnapping the bride. The Lithuanians were also familiar with polygamy. When Christianity was established in Lithuania (1387), marriage was regulated by the norms of church, customs, and secular law. Marriage terms were established: age (13-15 for girls and 18 for men), normal state of mind, etc. Being close relatives (up to fourth degree inclusive by canon law), in-laws (up to third degree), previous marriage, belonging to other religion was considered to be an obstacle to conclude the marriage. Peasants could not marry without their master's consent. Girls marrying to another manor had to receive their master's consent and pay a special fee. The marriages of Orthodox, Jews, Mohammedans (Tartars) etc. residing in Lithuania was contracted according to their customs and the rights granted by the rulers. Different church and secular punishments and fines were applied for the breach of marriage norms. The church was in charge of marriage contracting, registration, and dissolution. The secular courts decided only property matters related to marriage (Dičius, 1974).

Considering the regulation of family social and legal relations in XIX century, many essential differences and contradictions can be found in comparison to the modern family law. The differences are related to the political establishment, oppression, exploitation, and economic conditions; may also be found some similarities related to moral values that have not changed during the centuries as well as customs and religious beliefs.

When the Russian Empire occupied Lithuanian territory, Empress Catherine II by her order of 30 October 1794 (Full assembly of Laws of Russian Empire, 1794) approved the incorporation of some Lithuanian lands into Russian Empire. The addendum-manifest of 14 December 1795 to the order contained a promise to leave the previous rights, liberties, religious liberty and property safeguard to Lithuanian inhabitants (Development of Legal Institutions…, 1981).

The obligatory religious marriage form was valid both in Lithuania and Russia. In the Russian Empire, mixed religious marriages were regulated by the Synod decrees. The decrees required that a catholic had to adopt Orthodox beliefs to marry an Orthodox believer, otherwise the marriage was considered to be invalid. The Catholic Church in its turn required that a marriage of a Catholic to an adherent of a different faith had to be contracted in a Catholic church, but later the Orthodox marriage priority was confirmed. In cases when a mixed marriage contracted in the Orthodox Church was considered invalid, only the Orthodox Church canons were applied (Legal Institutions…, 1981).

In XIX century, youth were expected to marry at the age of 20-25. They usually met at village entertainments. The oldest daughter was supposed to marry the first, and the youngest - the last. Peasants did not marry without their parents' blessing. Parents or foster-parents usually did not interfere with the choice of the bride, unless he or she was not of equal standing. In this case the young people had to part (Fridman, 1890).

Free will marriages were also approved by the first Lithuanian Statute of 1529. When the marriage was concluded without the parents' consent, the parents could deny their children the right to succession (Fridman, 1890).

The differentiation of society, increasing of migration from the countryside to towns and abroad resulted in family model changes. The Lithuanian intelligentsia tried to adopt a new family model providing that a wife was expected to support the husband's social aspiration and to breed their children according to Lithuanian traditions (Navaitis, 2001).

At that time non-matrimonial relations among the Lithuanian peasantry were a rare phenomenon and they were not legally regulated.

Before the marriage in the engagement period the parents of both sides agreed on marriage portion. If a landless man married a well-off girl and received some land, the land was considered the property of the bride's father. After the wife's death all the property received from her parents went to his wife's parents, their children were also taken by the parents-in-law. The children received their mother's property only being of the full legal age. Sometimes the children stayed with their father, but in that case one of the in-laws stayed with them until the children reached the adulthood. The person was in charge of the children and their property. If the husband died, the land received from his parents-in – law was returned to them, and the wife did not have any rights to it (Development of Legal Institutions…, 1981).

The Russian Empire authorities did not amend the articles of the Lithuanian Statute regulating conjugal property rights as they were similar to those of the Russian Empire. The best reflection of conjugal property relations was the legal order of the wife's married portion, which the Lithuanian Statute regulated only to the privileged classes holding the exclusive right to land. If the property constituting the wife's married portion was warranted by a special portion agreement, the husband controlled the property, but he could not make free use of the property devised to his wife (Development of Legal Institutions…, 1981).

In XIX century, Lithuania had a prenuptial agreement establishment, not foreseen by the Russian Empire law. The prenuptial agreement was concluded by the bride's

parents or foster-parents and the groom or his parents. The agreement could provide any terms non-contradicting the valid laws. At those times the agreements, concluded by the people of different religious beliefs, usually set the religion to the future children.

As Lithuania was incorporated into the Russian Empire, the imperial criminal law came into force and the Article 30 of Lithuanian Statute XIV providing the capital punishment for conjugal infidelity became invalid (Development of Legal Institutions…, 1981).

Formal divorce was not acceptable to the peasantry because of the moral and legal reasons, but there were cases when the couple parted and lived separately with their parents. If such couples had children, they could remain with their father or mother, but usually with the mother. When the husband moved to live separately he had to maintain the wife and their children. The maintenance included bread, rations and money. The husband usually returned to his parents or relatives or found himself a service (Fridman, 1890).

After the death of one of spouses, the widow or widower could remarry not earlier than after three or four month. The daughter - widow or the son-widower staying with his/her parents had to obey them as their unmarried brothers and sisters. The parents' rule did not end until the children left their parents' home.

The majority of people in the countryside kept to the tradition to celebrate their children's full age, which was related to the new rights and duties. Natural children in the late XIX century did not have any rights or obligations in respect of their parents or relatives. They were given the mother's surname. Natural children's mothers often applied to local courts for their own and their children maintenance. But their actions were very seldom satisfied. The people in the countryside usually condemned such girls and women and they tried to avoid publicity. Despite the negative people's attitudes towards natural children, it was a frequent phenomenon in the late XIX century. Adoption was very popular in the Lithuanian countryside of that time. The most of children were adopted by childless peasants irrespective whether the children were their relatives or not (Fridman, 1890).

In 1919-1940, marriages in Lithuania were regulated by civil laws and the regulations of state recognized religious organizations. The matrimony was ecclesiastical, civil registry was only in Klaipėda region (introduced in 1874). Marriageable age was 16 years for women and 18 for men. Both women and men reached the legal age being 21years old. Until they had reached the age, they were in charge of their parents or foster-parents, whose consent was obligatory to contract a marriage. This was applied to the individuals of all religious beliefs. The sons and daughters having contracted a marriage without their parents' consent could be partially or in full deprived of their rights to succession. Adult sons and daughters, without their own means of subsistence or right to claim for their part of parents' property, had to obey their parents and often married according to their will. The military men of a fixed period service could marry according to the French Law, civil code, allowing civil marriage and divorce, introduced in Suvalkija in 1807. But in 1836 the matrimonial statute revoked civil marriage and divorce in Suvalkija and recognized only the ecclesiastical marriage. That law provided that the marriage between two Catholics could be broken only by the death. It did not recognize divorce. In the former Kaunas province and Palanga the Lithuanian Statute was valid until 1840. In Kaunas province the Statute was substituted by the provisions of the Civil Code part 1, volume 10 and in 1864 the Baltic civil laws came into force in Palanga. After the war Lithuania became an independent democratic republic and it was clear that the laws valid in tsarist Russia were to be replaced. On 8 April 1929, the secretary of state for home affairs issued a circular authorizing the municipal bodies to register marriage, birth and death acts to individuals, who did not want to have it done by their confession priests (Masiulis, 1963).

In the early XX century Lithuanians could be single by their own will and remain a full-blooded society member. In the Western Europe 15–20% of women were single, but in Lithuania this percentage was really low. To break the marriage and remarry in legal way was obviously impossible. The absolute majority of marriages were contracted inside a parish. The family firstly was a group of people corporately engaged in agriculture. The prevailing morals were very strict towards sexual life, natural children and their mothers were rejected by the community. On the other hand, looking at the Lithuanian families of that time we can find features characteristic not only of traditional, but also of the western family model. For instance, the average marriage age was rather mature (25-33 years). The modern attitudes towards the marriage and family life have changed in comparison to those of XX century and Soviet occupation periods. The population census of 2001 showed that the number of individuals leading a married family life is decreasing and the number of the divorced and widowed is increasing. Every fourth person over fifteen years old claimed that he or she had never married.

Every third man and every fifth woman had never had a family of his/her own.

These numbers differ a lot from the results of the population census carried out in 1923: 48.7% of men over 15 years old and 42.8% of women over 15 were married. In the middle of XX century the traditional family model prevailed in Lithuania. The main differences between the tra-

ditional and untraditional family models are the forms of marriage validation and its stability. The traditional family model recognized only formally confirmed marriage and denied all the other forms of cohabitation. The traditional family model also provided the non-termination of the marriage. In 1950, 0.2 out of 1000 inhabitants were divorced, now the number of divorced has increased to 3.2. Nearly 20% of those contracting a marriage have a tendency to remarry.

Family is not the result of human intellect, will or decision. Its institution takes origin in human nature. This is proved by the birth and existence of the human being himself (Čižiūnas, 1971).

In more recent times the legally defined marriage took an upper hand over the dogmatic one. The civil marriage became popular also because of the modified relation between the state and the church. In the Catholic countries the civil marriage had more complex requirements than in the Evangelic countries of mixed religion (Čižiūnas, 1971).

In all times the family was in close relation with politics. The nobility of one country married the nobility of another country at the same time consolidating the contacts of the two countries. Family relations also existed among a ruler and his dependants. Nearly till the middle of XX century cottars were called a family in Lithuania. Even in these days politicians use such definitions as the Kremlin family. As the family is the basis of religion and human society, it is considered to be of vital importance to keep it strong and indissoluble.

Today the family legal relations are regulated by the Civil Code of the Republic of Lithuania inured on 1 July 2001. The greatest changes are related to the regulation of marriage and family relations as the norms of family law became the constituent part of the Civil Code. Now marriages and family relations are regulated not only by the family law, but also by the civil law principles and methods.

The beginning of family relations is the marriage, which, according to the provisions of the Constitution of the Republic of Lithuania [Part 4, Art.38], adopted by the Civil Referendum of 25 October 1992, may be registered by the state; the state also recognizes marriages registered by the church. The second marriage form is grounded on the fact that the Christians, and the Catholics in particular, consider the marriage rather sacramental than legal act. These Constitutional provisions are realized by the Articles 3.24, 3.25, and 3.304 of the Civil Code.

However, these provisions are valid only for the state registration. This is confirmed by the Art. 3.25, p. 2 providing that the marriage registration in the order set by the church has the same legal consequences as the marriage registered at public registry office, provided that the marriage contracting terms set in the Art. 3.12-3.17 of the Code were not breached, i.e. the ban against homosexual marriages (Art. 3.12), voluntary marriage (Art.3.13), age of consent (Art. 3.14), ability to act (Art.3.15), the ban against the monogamy principle breach (Art.3.16), ban against the close relation marriage (Art.3.17) and (Art. 3.304) providing that the public registry office is in charge only of the recording of the marriages registered by the church. The church does not issue the certificate of marriage, but it sends information on the marriage registration, the public registry office, which having received the notification on the marriage registration according to the procedure set by the church issues the certificate of marriage in the order established by the Lithuanian Republic Civil Code (Art. 3.303). If the marriage meets all the marriage registration terms of the public registry office, the certificate of marriage is issued and corresponding entries are made in the passports or personal identity documents of the newly marred couple.

The Civil Code provides the marriage dissolution mechanism by which the marriage may be dissolved:

- by both spouses' consent;
- on one of the spouses request;
- Through the spouse's (spouses') fault (Art. 3.60-3.65) .

The courts are not united in deciding the marriage dissolution on one spouse's request. Some individuals applying for the marriage dissolution on the basis of the CC Art.3.55, p. 1.1, when the spouses have not lived together for a year and have not been doing joint household, are told that at first they have to apply the court for the confirmation of separation and only then, if the couple dos not live together for a year after the inured judgement, any of the spouses will be able to claim the marriage dissolution on the basis of Lithuanian Republic Civil Code (Art.3.55).

Other courts having received an application for marriage dissolution by a spouse, who has not lived in separation for one year, judge it considering such parting equal to separation and dissolve the marriage on the basis of Civil code (Art.3.55). This type of practice contradicts the legislator's will, which is very clear when analysing the marriage dissolution norms. The legislator's target is to diminish the number of groundless marriage dissolutions by establishing legal obstacles: separation (Art. 3.73-3.80), the spouses' common consent providing that not less than one year has passed from the day of marriage registration (Art. 3.51). For this reason, courts executing legislator's will should accept a bill of particulars referring to the marriage dissolution submitted by one spouse providing that he/she has lived in separation longer than one year (Art.3.79). Whereupon if one spouse wants to dissolve the marriage, he/she has firstly to go to law for the establishment of separation or through the spouse's fault according to (Art. 3.60): if the other spouse is sentenced for malice, infidel, or in cruel

with the spouse or family members, has left the family and has neglected it for more than a year.

According to the Civil Code of the Republic of Lithuania, minor children's parents, dissolving the marriage by common consent, and moving to live separately (separation) or dissolving the marriage on other basis, should submit an agreement specifying their obligations to maintain their minor children, the procedure of such maintenance, extent and forms (Art. 3.193). The Lithuanian Republic Civil code Art. 3.196 "The form and extent of maintenance" provides the form of maintenance – it may be monthly payments of fixed amounts or certain property sentenced to the benefit of the child. (Art. 3.192) gives the maintenance extent that must be proportional to the minor children's needs and their parents' material well-being and ensure proper conditions to the child's development. By the Lithuanian Republic Civil code (Art. 3.193), the parents' agreement on the minor children's maintenance should be approved by court (Civil Code, 2000).

The CC Book 3 "Family Law", part 6, chapter 15 legalizes the man and the woman's relations if they have lived together for not less than a year without formal marriage registration. Such individuals are granted a cohabitants' status. The cohabitants' joint property equals to the conjugal property or even to the marriage contract. The Civil code (Art. 3.161) specifies the children's rights, establishing that unmarried parents' children and married parents' children have equal rights.

The family being a primary societal cell has always played an important role, though nowadays in better economically developed countries the matrimony is becoming weaker.

Conclusions

The history of marriage is a part of general culture history. Its definition and forms have been changing according to the culture, the relations between the church and the state and philosophy of a particular time. Nowadays the matrimony is also paid a special attention and undergoes inevitable changes.

Analysing the development of legal and social relations at different periods of time, many essential differences and contradictions to the concept of modern family relations can be found. These differences are related to former political establishment, oppression, exploitation and economic conditions, which were perfectly well reflected in the countryside of that time.

The similarities are related to the moral values and moral features, which have not changed for ages, customs, and religious beliefs, influencing the modern legal and social establishment of the Lithuanian family.

Starting with the establishment of Christianity and till the end of World War II, only obligatory ecclesiastic marriages were contracted in nearly all the territory of Lithuania. By modern laws marriages may be registered by the state and the state in its turn recognizes ecclesiastic marriage registration. That second marriage form is grounded on the fact that the Christians and the Catholics in particular, consider the marriage rather sacramental than legal act. Legal marriage dissolution and formal remarriage have obviously been impossible in Lithuania at all times. Today the laws not only enable to dissolve the marriage, but also ensure the mechanism itself, provide all the dissolution terms and ensure the children's maintenance.

Non-matrimonial relations did not bear any legal consequences with minor exceptions, nowadays the Civil Code of the Republic of Lithuania grants a cohabitants' status to individuals having lived together for longer than a year. But their children's status has not been completely regulated. Cohabitants' and married parents' children should have equal rights and duties.

Both legal and social regulations of property relations until the end of XIX century and the beginning of the XX century were more favourable to the individuals of the superior classes and men, but the rights of the inferior classes and women were restricted and dependant on men's will or the nature of concluded contracts.

References

1. Bajoriūnas Z. (1998) Family Education. Vilnius, 345 pp.
2. Civil Code of Republic of Lithuania (2000) Vilnius: Legal Information Centre, 462 pp.
3. Constitution of Republic of Lithuania: ratified by Civil Referendum of Republic of Lithuania on 25 October 1992 (1993) Vilnius: Publishing House of Parliament of Republic of Lithuania, 76 pp.
4. Čižiūnas V. (1971) Family in National Community/ Publication of Educational Board of ILC, published in USA by means of Lithuanian fund. Vilnius, 275 pp.
5. Development of Legal Institutions in Lithuania in XIV-XIX (1981) Vilnius: Mintis, 278 pp.
6. Dičius P. (1974) Marriage and Family in Soviet Lithuania. Vilnius, 320 pp.
8. Giddens A. (1997) Sociology 140 3ed., Polity Press.
9. Karpel M., Strauss E. (1983) Family Evolution.-N.Y., 475 pp.
10. Leonas P. (1931) Encyclopaedia of Law/ Lectures on Encyclopaedia of Law. VMU. Kaunas, 370 pp.
11. Lietuvos Šeima: tradicijos ir ateitis (1995) (Lithuanian family: traditions and future). Meilutė Taljūnaitė et al. eds., Lietuvos Filosofijos ir Sociologijos Institutas, (in Lithuanian).
12. Masiulis Br. (1963) Lietuvių enciklopedijos leidykla (Lithuanian Encyclopedia Publishing). Santuoka, 29 Lietuvių enciklopedija 456. (in Lithuanian).

13. Murdock G.P. (1993) World and Family/ LAS, Institute of Philosophy, Sociology and Law. Vilnius, 280 pp.
14. Navaitis G. (2001) Paper on Human Social Development in Lithuania. Vilnius, 12 pp.
15. Peters J.F. (1991) What is the Family? // Paper presented at the International Committee for Family Research Seminar in Norway, 1145 pp.
16. Skolnick A., Skolnick J. (1993) Family in transition 23 6th ed., Scott, Foresman and company.
17. Фридман Ю. (1890) Юридическая воззрения и обычай крестьян. (Legal views and custom of peasants). Каунас, 320 с. (in Russian).
18. Полное собрание Законов Российской империи (1794) (Full assembly of Laws of Russian Empire). Москва, N 17264., 1245 с. (in Russian).
19. Соловьев Н.Я. (1977) Брак и семья сегодня. (Marriage and family today). Вильнюс, 285 с. (in Russian).

SOCIETY, SOCIAL CAPITAL AND SOCIAL NETS

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Abstract

The scientific article is prepared using monographic research method. The most important works by several scientists are examined. The author analyses guidelines for strengthening of civil society within Decree of 2005 by the Cabinet of Latvia; previous research on social capital in scientists' works is considered and indicators regarding economics of Latvia are characterized; formal and informal social networks and their norms are cleared. Importance of civil society is suggested by the Cabinet Decree No. 98 'Guidelines of Strengthening Policy for Civil Society' in 2005. The guidelines and directions for strengthening of civil society for the ten years describes actuality of this program. This theme is less researched in Latvia. Civil society promotes democracy, increases and mobilizes social capital, coordinating collaboration of citizens for common benefit. Civil society in Latvia is in its initial position. The concept of social capital by different foreign scientists and Latvian specialists is analysed in this article. American scientist R. Putnam (1995) has written about social capital that human capital regards individuals but social capital regards relationships among individuals as well as social networks and exchange norms. Another researcher F. Fukuyama (1995) analyses social capital by comparison of economical development of different peoples and nations. Research by several scientists on indicators of social capital and their use in economics of Latvia are analysed in the work. The author concludes that social capital of Latvia has tendency to develop, and social networks and their expansion is little explored in Latvia.
Key words: social capital, civil society, social networks.

Introduction

Social capital arises from a completed and existing society, from social interaction and economical relationships. It promotes sustainable relations and trust. This is the main element of competitiveness and economical development. Society as communion of people and different associations of enterprises and a fair and democratically economic organization as well is an important means for creating necessary circumstances for social capital. Importance of the issue of civil society in Latvia is determined by its active discussing in 2005. Results of the discussing can be concluded from the basic political statements confirmed by the Cabinet and the state program for strengthening the civil society to 2014 (7). Civil society promotes democracy, prospers and mobilizes social capital, encouraging interaction and integrated activities for common benefit, helps to solve problems of the citizens.

Latvian scientists B. Rivza, V. Strikis, J. Abele, S. Ancans, J. Leikums, M. Pelse (personal communication) and others are performing research on social capital in Latvia. Different methodological and theoretical guidelines are used. However theme of social capital is rarely mentioned in mass media and scientific journals of Latvia (Ziverte et al., 2002). Social capital is usually understood as amount and quality of social nets and related social norms. However different authors try to concretize it and exclude three fields or forms: involvement in different organizations; existence and importance of civil and social norms; individual trust to others, different social groups and institutes (Putnam, 1995). R. Putnam popularized the term 'social capital' and he is mostly associated with cognizing social capital. More and more approvals arise that social unity is necessary for economical boom and sustainable development of the society. American scientist F. Fukuyama analyses social capital in economics. He assumes that social capital is made by informal relationships in a group and among social groups (Fukuyama, 1995). Italian sociologist A. Portes divides social capital into three elements: members with potential of social capital, source of social capital and resources themselves (Portes, 1998).

Social nets have been forming among people who know each other in families, among relatives, friends, colleagues. Expansion of social nets can cover one family or bigger territory, for instance, village, region, town, state or even exceed one state territory. Social nets are an important social capital pattern among Latvian citizens who want to make nets. Citizens of Latvia are eager to make informal nets. They are more elastic, more opened towards new ideas because they are not restricted by any formal rules (Ziverte et al., 2002).

The aim of the scientific article is to analyze the civil society of Latvia, the concept of social capital in economics, and importance of social nets in individual lives and within development of a balanced nation.

The work is of restricted volume and therefore civil society, concept of social capital and social nets in the Republic of Latvia are researched using the monographic method. The mentioned concepts are less examined outside Latvia.

There are research parts submitted:

- to analyze basic statements of civil society strengthening in Latvia within decree by the Cabinet of 2005;
- to evaluate previous research on social capital in scientific works and to characterize indicators re-

lated to economical field of Latvia;
- to recognize formal and informal social nets and their norms.

Materials and Methods

To carry out the aim and the tasks of the article, emphasis was laid on the concepts of society, social capital and social nets as well. The concept of social capital was analysed in works of different foreign scientists. It was important to determine indicators of social capital applicable for examination of social capital in economics of Latvia. It resulted in research method. At first, various scientific literature on civil society of Latvia, on analyses of concept of social capital in foreign scientific works, on informal and formal nets of social contacts, their usage and analyses in Latvia was examined by monographic research method. Scientific articles, publications and research works were used. Methods used by the scientists for research of social capital were selected purposefully to continue their use in economical research. Works by the most important scientists on this theme were selected.

Results and Discussion

1. Civil society in Latvia

Civil society of Latvia is in the beginning of its development. Many citizens of Latvia have experienced their fellow- citizens joining different organizations for solution of their problems. They cognize that the time they spend in the organization is bringing some result. If a person can solve different questions in his/ her community he/ she does it without support of the others. If a question is in competence of a local government, people turn to the local government for the solution. Number of people is growing who consider collaboration and trust as useful and effective method for problems solving. That is why people are trying to join social organizations, forming 'clubs'. For instance, there are social capital clubs in Talsi. People are meeting popular personalities and discussing theme 'civil society and social capital'. Civil society is developing in North Kurzeme: members of organization 'Vinoga' conclude.

However there are problems of society forming and maintenance in Latvia. They are as follows:
- low social activity and trust;
- alienation of citizens from public government;
- citizens know less about activities of nongovernmental organizations;
- citizens know less about the results of nongovernmental organizations.

A great number of citizens of Latvia do not feel a need for influencing events of their lives and society in whole. They do not see benefit from society and collaboration with others, so they are not inclined to be active (7). People often do not have skills and knowledge necessary for collaboration. Nongovernmental organizations insufficiently promote citizens for collaboration. Many local governments do not create conditions for people co- operation to solve different questions. There are no independent means sources- foundations- for solving social questions. Part of the citizens of the Republic alienates from the public government because they do not trust the power of the state and local governments, they do not see sense in striving to take part in making politics (Gaugere, et al., 2005). The local governments and the central state government involve citizens insufficiently. Although the Law does not encumber the citizens to participate, workers of social and public governments are not informed enough about real opportunities and methods, results and purposes of the participation. Part of citizens know less about activities of nongovernmental organizations and their usefulness. Workers of nongovernmental organizations lack skills to inform citizens of the Republic about their success and to attract necessary means. There is no diversity of finance sources in the organizations. Reliance on occasional finance sources can endanger their independence. To avert the low activity of the civil society, Secretariat of the Special Assignments Minister for Social Integration assumed steering directions: 'to increase the percentage of people in Latvia that are growing social capital by their formal or informal cooperation for the sake of their own and social aims' (Pilsoniskās sabiedrības stiprināšanas politikas pamatnostādnes, 2005). It can be achieved by promoting charity, involving people in social organizations, organizing more discussions with people of local governments about necessity and opportunities of nongovernmental organizations, supplying accessible and understandable information about processes illustrated by real examples.

A person joins social organizations dealing with questions he/ she is interested in. Thus the person can get necessary information, take part in different activities, be a member of the social organization. The citizen is prepared to donate finances and material values and support to the social organization. He/ she sees the results of activities of the organization and believes in its aims. The interest in taking part in social organizations changes with changing his/ her needs. Social organizations exist as long as they are dealing with socially essential job. Since 2003, Secretariat of the Special Assignments Minister for Social Integration is responsible for formation of civil society in Latvia (7). It determines making Council of Civil Society with 50% representatives from the side of the civil society and 50%- from the side of public government (7).

Society of Latvia promotes democracy including qualitative decisions regarding public government, interaction and trust between the government and citizens. It increases

and mobilizes social capital, promoting collaboration and coordinated activities for common benefit of the citizens. It helps to solve citizens' problems that can be better solved by formal or informal social nets than by state structural organizations. Society of Latvia can be characterized in three expressions:

- collaboration of citizens for solution of the questions they are interested in;
- participation of the society for making policy at the level of local governments, central state government, and European Union;
- sustainability of nongovernmental organizations.

In general, minor part of citizens is involved in social activities in Latvia. Traditions of volunteer work and charity are developed poorly. Citizens of Latvia are not socially active. Only one third of them are sure that social activities can improve quality of their daily lives. Another third part thinks that they change nothing. But one more third assume that they do not take part in social life at all (Gaugere et al., 2005). Among the people who respond they do not take part in the work of social organizations, are those between 45 and 54 (66.8%), and with basic education (69.7%). People of other nationalities and noncitizens do not take part in social life more than Latvians. The least part of socially active inhabitants consists of pensioners, housewives, and the unemployed (65.2%) (7).

The Law of Latvia envisages different ways how the society can be involved in policy making at the level of the state and local governments. Only small part of people use this opportunity. The citizens are not informed about positive examples yet. Participation in different processes of EU level is a new sphere in general, and organizations of Latvia have not gained collaboration experience yet. The direction is being planned in the society to implement the policy- to enlarge percentage of the people increasing social capital by their formal collaboration for their own and social aims.

In regional support centres and Riga, nongovernmental organizations are looking for information and counseling helping them to improve their capability. The centres are also supporting Ministries and the local governments involving the nongovernmental organizations in policy making. The Centre supplies information about the governmental work and actualities connected with the sector of nongovernmental organizations, and mobilizes them for their interests protection as well. Existence of those centres is connected with projects financed by other state subsiding service of the nongovernmental organizations. For success of the nongovernmental organizations, they have following directions:

- citizens are informed about the aims of the social organizations and they support these organizations;
- number of the social organizations and their members are increasing;
- the social organizations have access to bigger finance (Gaugere et al., 2005).

In 1990, the first social organization was established in Latvia. But already in 2005, the number of social organizations had increased to 9246 (Pārskats par tautas attīstību, 2005). Research on social thought, carried out in 2004 shows that about 41% of the citizens of Latvia are involved in some nongovernmental organization. A slightly lower percentage is in Riga and rural areas. The most of not involved inhabitants live in Zemgale (66%) and Riga (60%), Vidzeme (56%), Kurzeme (54%), and Latgale (54%). Mostly Latvians, women and leaders of higher or medium level take part in the work of the organizations (Pārskats par tautas attīstību, 2005). This data confirm also the tendency of other states: mostly individuals with more knowledge, skills and financial resources are getting involved in nongovernmental organizations.

2. Social Capital in Economics

French scientist Pierre Bourdieu (1986) is one of the first who systematically analyzed the term of social capital (Bourdieu, 1986). He defines social capital as 'bearing of social obligations' or 'concrete amount of social capital that belongs to a concrete participant depends on the coverage of the net it can mobilize effectively, and on amount of capital it can gain from each net element it is connected with'. Social capital is formed of following elements: social relations and quality and quantity of resources. Robert Putnam (1995) writes about social capital that 'human capital regards individuals but social capital regards relationships among individuals as well as social nets and exchange norms arising from them'. The essence of Putnams' theory of social capital is that people create and involve in horizontal and mutual exchange relations by trusting each other. People know that the others they are connected with are living by mutual code of honour: 'I trust you because I trust her who ensured me that she trusts you' (Putnam, 2000). By Putnam, we do not evaluate high enough importance of informal social organizations in the modern society. James Coleman (1988) defines theories of social capital as follows: 'they are not whole but amount of separate elements characterized by two features: they are all a kind of social structures and they release activities of the participants independently either it is an individual or a corporative agent within this structure'. Italian sociologist Alejandro Portes (1998) defines social capital as 'ability of the participants to supply some goods for themselves using social nets or social structure'. Scientist F. Fukuyama (1995) has explored change of market value of the company before and after joining proposal. Market capitalization of any company is measurable and a sum of nonmeasurable values.

Nonmeasurable value is part of social capital in company's employees and managers. Company is usually bought for higher price than its value before joining. Then we can assume that enlarged price is the level of confidence of the new owners that they are able to rule the new company better than previous owners, remaining other values the same. In many cases, part of the supplement reflects savings from expenses that the new owner hopes to get with enlargement. Difference of this supplement is not clear social capital but comes together with human capital. According to F. Fukuyama , social capital is institutionalized informal norms succeeding co- operation among two and more individuals. These norms vary from friends communication to complex norm doctrines. Trust, cooperation, civil society are consequences of this collaboration nevertheless they do not form social capital themselves. Each social group has its own people circle; the collaboration norms are current among them. Traditional social groups experience lack of groups of individuals in their peripheries that could be able to move from one group to other bearing new ideas and relations. There are mutually covering social groups in the society. Regarding economics, informal norms based cooperation becomes more and more important with economics becoming more and more difficult. Fukuyama (1995) points out family as an organization that starts to make trust first. When relatives make business companies, their structures are influenced by their family structure big families grow basis of bigger and dynamic enterprise. Extra links with other relatives can enlarge radius of trust. The negative side of the culture is to exceed importance of family relationships over any others thus weakening the ability to cooperate equally with other people. Fukuyama (1995) considers that cultural peculiarities are ignored in the analyses of state role in the economics. Main differences to be considered seriously are differences of states and cultures: social and moral habits, religion, informal institutions.

Considering research of the mentioned scientists, there were indicators of social capital assumed that can be applied for determining presence of social capital in economics of Latvia (Sociālais kapitāls. Starptautiskā zinātniskā konference, 2002). They are as follows:

- belonging to a nongovernmental organization promotes forming of social capital;
- cooperation characterizes volunteering collaboration of economical character;
- participation in election is active position of an individual towards social and political activities;
- subscribers of newspapers work actively for obtaining information;
- frequency of participation in different meetings expresses abilities of cooperation and contacts;
- trust and educating includes personal traits.

Questioning of citizens in 2004 (Gaugere et al., 2005) shows that approximately 1% of Latvian inhabitants are employed in the sector of non- governmental organizations. Altogether 44% of these organizations do not employ any paid workers, or there are not more than two or three of them. Paid personnel are in nongovernmental organizations of Riga and Riga region. They are employed for solving questions of interest protection, social service, and professional issues. About two thirds of the organizations are collecting member fees and they form 22% of the budget of the organizations. Citizens assert carefully capability of the nongovernmental organizations. In the scale 1-10 (extremely high capability), ability of a nongovernmental organization to influence local development is evaluated on the average at 4.3; but its ability to influence state development at 3.8 (Pārskats par tautas attīstību, 2005). There comes conclusion that development of social capital is in its beginning in Latvia.

Local leaders have an important role in municipalities their potential is as important as their municipalities leader's education, experience, and age. Since 1997, political competence has been growing in elections of the municipalities. In 1997, 11 492 candidates competed for mandates in 1454 lists of 566 municipalities; in 2005, already 15 681 candidates reached for mandates in 1696 lists of 530 municipalities (Pārskats par tautas attīstību, 2005). These calculations show that average number of candidates per mandate has grown as well as average number of candidates in one list. It witnesses of a competition within one list.

There are many daily newspapers issued in Latvia. The citizens subscribe or buy them at press distributors. In 1995, there were 12.4 newspaper copies per 100 citizens of the Republic, in 2000 - 8.3 copies, in 2001 - 9 exemplars, in 2002 - 9.4 copies, in 2003 - 10.8 and in 2004 - 10.9 copies (Pārskats par tautas attīstību, 2005). The number of newspapers per 100 citizens has been growing over the recent years. Local media are extremely oriented towards community cultural life. Local newspapers are patriotic regarding their coverage territory. Number of journals and other periodicals is also increasing: it was 235 in 1995 and 353 in 2004 (Latvijas statistikas gadagrāmata, 2005).

Different dynamics of economical development in different areas of Latvia, nonhomogenous covering and supply of cultural institutions as well as limited mobility of the inhabitants have caused differences in accessibility of culture between cities and rural areas and between the rich and the poor. Cultural activity of people is essentially influenced by opportunities in their living places. Riga has the widest supply range of cultural events. Regions have limited access to theatre, ballet or art galleries but there are

more developed amateur performances. On the whole, 74% of citizens of Latvia have attended at least one cultural event in 2004 (Vilka et al., 2004).

The greatest national treasure of Latvia is people as this is a state with limited natural resources. Education and access to information extend opportunities to get and use important life resources: financial, technological and improvement of social conditions. Policy of professional education and employment is a part of the state economical and social policy and it is connected with changes in labour market. At least one vocational education establishment is situated in each city and region (with exception of Balvi region) of the Republic. The number of vocational students was 47627 in 2001 and 46861 in 2004. In 2005, they chose mostly engineering sciences (27%), and services studies (19%). Recently educating opportunities for adults and disabled youths are being developed. By location of universities and their branches all over the territory of Latvia, it is seen that opportunities of getting higher education are well balanced and developed. In the study year 2004/2005, there were 56 universities with 130 705 students in Latvia. They were distributed as 65% in the basic studies and 0.5% in doctoral studies (Pārskats par tautas attīstību, 2005). Analyses of economical situation of the students show that many students are working although this diminishes quality of their studies. To promote the program of Latvian education, I think it would be necessary to improve social supply for the students: infrastructure of the universities, hostels, grants and conditions of repayment of students' credits.

3. Social networks

Social networks are relations among people, groups or organizations. Relations are aimed at reaching some concrete target, they have definite qualities, and they work more or less naturally. They can be attached to some concrete place or concrete time period. Social networks create important advantages- social capital for its members. Citizens of Latvia support actively the informal networks but formal networks are rarely used for diversion of concrete risks. Contacts among people are a natural and integral part of life. They determine the present and future life quality. Networking is a process of asking for help and support to each other.

Narrow sense of social capital shows it as a complex of horizontal relationships among people that consists of social nets and norms collaborating with them and influencing prosperity of the society. Social connections can result in increase of work production and decrease of business expenditures. Social capital releases coordination and collaboration. Social capital has also an important, socially negative side: isolated, closed or antisocially aimed groups and unions, for instance, corrupted racket. It can disturb economical and social development (Portes, 1998). Wider social nomination explains both positive and negative sides, observation of vertical and horizontal associations among people. It includes organizational behaviour of companies. This approach assumes that horizontal connections are necessary to give society feelings of self- confidence and common aim. It also suggests that without establishing connections above different social restrictions, for instance, religion or socially economical position, these horizontal connections can become of narrow interest and can even make obstacles actively for access to information or material resources that could be a great help for society otherwise.

We can talk about high potential of social nets in Latvia (Ziverte et al., 2002). There are wide social contacts with parents, sisters, brothers, other relatives, colleagues, friends, and neighbors. Essential factor influencing work of social nets is norms and control. In the case of social nets, norms determine work within the group so the central place is taken by trust of duty and word. To serve as social capital of some group, the people of the social net cannot avoid, for instance, mutuality as a norm in their relationships. Members of social nets have duties and trust of reward for their investments regarding each other. Other element regulating social nets is their limited solidarity. For instance, members of the social net care for behaviour of each other because dishonest behaviour of one of them can be ascribed to all the members of the social net. Trust and honesty in the sight of members is lost in the case of norms contempt.

Also family members with common household can be regarded as informal social nets. Examples of informal nets are also the rest of the family members not living together, friends, partners, and neighbours. Formal social nets are formed and based on work relations, associations of local and state levels and other group relationships: education, sports, entertainment, art, religion and charity organizations. Also civil relationships that are not group-based, for instance, political actions make social nets. A state is an example of a formal social net at institutional level. Differences among different types of social nets were especially well seen during soviet times (Ziverte et al., 2002). It was impossible to form organizations on the basis of real civil participation and volunteering principles. It was prescribed by the state ideology.

L. Ziverte mentions economical safety as one of the means for diminishing feelings of unsafety within social networks (Ziverte et al., 2002). It includes employment and income. In 1992, there were 31 284 unemployed people registered at the Employment State Agency, but in 2004 were registered 90 800 people. The number of registered unemployed people for benefits was 25 175 in 1992 and 39 681 in 2004 (CSP, 2005). So it can be concluded that there are several ten thousand of unemployed people who

cannot find job for a longer time period in Latvia. Average bruto wage per worker was 150 lats in 2000 and 211 lats in 2004, which witnesses that wages on average have grown for about 61 lats. There are differences between average wages of men and women in Latvia. In 2000, men's average wage was 160 lats while that of women was 126 lats; correspondingly in 2004 they were 212 and 179 lats. (Latvijas statistikas gadagrāmata, 2005). This means that men work at better paid jobs than women.

Conclusions

1. Civil society in Latvia is on the way of its development. Activities of nongovernmental organizations have set directions for their sustainability.

2. Citizens of Latvia are not socially active. Only one third believe that social activities can improve their life quality. Support centers of nongovernmental organizations should provide more positive information on their activities.

3. The Law of Latvia provides different ways for involvement of society in policy making at the state and municipality level. Only small part of people uses this opportunity. The citizens are insufficiently informed on positive examples.

4. Foreign scientists elaborated indicators of social capital that can be applied for determining presence of social capital in economics of Latvia. About 1% of citizens of Latvia are employed in the sector of non- governmental organizations. Development of social capital of Latvia is at its beginning stage.

5. Political competition is growing in elections of municipalities. Data show that average number of candidates per one mandate as well as average number of candidates in one list increases, which indicates competition within one list.

6. Analyses of economical situation of students show that many students are working although their knowledge quality can decrease.

7. Citizens of Latvia join informal nets successfully. But formal nets for possible risk discretion are used rarely.

References

1. Bourdieu P. (1986) Les trois erats du capital cuturel, Actes de la Recberche en Sciences Sociales, 30, 322 pp.
2. Coleman J. (1988) Social Capital in the Creation of Human Capital. American Journal of Sociology, 94, pp. 95-120.
3. Fukuyama F. (1995) Social Capital and the global economy. Foreign affairs, 74, pp. 235- 250.
4. Gaugere K., Austers I. (2005) Nevalstiskās organizācijas Latvijā: sabiedrības zināšanas, attieksme un iesaistīšanās. (Non-governmental organizations in Latvia: knowledge of the society, relations and involvement). Sorosa fonds-Latvija. Rīga, 122 pp. (in Latvian).
5. Pārskats par tautas attīstību.(Survey on NationalDevelopment) 2004/2005. Sociālo un politisko pētījumu institūts, pp. 1-148 (in Latvian).
6. Latvijas statistikas gadagrāmata 2005 (Yearbook of Statistics of Latvia 2005)(2005) LR CSP, 302 pp.(in Latvian).
7. Pilsoniskās sabiedrības stiprināšanas politikas pamatnostādnes (Basic Statements of Strengthening of Civil Society) IUMSILS, MK 15.02.2005. Rīkojums Nr. 98, 22 pp. (in Latvian).
8. Putnam R. (1995) Bowling alone: Americans destining social capital, American Planning Association, Chicago, pp. 65-78.
9. Putnam R. (2000) Social Capital Theory Goes East: A Case Study of Western Ukraine and Lvov. By: Aberg, Martin. Europe- Asia Studies, 52 Issue 2, pp. 295-317.
10. Portes A. (1998) Social Capital: Its origins and applications in modern sociology. Annual Review of Sociology, pp. 1-24.
11. Sociālais kapitāls (Social Capital) (2002) Starptautiskā zinātniskā konference. Jūnijs 13.-14. LLU SZK. Jelgava, 187 pp. (in Latvian).
12. Vilka I., Strupišs A. (2004) Pilsoniskās sabiedrības attīstība Latvijā: 2004. gada situācijas analīze. (Development of Civil Society in Latvia: analyses of the situation of 2004) Rīga, IUMSILS, 84 pp. (in Latvian).
13. Zīverte L., Austers I. (2002) Sociālo kontaktu tīkli kā drošumspējas faktors.(Social Nets as a Safety Factor) Pārskats par tautas attīstību 2002/2003. Rīga, IUMSILS, 80 pp. (in Latvian).

PECULIARITIES OF WATER AND WASTE UTILITIES REGULATORY SYSTEMS IN THE VIDZEME REGION AND THE WORLD

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Abstract

Currently public services become more and more significant in procurement of daily activities of each inhabitant and the entire society. Therefore optimal solutions of the regulatory issues is the topic of the day.
Objective of the article is to analyse regulatory systems of the provision of water and waste water utilities in Latvia and in other countries, to draw conclusions derived from the analyses and put forward suggestions for the choise of the most appropriate regulatory system in the local governments of Latvia.
The hypotheses advanced in the study have proved that each country may use its own discretion when selecting the regulatory system for water and waste water utilities.
Key words: regulator, water and wast water management, public services.

Introduction

Providers of public utilities predominantly are historically formed monopoly enterprises and the provision of such public utilities shall be regulated as proved by the experience of several countries. The target of public utilities is gaining superior profit. Consumers of the public utilities are interested to have the lowest cost for the services received. Different regulatory systems have been introduced in each country to compound these antipodal interests within limits of legislation and economical costs. We cannot evaluate them being either positive or negative. Latvia in recent years is facing economical and political problem of an extremely high inflation. Experts not without reason point out the strong impact of the rise in regulatory prices. Therefore formation of an optimal regulatory system has become an urgent problem. The law 'On Local Governments' sets an obligation for them to manage provision of water and waste water services. Consequently regulation of these services is the competence of the public regulators. This sphere has not been much investigated and there are few publications with scientific trend on the regulation of water supply services.

Hypothesis**:** by evaluating systems of water and waste water utilities in Vidzeme region, Latvia and in the world it is possible to facilitate their development.

The target for the proof of the hypothesis: evaluate regulatory systems of water and waste water utilities in Vidzeme region and in the territories of other countries and develop upgrowth activities of water utilities regulatory systems in local governments.

Assignments for reaching the target.

1. Study peculiarities of water supply and waste water utilities regulatory systems in other countries.
2. Investigate operation of systems of water supply and waste water utilities in local governments of Vidzeme region, Latvia.
3. Analyse factors affecting water consumption.
4. Elaborate suggestions for the perfection of water supply and waste water utilities regulatory system..

Materials and Methods

Methods:

- monographic, as well as analyses and syntheses in order to study the problem elements and to make synthesis of interconnection or to formulate regularities, deductions and inductions;
- the dynamic analyses method has been utilized for the statistic data analyses;
- correlation and multiple regression analyses.

Several information sources have been used for the elaboration of work assignments in line with the targets, like the state normative documentation, information by the Latvian Association of Local and Regional Governments, statistical data, data by water and waste water companies, information by the Regulator of Vidzeme Public utilities.

Results and Discussion

Water and waste water services in a certain geographic area are rendered by one service provider. It means that these services in this certain territory are monopoly and the customers are deprived of the right to choose the service provider. Therefore the customers are subject to the force of the monopoly that can and do regulate the rise in prices as well as limits the quality of services. A new regulatory system of two-level regulators has been formed in Latvia following the advise by the World Bank in order to improve the situation:

Level 1 – regulates entrepreneurship in the state regulatory spheres /gas, telecommunications, energy, railway services/, they are regulated by the Public Utilities Commission;

Level 2 – regulates entrepreneurship in the local government regulatory spheres/ heat supply, except for that

resulting in energy production, waste disposal, provision of water and waste water services/ these regulate enterprises formed by the local government. (Concept on the development of an efficient public services regulatory model tailored for the situation of Latvia, 2005)

Both the regulators are many-branched. One regulator governs several types of services. (Sabiedrisko pakalpojumu regulēšanas sistēma Latvijā, 2004) Since this regulatory system has been formed anew in this country, perfection of it may last for many years. Public utilities regulators of local governments in Latvia govern business related to the provision of water and waste water services. Obligation of local governments to organise water and waste water services has been set by the Law in Latvia (LR likums 'Par sabiedrisko pakalpojumu regulatoriem', 2001). Similar it is in many other countries in Western Europe and America.

Several arguments speak in favour of the services being rendered by regulators of local governments. Formation of independent control mechanism of the service providers is the way to reach the goal – good quality, safe, regular receipt of services for economically grounded prices, yet we cannot assume that they are provided for a sufficiently long period of operation. For a sustained period these property rights should be set apart thus better reaching rise in responsibilty of the economical regulation by local governments. For instance, a local government and the service provider often make an agreement therefore tariffs submitted do not any longer correspond to the real economical situation.

A converse opinion exists stating that water and waste water utilities should be governed by the Public Utilities Commission. Handing over of these services to the Public Utilities Commission shall have several benefits: competence of the staff, wide financial potentialities for the involvement of experts and quality services by the legal counsel. Yet the weaknesses shall be physical distance of the regulator from the service provider, concrete situation, and ignorance of the environment.

Countries have different experience. State regulators most frequently are responsible for several sectors since in lower levels they take care of one concrete sector like water supply. This system operates sucessfully in the USA and the United Kingdom. Increasing competition in the United Kingdom shall be highly appraised, the specific legislation prohibits amalgamation of two or more water companies in case they cannot prove to the regulator that the benefits of the amalgamation will compensate losses. Services regulatory institutions exist a good while in the United Kingdom. The state regulator is in charge for several separate sectors there hence special institutions have been formed for supervision on a federal level.

In Sweden, the water department has been established that sets competences of water supply companies, tariffs for services, and the order of their subsidy. The aim of regulation is providing that 1/3 of water supply pipes network shall be accessible for third parties also. The Swedish legislation prohibits to earn by providing water services that secures possibly lower tariffs for the consumers. A total of 290 local governments are in charge for providing services. They organise delivery of potable water, discharge and treatment of waste water. Seven regional supervisory authorities monitor operation of local governments (NERA,2000).

In many countries services regulatory organisations are almost always related to one sector. For instance, regulation of water and waste water services is delegated to special institutions in the Philippines, Argentina, the United Kingdom, Chile, Peru, and Mexico. A multisectoral regulatory institution usually tends to develop special subdepartments. It may as if prove that potentialities of multisectoral regulators are higher as well as it is easier to implement the regulatory principles and ideas. Yet the experience in the United Kigdom shows that these advantages exist theoretically only and not in reality. Another argument is that significant problems related to ecology are easier to solve by a unitary regulator that oversees the teritory. Although this to a great extent is an issue of the legislation. Therefore the multisectoral regulation does exist, yet it is neither simple nor strictly regulated. The main drawback is feasible conflicts and misunderstanding between the sectors of services and regulators thus resulting in decline of responsibility.

In England predominant regulatory structure is similar to the one in Latvia. Following the reforms of 1989, a solitary private water company 'Thames Water' was established controlled by three types of regulators – economical regulator (Ofwat), environmental protection regulator (the Environment Agency) and potable water regulator (the Drinking Water Inspectorate). In Australia, 'The State Water Agency' is in charge of water supply services. Hystorically water services have been under the state control since there is a trend and desire to hand them over to the municipalities which are interested in preserving clean environment and help to avoid breach of law, and they have closer co-operation with businessmen. All this maximises responsibility of local governments and enterprises.

Water and waste water services in Latvia are provided both centralised and decentralised. In bigger sized settlements, in most cases a solitary enterprise or agency formed by the local government, provides the centralised services. In smaller local governments, often a single enterprise or agency fomed by the local government provides all the public utilities like water and heat supply, and waste

collection. Since the law "On Public Utilities Commission' states that only business activities are being regulated, services provided by an agency formed by the local government are not being regulated. This results in a paradoxical situation where some service providers are controlled since they do business and some are not controlled as they tell against the business definition and they do not aim to gain profit. On this source municipal regulators have furnished recurrently modifications for the alteration of the current terminology in the legislation in order to replace the term "business activity' with the term "companies providing public utilities', unfortunately there are no results by now. Obviously it is connected with the current political standing in Latvia and the frequent changes of the government. The feasibly optimum regulatory system is the goal for further investigations by the author. Then data acquired shall be analysed and suggestions formulated.

In line with the information by the Regulator of Vidzeme public services, which has concluded agreements on regulation of public utilities with 94 local governments, in 39 local governments these services are provided by limited liability companies and in 55 local governments by agencies formed by local governments that are regulated, therefore the local governments solely set tariffs and take care of their economical grounds.

The following institutions control providers of water and waste water services in Latvia:

1) State Revenue Service;

2) Ministry of Welfare of the Republic of Latvia, which subordinate is State Environment Agency;

3) Ministry of Health of the Republic of Latvia, which subordinate is State Health Centre;

4) Public Utilities Commission;

5) Central Statistics Agency, etc.

Operation of public services providers is governed by:

1) Law 'On Public Services Utilities';

2) Law 'On Earth Entrails';

3) Law 'On Entrepreneurship';

4) 'Business Law';

5) Law 'On Local Governments';

6) Law 'Evaluation of the Impact on the Environment';

7) Shelter Belt Law;

8) Law 'On Environmental Protection';

9) Law 'On Pollution';

10) Miscellenious Cabinet regulations and other laws and regulations.

In order to investigate more thoroughly the factors effecting water consumption in Vidzeme region the author has made analyses of the data by one provider of these services.

The study made use of the materials of Cesis municipal enterprise VINDA SIA.

The town of Cesis is located about 92 km North-East of Riga in Vidzeme region covering 19,3 km^2. Several deep water course channels are crossing the teritory of the town with inlet into the river Gauja. Number of population has decreased from 22 100 in 1990 to 10 039 in 2004. There are two independent water sypply systems in the town. One of them serves the central part of the town and another one, which is a small subsystem, serves a separate part of the town to the South West of the centre of the main part of the town. Both systems derive only ground water. Residents whose dwellings are not connected to the centralised water sypply system take water from private wells. Brewery, dairy and the meet processing factory are the industries of Cesis. The town has a hospital, hotels, schools and other public institutions corresponding to the size of the town. Total length of the transmission water pipeline equals 72 km and total length of the sewerage network is 52 km (VINDA, 2004). Table 1 shows status of unemployemnt in Cesis town.

Table 1 shows that real payers for water and waste water services are able-bodied inhabitants being employed (7869 or 41.33%) and the retired (4998 or 26. 25%).

Making use of SPSS, statistic data processing packet, the author carried out statistic study on variations of water

Table 1

Residents of Cesis and the employment, 2004

Group	Number	As %
Working age incl.	8579	45.06
Employed	7869	41.33
Unemployed	710	3.73
Retired	4998	26.25
Kids of school age	2433	12.78
Pre-school age kids	2145	11.27
Youth	884	4.64
Total:	19039	100

Source: data by Cesis City Cuncil, 2005

Table 2

Water consumption factors in the Cesis town

Year	Water tariff, LVLm^3	Water consumption, m^3	Cost of living, LVL	Amount of consumers	Amount of meters
1998	0.16	879795	82.15	16001	2400
1999	0.19	703762	83.18	15957	4787
2000	0.26	558316	84.47	15922	12737
2001	0.31	500544	86.93	15876	12755
2002	0.35	460130	88.76	15977	13096
2003	0.35	444307	93.54	15976	14005
2004	0.35	438941	98.78	15802	15012

Source: Cesis municipal enterprise VINDA SIA

consumption in the period from 1998 to 2004. Investigated factors impacting the water consumption have been reflected in table 2.

Table 2 shows a sharp decline in water consumption in 2000 (by 36,54% or 321479m^3) compared to the year 1998, when the tariff for water was also raised. When compared results of 1998 to the ones in 2004, the consumption has fallen by 50% or by 440854 m^3. This could prove that tariff make a resonable impact on the water consumption. The author has used correlation and multifactoral regression analyses to evaluate the situation.

The already existing data in the factors analyses was supplemented by living wage fixed in Latvia. The following formula was applied:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4, \quad (1)$$

Where:

Y – water consumption – resulting feature, yet the factoral features x are:

x_1 – amount of consumers;

x_2 – number of water meters;

x_3 – water tariffs;

x_4 – living wage (consumption standard).

The aims of the correlation analyses: to state the tightness of interconnections between the factoral and resultative feature or the factors that affect substantially water consumption.

This is a multifactoral correlation because of the present 4 factors. The multisectoral correlation analysis studies the strength of coherence among the resultative factor Y and several factoral features of x_1, x_2, …..x_n.

The tightness of the linear coherence is characterized by the correlation ratio. The correlation ratio of the general group is marked as p, and the ratio of selection correlation is r. The value of the correlation ratio stands within limits from (–) 1 to 1. (Arhipova et al., 2003).

When correlating in relation to years the following correlation ratios were obtained (see table 3).

In cases where the correlation ratio is statistically significant with probability of 99%, two stars are attached. The author concludes that statistically significant correlation exists among all the features. Analyses of correlation resulted in the table showing all the ratios of pair correlation. A very tight correlation (r = -0.8618 and r = -0.9335) does exist between the number of water meters and water consumption as well as the living age and the water tariff.

The author investigated which regularity the resultative

Table 3

Partial correlation ratios

Factors	Water consumption, m^3	Water tariffs, LVLm^3	Cost of living, LVL	Number of consumers	Number of meters
Water consumption m^3	1.0000	– 0.7949	– 0.0539	0.9068*	– 0.8618*
Water tariffs Ls m^{-3}	– 0.7949	1.0000	0.4275	– 0.9335**	0.7219
Cost of living Ls	– 0.0539	0.4275	1.0000	– 0.4363	– 0.1182
Number of consumers	0.9068*	– 0.9335**	– 0.4363	1.0000	– 0.7112
Number of meters	– 0.8618*	0.7219	– 0.1182	– 0.7112	1.0000

* - average correlation
** - tight correlation
Source: results of the author's research

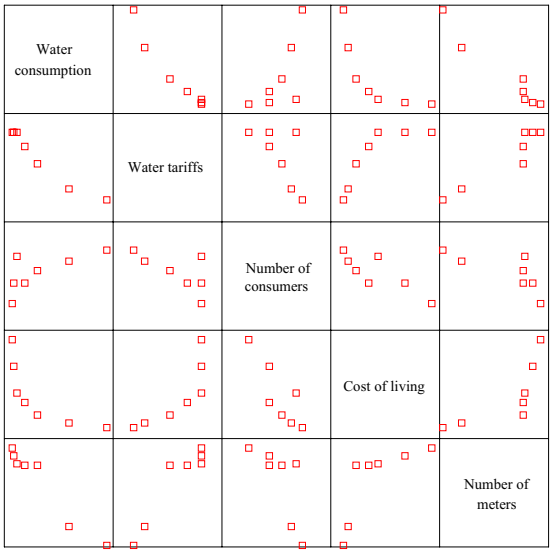

Figure 1. Impact of factors analysed on water consumption.

feature follows when the values of factoral feature are changing.

In order to apply the multifactoral regression analyses:

1) the resultative feature is to be tightly correlated with factorial features;

2) factorial features may not be internally tightly correlated.

In this occasion a tight connection exists amongst factorial features and these factors are called multicolinear. Multicolinearity is undesirable since it proves interdependency of factorial features. In this case one factor regression method shall be applied thus finding out what regularity is followed by the change of resultative feature when the values of factorial features are changing.

In order to foresee changes of the resultative feature the author performed regression analyses. Picture 1 show resultative features on axis X and mutual coherence of the studied factor on axis Y.

The Figure 1 shows that all the factors substantially effect the water consumption. Yet the practical experience of the author proves that number of water meters is the most significant of the factors. Water meters have been installed in 2000 making bulk impact on water consumption (Table 1). People started paying for the real consumption and not following the water norms per capita. Following the induction method the author concluded that the experience by other water companies ('Madona water', 'Rīga water', 'Rūjiena heat supply') as well as the analogous world experience proves that after this process water consumption drops considerably. Water supply is identical not only in Cesis district but also in the neighbouring districts. Results of the study demonstrate that water consumption is less effected by other factors like the living wage or the fixed water tariff, yet the ruling factor is the number of water meters and amount of water consumers.

Regression equation is applied for prognoses of the values of resultative feature.

Regression equations obtained as a result of the study are:

water consumption = – 5425439 – 1484547 x water tariff; (2)

water consumption = – 5425439 + 378.193 x amount of conconsumers; (3)

water consumption = – 5425439 + 5807.120 x cost of living; (4)

water consumption = – 5425439 – 11.164 x number of water meters, (5)

Since F-test value of p equaled 0.0590 we can conclude that the model is statistically significant with probability of 95%. The acquired determination ratio (R2) equals 0.970. It means that 97.0% of changes in water consumption shall be explained by the formed regression model. One can conclude following the results that tariffs set by the public utilities regulatory institutions have a little impact on the real water consumption.

In order to perfect the existing situation in the field of public utilities regulation, the author supports the conception by the Ministry of Economics for the project 'Conception on the development of effective and suitable best for the situation of Latvia public utilities regulatory model'. It means that the Public Utilities Commission regulates public utilities on the state level and regional regulators on the local governments level being under supervision of the planning region development board which in its turn is subordinated to the Ministry of Regional Development and Local Governments Affairs. A two-type regulatory system of today shall be preserved by separating regulatory fields

on the state level from the local governments regulatory spheres.

Conclusions

1. Monopolies control the sphere of water and waste water utilities, and consumers have no option,

2. The world experience shows that systems of monopoly spheres regulatory institutions are very diverse, countries establish regulatory systems using their own discretion.

3. Two-level regulators have been formed in Latvia following the advice by the World Bank:

4. The Public Utilities Commission in state regulatory institutions;

5. Public utilities regulators of local governments in regulatory spheres of local governments, regulators of both levels are multisectoral, meaning that one regulator controls several types of public utilities.

6. The factor most impacting water consumption in the local government territories of Latvia is installation of water meters, then follows the amount of water tariffs, and the living wage.

7. It is feasible that observation of environmental protection demands shall be one more significant factor related to the tariff and consequently with the water consumption and resulting in rise of companies' costs for 1 m^3.

Suggestions

1. Organise seminars, courses, exchange of know-how with water utilities regulatory institutions from oversees for the regulators of local governments aiming to find the most successful solutions related to the control of these institutions.

2. For the regulatory institutions to co-operate with other authorities controlling providers of the public utilities, like the Environmental Agency, the Central Statistics Authority, and State Revenue Service.

3. For the sake of governing all the providers of water and waste water services to replace wording 'business activity' with 'enterprises providing public utilities' in the law 'On Public Utilities Commission'.

4. In order not to substantially raise tariffs for water and waste water that could effect water consumption, the service providers shall reconcile building and reconstruction plans with the regulatory institutions prior the attraction of investments.

5. To maintain the current two-type regulatory system isolating the fields regulated on the state level from the fields regulated on the level of local governments, concurrently envisaging that the planning region local government regulators are subordinated to the planning region development board which in its turn is supervised by the Ministry of Regional Development Local Governments Affairs.

References

1. Arhipova I., Bāliņa S. (2003) Statistika ekonomikā (Statistics in economics). Datorzinību centrs, Rīga, pp. 233-267. (in Latvian).
2. Ekonomikas Ministrija. (2005) Koncepcija par efektīva un Latvijas situācijai vislabāk atbilstoša sabiedrisko pakalpojumu regulēšanas modeļa izveidi (Conception on the development of effective and suitable best for the situation of Latvia public utilities regulatory model), Ministry of Economics, Rīga, 22 pp. (in Latvian).
3. LR likums. (2001) Par sabiedrisko pakalpojumu regulatoriem (The law of the Republic of Latvia On Public Utilities Commission). Latvijas Vēstnesis, No 75, Rīga, 1 pp. (in Latvian).
4. National Economic Researsh Associates. (2000) (National Economic Researsh Associates) NERA, 37 pp.
5. Sabiedrisko pakalpojumu regulēšanas sistēma Latvijā, (2004) (Materials by the World Bank Study on Regulatory System of Public Utilities) World Bank and EM, Rīga, 51 pp. (in Latvia).
6. SIA 'Vinda'. (1998, 1999, 2000, 2001, 2002, 2003, 2004) SIA VINDA Gada pārskats (Annual reports by VINDA SIA). Nepublicēti materiāli, 67 pp. (in Latvian).
7. Data by Cesis City Council, 2005.

FOOD SCIENCES

THE CHANGES OF THE CONCENTRATIONS OF THIAMIN AND RIBOFLAVIN IN MILK ENRICHED WITH PREBIOTICS AND PROBIOTICS

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Abstact

Fermentation of milk with probiotics and prebiotics has been shown to increase the concentration of B group vitamins in fermented milk products.

The task of the study was to investigate the influence of prebiotics on the increasing of thiamin and riboflavin concentrations in milk during fermentation by *Bifidobacterium lactis*.

Lactulose (Duphilac, Netherlands) and inulin (Raftiline, Belgium) were added (1, 2, 3, 4, and 5%) into 100 g of milk. The milk samples were inoculated with *Bifidobacterium lactis* (BB-12, Chr. Hansen, Denmark) and incubated at 38 °C for 16 hours. The amount of thiamine and riboflavin was determined by fluorometric method.

Laboratory studies have shown that the increasing of thiamin and riboflavin concentrations in milk depends on the concentration of lactulose and inulin.

Data on the final thiamin and riboflavin concentrations in fermented milk indicates that increasing the lactulose concentration from 1% to 3% enhanced the production of thiamin and riboflavin. The similar data was obtained with inulin. Increasing of inulin concentration from 1% to 4% enhanced the production of vitamins thiamin and riboflavin.

The present results furthermore indicate that finding optimal combination of prebiotics and probiotic pairs where the prebiotic would benefit the specific probiotic strain, e.g. during production and formulation into foods, is one of the research priority for functional foods.

Key words: thiamin, riboflavin, inulin, lactulose, bifidobacteria, milk.

Introduction

Vitamins are organic substances that are present in human natural foods. They cannot be made by the body itself and are essential for growth, maintenance and normal metabolism.

Whole cows' milk contains about 37 mg of thiamine 100^{-1}g, mostly in the free form. The main physiological function of thiamin is to serve as a cofactor in intermediary metabolism, i.e. in the oxidative decarboxylation of a-ketoacids and in transketolase reactions. When looking at changes in thiamin concentration during milk processing, the most dramatic reductions occur when high temperatures are applied over a long period of time or when the product is stored over an extended period. The best dietary sources of thiamin are pork, beef, whole grain cereals, and legumes. Milk can contribute up to 20% to the daily thiamine requirements of adults in Latvia where milk and dairy products are commonly consumed.

Milk and milk products are important sources of riboflavin in human nutrition, accounting for up to 70% of total daily intake in industrial countries. Riboflavin is heat stable in the absence of light, but extremely photosensitive. As it is known, dairy products compile the important part of daily intake, therefore dairy products are considered as one of the most import sources of B group vitamins, which provide significant part of B group vitamins in the total daily intake.

The amount of thiamin and riboflavin in milk can increase during fermentation using lactic acid bacteria. As it is known about the possibilities to increase the concentration of B group vitamins, one of the most important questions is to determine the suitable concentrations of prebiotics for stimulation of the growth of *Bifidobacterium lactis* in milk and to achieve the higher concentrations of thiamin and riboflavin in fermented milk. Probably, there is connection between the growth of bifidobacteria and the synthesis of thiamin and riboflavin during fermentation, depending on the concentration of the prebiotic. Summarizing the above mentioned information, the task of the study was to investigate the influence of prebiotics on the increasing of thiamin and riboflavin concentrations in milk during fermentation by *Bifidobacterium lactis*.

Materials and Methods

The research was performed at the microbiological laboratory of the Department of Food Technology of Latvia University of Agriculture and at the Laboratory of Biochemistry and Physiology of Animals of the Institute of Biology of University of Latvia.

The strain of *Bifidobacterium lactis* (BB-12, Chr.Hansen, Denmark) was used. During the experiments, the culture was maintained at - 18 °C.

The lactulose syrup (Duphalac®, Netherland) was used for growing of bifidobacteria in milk. The composition of the

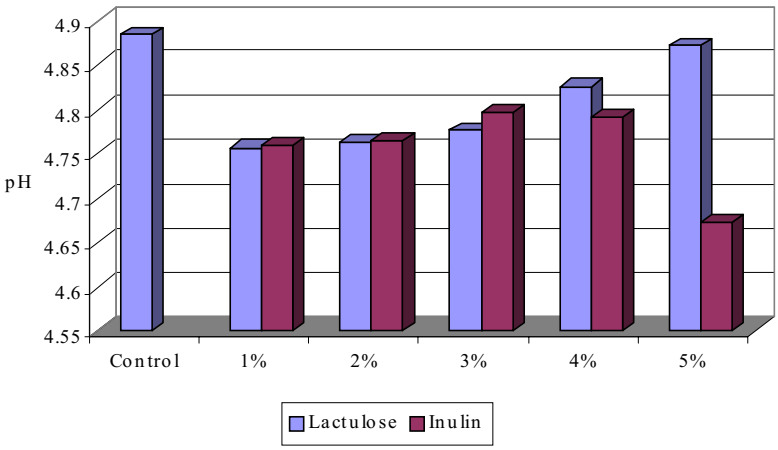

Figure 1. pH of fermented milk samples with different concentrations of prebiotics.

syrup of lactulose was as follows (%): lactulose 67, lactose less than 6, galactose less than 10.

The inulin RaftilineāHP (ORAFI Active Food Ingredients, Belgium) was used for growing of bifidobacteria in milk. The composition of inulin was as follows (%): inulin - more than 99.5; glucose, fructose and sucrose - less than 0.5.

Control sample without inulin and lactulose was prepared for comparison of obtained results.

Bifidobacterium lactis was incubated in milk. Different lactulose and inulin contents (1, 2, 3, 4, and 5%) were added individually in 100 g of milk. *Bifidobacterium lactis* was inoculated with 2 ml of milk suspension (about $1*10^6$ bifidobacteria) and cultured at 36 °C for 16 hours.

pH of fermented milk was determined by pH-meter WTW series inoLAB pH 720. The amount of thiamin and riboflavin was determined by fluorometric methods. Thiamin was determined according to AOAC Official Standard Method 986.27 and riboflavin – AOAC Official Standard method 970.65.

Fermentations were performed in triplicate, and the analyses were carried out in duplicate. The data given here are the mean values of the measurements.

Results and Discussion

In contrast with lactobacilli, bifidobacteria exhibit a weak growth in milk or do not grow at all in milk (Mizota, 1996). The addition of prebiotics such as inulin and lactulose in milk stimulates growth of bifidobacteria (Rastall et al., 2002, Strohmaier, 1998).

The changes of pH value (Figure 1) is an important factor in milk fermentation by bifidobacteria. The chemical composition of the fermentation medium for growth (for instance, the carbohydrate source, total solid content, availability of nutrients and growing parameters, dissolved oxygen content) and the cultivation conditions (for instance, the level of inoculation, the incubation temperature, the fermentation time) can influence changes of pH value. The final active acidity may affect the viability of probiotic organisms in fermented products. As obtained results showed, medium active acidity can be increased by addition of 5% of inulin and 2-3% of lactulose.

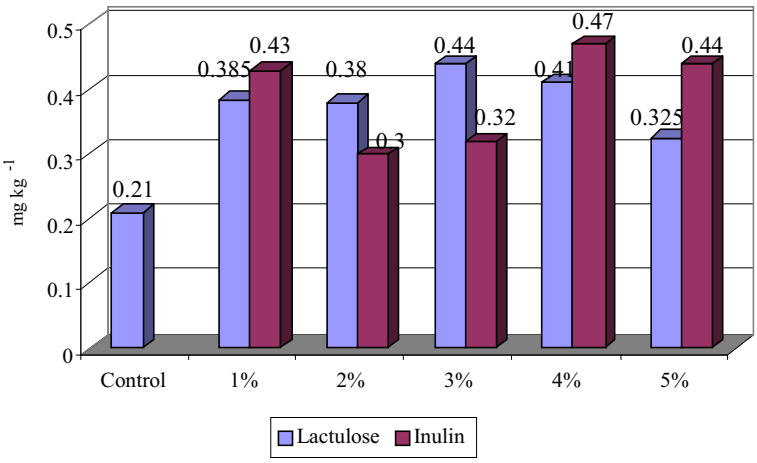

Figure 2. Thiamin concentration in fermented milk samples.

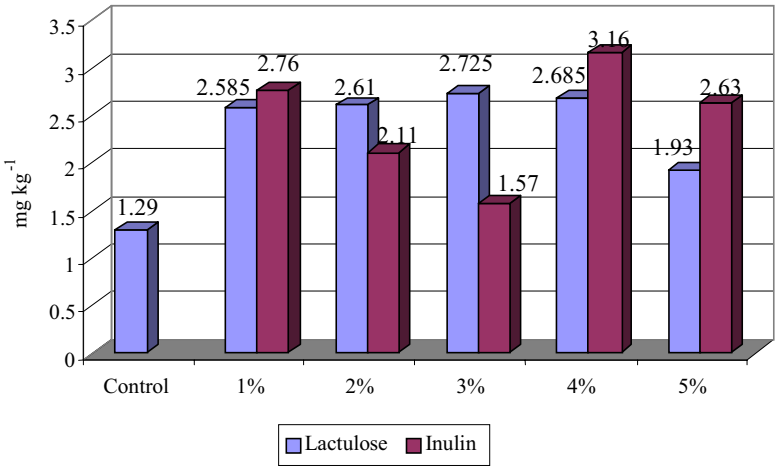

Figure 3. Riboflavin concentration in fermented milk samples.

Shin, Lee, Petska, and Ustunol (2000) were able to show that adding large quantities (5%) of fructo-oligosaccharides to skimmed milk enhanced the survival of the two *Bifidobacterium* strains and promoted the development of acidity of skimmed milk samples. One of the explanations of the above mentioned conclusion is the chemical composition of fructo-oligosaccharides and lacto-oligosaccharides and the ability of bifidobacteria to ferment that substrate.

The changes of the concentrations of thiamin and riboflavin in fermented milk samples depending on the concentration of the prebiotic are showed in Figures 2 and 3.

One of the most important properties of bifidobacteria is ability to produce different concentrations of B group vitamins (Roberfroid, 2002). As it is known, bifidobacteria exhibit a weak growth in milk and the addition of growth promoting factors would stimulate not only the development of bifidobacteria but would also promote the increasing of the concentrations of B group vitamins in milk (Modler, 1994). Our hypothesis is that there is connection between the growth of bifidobacteria and the synthesis of thiamin and riboflavin during milk fermentation depending on the concentration of prebiotic. With the exception of some B group vitamins, for example, thiamin, riboflavin, cobalamin and pyridoxine, changes in the vitamin and mineral content of fermented milk products are negligible. Moreover, the pasteurisation of milk prior to fermentation may destroy some vitamins such as thiamin, riboflavin, pyridoxine and cobalamin while the level of thermostable vitamins (niacin and pantothenic acid) remains unchanged.

Laboratory studies have shown that the level of thiamin and riboflavin in fermented milk depends on the concentration of prebiotics and probiotic properties and may be lower or higher than in control sample and non-cultured milk.

Data on the final thiamin and riboflavin concentrations in fermented milk indicate that increasing the lactulose concentration from 1% to 3% enhanced the production of thiamin and riboflavin, but increasing the lactulose concentration from 4% to 5% decreased the production of thiamin and riboflavin. Similar data was obtained with inulin. Increasing of inulin concentration from 1% to 4% enhanced the production of thiamin and riboflavin, but increasing the inulin concentration till 5% decreased the production of thiamin and riboflavin. From the investigation of R.Palframan, G.Gibson and R.Rastall was observed that FOS and inulin demonstrated the greatest bifidogenic effect at pH 6.8 and 1% (w/v) carbohydrate, whereas GOS, IMO and lactulose demonstrated their greatest bifidogenic effect at pH 6 and 2% (w/v) carbohydrate. From this we can try to explain also our research results.

For detection of most suitable concentrations of inulin and lactulose there are planned to determine the concentrations of pyridoxine and cobalamin in fermented milk.

Conclusions

1. The addition of large quantities (till 5%) of inulin to milk enhanced the survival of *Bifidobacterium lactis* and increased pH of fermented milk.

2. The increasing of concentrations of thiamin and riboflavin in milk is dependent on the ability of bifidobacteria to grow in milk enriched with different concentrations of lactulose and inulin.

3. The most suitable concentrations of inulin and lactulose are 4% and 3% based on the results of optimal concentrations of thiamin and riboflavin.

References

1. Mizota T. (1996) Lactulose as a growth promoting factor for Bifidobacterium and its physiological aspects. International Dairy Federation, Bulletin 313, pp. 43-48

2. Modler H.W. (1994) Bifidogenic factors – Sources, Metabolism and Applications. International Dairy Journal, 4, pp. 383-407.
3. Rastall R.A., Maitin V. (2002) Prebiotics and synbiotics: towards the next generation. Current Opinion in Biotechnology 13: pp. 490-496
4. Roberfroid M. (2002) Functional food concept and its application to prebiotics. Digest Liver Dis 34 (Suppl.2): S 105-110.
5. Shin H.S., Lee J.H., Petska J.J. and Ustunol Z. (2000) Growth and viability of commercial Bifidobacterium spp. in skim milk containing oligosaccharides and inulin. Journal of Food Science 65: pp. 884-887.
6. Strohmaier W. (1998) Lactulose: Status of health-related applications. International Dairy Federation, Bulletin 9804, pp. 262-271.
7. Palframan R.J., Gibson G.R., Rastall R.A. (2002) Effect of pH and Dose on the Growth of Gut Bacteria on Prebiotic Carbohydrates in vitro. Anaerobe 8; pp. 287-292

INFLUENCE OF HIDROLYSED OATS INSOLUBLE FRACTION ON DOUGH QUALITY

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Abstract

The major wheat flour constituent, which determines the dough quality, is gluten. Oatmeal has higher biological value due to amino acid composition and content if compared to other cereals, but the technological properties of proteins are not as good as the ones of wheat flour. Oat products can be used in bread making although the increased amount of additive shows negative influence on bread texture, elasticity, volume, taste, and flavour. The method is developed for hydrolysed oatmeal separation in soluble and insoluble fractions, thus extending the oatmeal application possibilities.

The aim of the current research was the investigation of influence of hydrolysed oats insoluble fraction on wheat dough rheological properties.

The obtained results proved that in case hydrolysed oats insoluble fraction additive was used, water adsorption was increased by 63.8%–66.4% and dough stability time was changed from 4.8 to 10.0 min. The negative influence on dough development time and dough softening degree was observed. The farinograph quality index was within acceptable limits (less than 120 FU), if the oat additive of 10% and 15% was used. It is possible to obtain dough with better rheological properties if the hydrolysed oats insoluble fraction additive is 15% from flour mass.

Key words: hydrolysed oats, dough rheological properties.

Introduction

Wheat bread is one of the main foods consumed, but it has low nutritional value. Various additives such as whole or split grains, cereal flakes, flax seed, bran, and sesame are used to enhance the nutritive value of bread.

The major wheat flour constituent, which determines the dough quality, is gluten. Gluten consists of proteins (Matz, 1999). The gluten quality depends on the ratio between two proteins – gliadin and glutelin. Gliadin absorbs water, swells and tends to softening, but glutelin provides the stability and elasticity for the swollen glutelin. The optimum ratio between glutenin and gliadin for high quality gluten is found 1:1.1 (Ruža, 2001).

Oats have higher nutritive value comparing to other cereals due to high content of dietary fiber (soluble, insoluble), especially b-glucan, and presence of polyunsaturated fatty acids (linoleic acid, linolenic acid), antioxidants, and vitamin E. Oats contain more essential amino acids (isoleucine, leucine, methionin, etc.). The technological properties of proteins are not as good as the ones of wheat flour (Welch, 1995).

The research demonstrates that the baking properties of oat products are not satisfactory. Oat protein fraction forms emulsion, it has good fat binding ability and hydrating properties, but it does not form dough with good rheological properties. Oomah (1983) and Salovara (2003) carried out extensive research on oatmeal use in bread making. The increased amount of oat additive shows negative influence on bread texture, elasticity, volume, taste, and flavour (Ma et al., 1984). Oatmeal promotes bread crust forming and dough gas retaining ability (Ranhotra et al., 1995). The research of Oomah (1983) proved that in case of wheat flour replacement with oatmeal in quantities exceeding 25% the dough development time, dough strength and volume are reduced. The flour chemical composition is changed when oatmeal is added to wheat flour, therefore the dough tolerance is reduced, but it does not influence the amount of CO_2 formed (He et al., 1991).

In order to widen the possibilities for oat use in human nutrition, the method was developed for hydrolysed oatmeal products (grains, flour and flakes) separation in soluble and insoluble fractions, thus extending the oatmeal application possibilities (Gramatina et al., 2002).

The research is carried out on the possibilities for hydrolysed oats insoluble fraction use in bread making. After visual and organoleptic evaluation of experimental bread samples, the maximum amount of oat additive was determined to be less than 20% from wheat flour.

Taking into account the above mentioned, the following tasks were set for the current research: 1) to compare the chemical composition of hydrolysed oatmeal insoluble fraction with composition of oatmeal without hydrolyses; 2) to study influence of hydrolysed oatmeal insoluble fraction additive on wheat dough rheological properties; 3) to determine the optimum amount of additive.

Materials and Methods

The hydrolysed oatmeal insoluble fraction was prepared from oatmeal produced by the company 'Rīgas Dzirnavnieks'. The extra grade wheat flour from the company 'Dobeles Dzirnavnieks' and water was used for dough making.

The following technology was used for preparation of hydrolysed oatmeal insoluble fraction additive:

1) the preparation of mixture with 12 % oat flakes with water;

2) adding enzyme Amilosubtiline G3x (α-amylase, ISC 'Biosinteze', Lithuania) to the mixture at temperature 65 °C;

3) fermentation for 20-25 min;
4) inhibition of the added enzyme by heating (t=85 °C, τ=20 min);
5) sample chilling (t=20-25 °C);
6) separation of the oat extract in two fractions using a sieve (mesh size 1.00×1.00 mm);
7) drying of the hydrolysed oatmeal insoluble fraction up to constant weight (t=60 °C, ϖ=5%).

The content of insoluble fibres, lipids and proteins were determined in the obtained sample of hydrolysed oatmeal insoluble fraction and the results were compared with oatmeal without hydrolyses. The content of insoluble fibres % was determined using standard method ISO 5498. Using the standard method ISO 6492, the content of lipids % was determined, but the protein content %–by standard method ISO 5983.

For the further experiments dough, was made replacing 10, 15 or 20% of wheat flour with hydrolyzed oatmeal insoluble fraction additive. The dough without hydrolyzed oatmeal insoluble fraction was used as a control sample.

The rheological properties of the prepared samples were tested on the Brabender farinograph in the laboratory of company 'Rīgas Dzirnavnieks' according to the standard method ICC–115/1. As a result farinograms were obtained (Fig. 1).

The following indices are determined and calculated from the farinograms:

- consistency (FU[1]);
- water adsorption ability (%);
- dough development time (min) A;
- dough stability (min) B;
- degree of dough softening (FU) C;
- farinograph quality index (FU).

Consistency (FU) is determined for flour with water added.

Water adsorption ability (%) is the amount of water which is used for dough mixing until the required consistency.

Dough development time (min) (A) is a period from the start point of mixing until the obtaining of homogeneous consistency of dough.

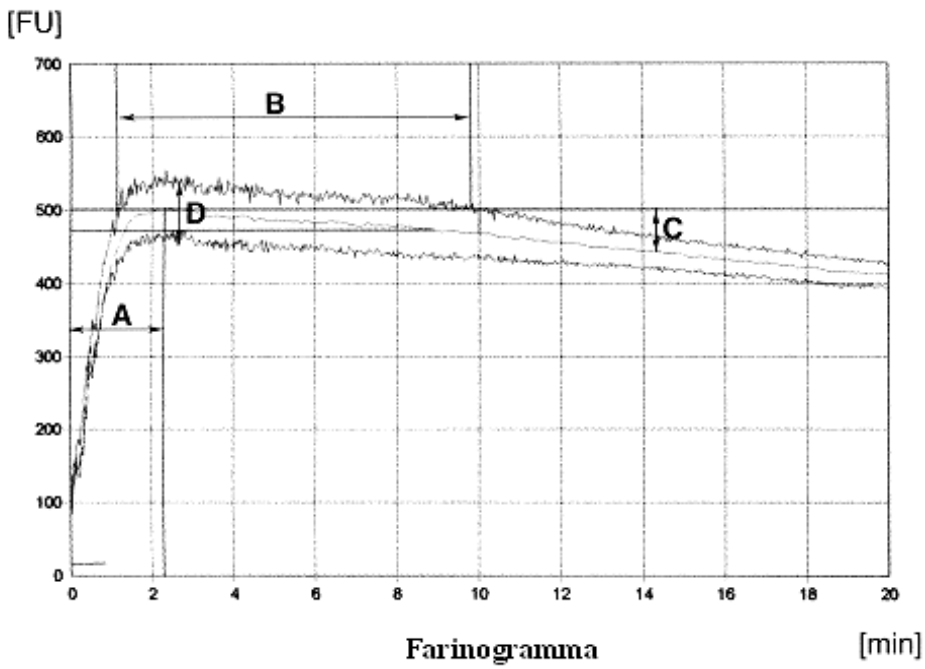
Dough stability (min) (B) shows the maximum time of dough stability.

Degree of dough softening (FU) (C) characterizes the dough gluten quality after the obtaining of the required dough quality.

Farinograph quality index (FU) is a point on the graph which is measured when the value is decreased by 30 FU.

Results and Discussion

The results of chemical composition for oatmeal and hydrolysed oatmeal insoluble fraction are presented in Table 1.



Source: 'Quality control – Quality control equipment' (2006)

Figure.1. Farinogram.

[1] FU – FARINOGRAPH Units

Table 1

The chemical composition of oatmeal and hydrolysed oatmeal insoluble fraction (%)

Test samples	Amount of insoluble fibres, %	Amount of lipids, %	Amount of protein, %
Oatmeal	1.09±0.02	6.96±0.02	12.92±0.05
Hydrolysed oatmeal insoluble fraction	3.78±0.03	7.13±0.06	19.40±0.03

The obtained results (Table 1) show that the amount of insoluble fibres in hydrolysed oatmeal soluble fraction was increased reaching 3.78% or it is 3.5 times more, if compared with oatmeal. The amount of lipids in soluble fraction of hydrolysed oatmeal increased from 6.96% up to 7.13%, but the amount of protein–from 12.92% up to 19.40% or by 1.5 times, comparing with oatmeal without hydrolysis. Such results can be explained by the regrouping and restructuring of soluble and insoluble lipids, fiber and other compounds during oat hydrolysis.

The farinograms for the experimental control sample and samples with different amounts of hydrolysed oat insoluble fraction additives are presented in Fig. 2.

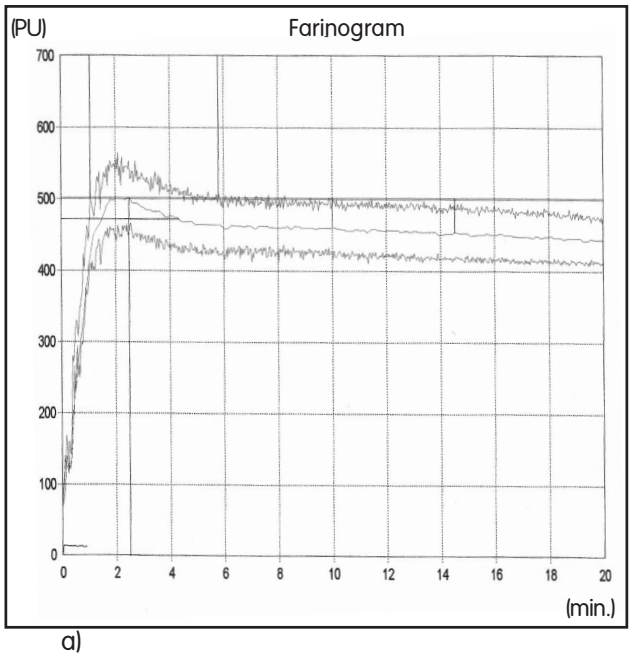
The data obtained from the farinogram for a control sample and the dough samples with hydrolysed oatmeal insoluble fraction additive are collected in Table 2.

The data shows that consistency for all dough samples was between 490 FU and 520 FU.

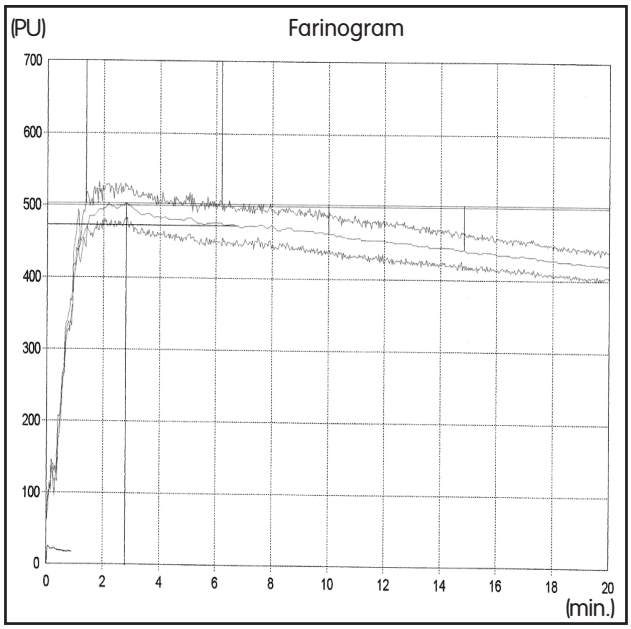
The water adsorption ability of tested dough samples are in within the permissible limits, which was 50.4–75.6%. The water adsorption ability was increased from 63.8% to 66.4% with an increased amount of hydrolysed oatmeal insoluble fraction additive if results compare with the control sample (59.7%). Such results can be explained by the higher amount of insoluble fiber and cellulose in the dough with hydrolysed oatmeal insoluble fraction additive. These compounds (fiber and cellulose) swell and in result bigger amount of water can be adsorbed comparing with wheat flour.

The dough development time was increased for the samples with a hydrolysed oatmeal insoluble fraction additive by 2.8–5.7 min or 1.1–2.3 times depending on the amount of the additive in comparison with the control sample (2.5 min). The results demonstrate that water binding by gluten proceeds slower in the dough with hydrolysed oatmeal additive.

If dough is made from high-quality flour, the time of dough stability is 10 minutes, but if it is made from poor quality flour – 3 minutes. Dough stability time changed from 4.8 min up to 10.0 min with an increased amount of additive in comparison with the control sample (4.7 min). It shows that dough stability was increased during a longer



a)



b)

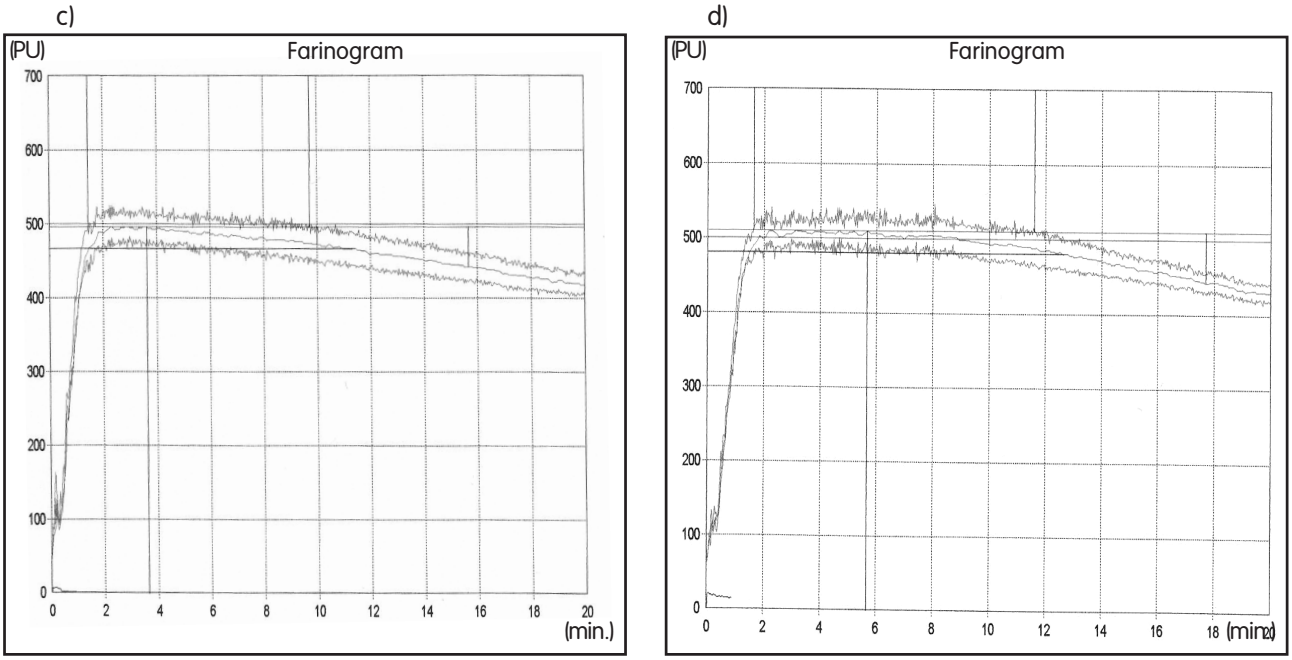


Fig. 2. Farinograms for the following samples:
a) a control sample;
b) a sample with 10% hydrolysed oatmeal insoluble fraction additive;
c) a sample with 15% hydrolysed oatmeal insoluble fraction additive;
d) a sample with 20% hydrolysed oatmeal insoluble fraction additive.

fermentation and mechanical treatment time. Such results can be explained by additional content of proteins added with hydrolysed oatmeal insoluble fraction. Proteins can bind water and swell, which is demonstrated by shorter time of dough development. Although the stability time of dough shows that the stability and elasticity of gluten can not be provided with the oat proteins.

The degree of dough softening was increased from 54 FU to 67 FU comparing with the control sample (48 FU). It was found that the degree of dough softening approaches the minimum acceptable value of 70 FU, when the hydrolysed oatmeal additive is up to 20%.

Farinograph quality index is within acceptable limits (less than 120 FU) if the amount of additive is 10% or 15% from flour mass.

The analysis of the rheological properties such as consistency, water adsorption, development time, stability, degree of softening and farinograph quality index of dough proved that the optimum amount of hydrolysed oatmeal insoluble additive is 15% from wheat flour. The changes of rheological properties of dough do not influence the taste of bread and as a result good quality bread can be obtained.

Table 2

The data obtained by the farinograph

Parameters	Dough samples			
	Control sample	With hydrolysed oatmeal insoluble fraction additive		
		10%	15%	20%
Consistency, FU	502	503	496	510
Water adsorption, %	59.7	63.8	64.7	66.4
Development time, min	2.5	2.8	3.7	5.7
Stability, min	4.7	4.8	8.3	10.0
Degree of softening, FU	48	54	61	67
Farinograph quality index, FU	43	68	115	128

Conclusions

1. In the insoluble fraction of hydrolysed oatmeal, the amount of insoluble fibres is increased up to 3.5 times, amount of lipids is increased for 1 time, but amount of protein–for 1.5 times if compared with oatmeal.
2. Water absorption ability and dough stability was increased with an increased amount of hydrolysed oatmeal insoluble fraction additive in dough.
3. Dough development time was increased with an increased amount of hydrolysed oatmeal insoluble fraction additive.
4. The degree of dough softening was increased and, in the case of 20% additive, approached the minimum acceptable value.
5. The farinograph quality index was considerably higher if 10% or 15% of a hydrolysed oatmeal insoluble fraction additive was used.
6. The best rheological properties were found for the wheat dough made with 15% of a hydrolysed oatmeal insoluble fraction additive.

References

1. Gramatina I., Lauberte L., Kreicbergs V. and Strautniece E. (2002) Sensorical valuation of modified oat extracts. Latvia University of Agriculture, Faculty of Food Technology. International Scientific Practical Conference 'New trends in quality food production', Latvia: Jelgava, pp. 27-32.
2. He H. and Hoseney R.C. (1991) Gas Retention of Different Cereal Flours. Cereal Chemistry, 68, pp. 334-336.
3. Ma C.Y. and Harwalkar V.R. (1984) Chemical Characterization and Functionality Assessment of Oat Protein Fractions. Journal of Agriculture and Food Chemistry, 32, pp. 144-149.
4. Matz S.A. (1999) The chemistry and technology of cereals. Nostroad Binhold, New York, 751 pp.
5. Oomah B.D. (1983) Baking and Related Properties of Wheat-oat Composite Flours. Cereal Chemistry, 60, pp. 220-225.
6. Ranhotra G.S. and Gelroth J.A. (1995) Food Uses of Oats. The Oat Crop. Production and Utilization// Welch, R.W. Chapman and Hall, London, pp. 409-432.
7. Ruža A. (2001) Augkopība (Cultivation of Plants). Latvia: Jelgava, pp. 102-128. (in Latvian).
8. Welch R.W. (1995) The Oat Crop. Chapman and Hall, London, 584 pp.

FORTIFIED WHEAT GRAINS WITH MICROELEMENT SELENIUM

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Abstract

Selenium (Se) is an essential microelement for human health, it is not synthesized in human body and cannot be substituted by any other element. Many health problems have a link with Se deficiency. People need to obtain all necessary amounts of selenium with food. Cereal products are important components of our diets and can contribute comparatively large part of the total dietary intake of Se. The wheat grains growing in Latvia contain comparatively small amount of selenium – on average 0.04 mg kg^{-1}.

The objective of this study was to investigate the possibilities of fortifying wheat grains with microelement selenium during soaking grains in selenium containing solutions. Wheat grains were soaked in sodium selenite and sodium selenate solutions with selenium concentration from 10 to 200 mg l^{-1}. Sprouting activity was determined after 24, 72 and 120 hours, the influence of selenium valence in compound was observed. Comparing the influence of Se^{+4} and Se^{+6}, it can be concluded that Se^{+4} does not promote sprouting activity of wheat grains in opposition to Se^{+6} which increases sprouting activity till selenium concentration 100 mg l^{-1}. Uptake of selenium in grains was studied by determination of total Se using atomic absorption spectroscopy method. Linear correlation between Se concentrations in applied soaking solutions and Se concentration in grains was observed. The content of total protein did not change significantly – it varied from 13.64% in the control sample to 13.87% in the wheat sample with the highest applied selenium concentration (200 mg l^{-1}).

Key words: selenium, wheat grains, sprouting activity.

Introduction

In areas such as Latvia where soils are low in bioavailable selenium (Se), its potential deficiencies can cause health risks for humans. Selenium is an essential nutrient for animals and humans, but it is toxic at high concentrations. It is not synthesized in human body and cannot be substituted by any other element. It is known that human body should contain 5-20 mg of Se (Combs, 2001).

Selenium was discovered by Swedish chemist Jons Jakob Berzelius in 1817. Klaus Schwarz established selenium as an essential nutrient for animals in 1957, but the first selenium function in humans was not discovered until 1973 (Rotruck et.al., 1973).

Se deficiency has been extensively studied in relation to Keshan and Kashin-Beck diseases in China (Foster et al., 1997). This nutrient is an important part of antioxidant enzymes that protect cells again the effects of free radicals that are produced during normal oxygen metabolism. Selenium is also important for normal functioning of the immune system and thyroid gland. Selenium may also protect the body against contaminants such as mercury, cadmium, silver and help speed the elimination of cancer cells, and slow tumor growth.

The best-known biochemical role of selenium is its function as part of the enzyme glutathione peroxidase which protects vital components of cells against oxidative damage (Standman, 1990).

Low selenium status may contribute to the aetiology of the disease process but in some cases it may be an outcome of the condition itself and may exacerbate disease progression (Rayman, 2002).

The maintenance dose is 55-70 μg day^{-1}, but a daily extra-dietary supplement of 200 ǵg Se has been indicated to increase resistance to viral infections and reduce cancer risk (Schrauzer, 2002).

The consumption of food provides the principal route of Se intake for population. Cereal products are important components of our diets and can contribute comparatively large part of the total dietary intake of Se.

Wheat (*Triticum aestivum L*) is the most important of all wheat species as well as one of most suited to bread making. It contains useful amounts of several of the B vitamins including thiamine, riboflavin and niacin, and also vitamin E. Wheat also contains the minerals potassium and zinc as well as trace elements such as selenium. The selenium content in wheat will depend on the amount of selenium in the soil which it is grown in.

Wheat is a good source for bioavailable selenium and many studies have been performed to enrich selenium in wheat by selenium fertilization of the soil (Eurola et al., 1990).

Several studies show that selenium-rich wheat products are able to significantly enhance selenium blood levels and glutathione peroxidase activity (Barkclay et al., 1992).

Summarizing above mentioned information, the present study was to investigate the possibilities of fortifying wheat grains with microelement selenium during soaking grains in selenium containing solutions. Germinating sprouts might be used directly for food or for supplementing of different diets. Sprouting was used because it is known that it additionally improves the nutritional value of grains due to better quality of protein, a more favourable distribution of amino acids, a higher content of polyunsaturated fatty acids, and higher content of vitamins (Lintschinger et al., 1997).

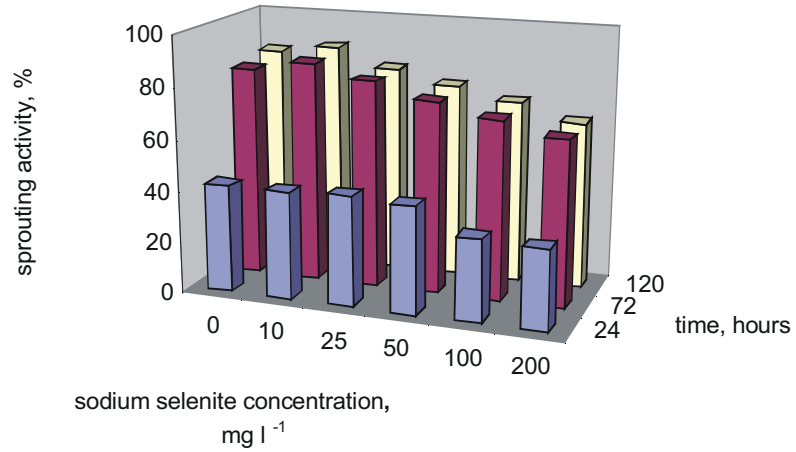

Figure. 1. Sprouting activity of wheat grains depending on the Se^{+4} concentration in solution and the sprouting time.

Materials and Methods

The winter wheat grain variety 'Zentos' was used in this study.

The germinating of wheat variety 'Zentos' was performed in different solutions containing different concentrations of selenium (from 10 to 200 mg l^{-1}) in forms of sodium selenite (Se^{+4}) and sodium selenate (Se^{+6}). In all, 50 g of wheat grains were soaked in 500 ml of corresponding solutions for total of 120 hours. Grains with moisture content 43-44% were let to sprout at ambient temperature (19-20 °C). Sprouting activity was determined after 24, 72, and 120 hours. Grains soaked in deionised water were used as controls (using cationite Amberlite 252 NA layer). After germination the soaked grains were washed 3 times with 500 ml of deionized water to prevent the sprouts surface contamination with selenium. After that, the grains were put into plastic packs and stored at -18 °C in a freezer for 24 h, then dried and ground. The experiments were performed in triplicates.

Visible germination rates were determined by measuring the number of sprouting grains. The protein content was determined by Kjeldhal method according to ISO 5983 standard method.

The concentration of selenium in the dry matter of analysing grains and sprouts was determined by the atomic absorption spectrometric (AAS) method using standard method AOAC 986.15.16th.Ed.1995.

The data given here are the mean values of the measurements.

Results and Discussion

Analysis of the obtained results shows that sprouting activity of wheat depends on selenium valence in applied

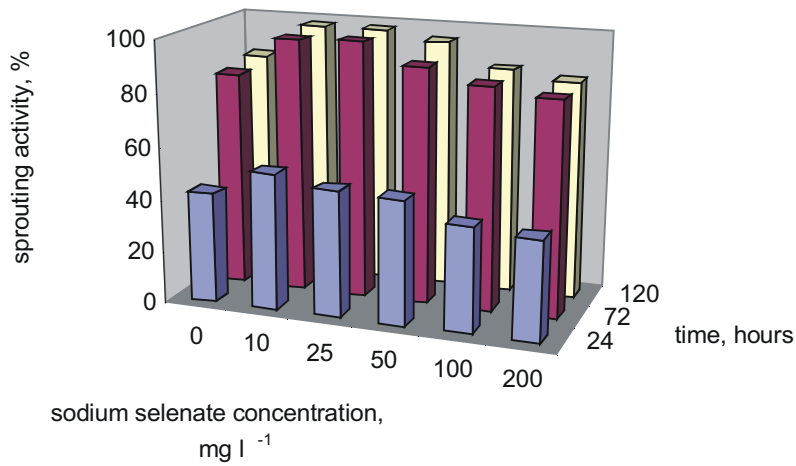

Figure. 2. Sprouting activity of wheat grains depending on the Q concentration in solution and the sprouting time.

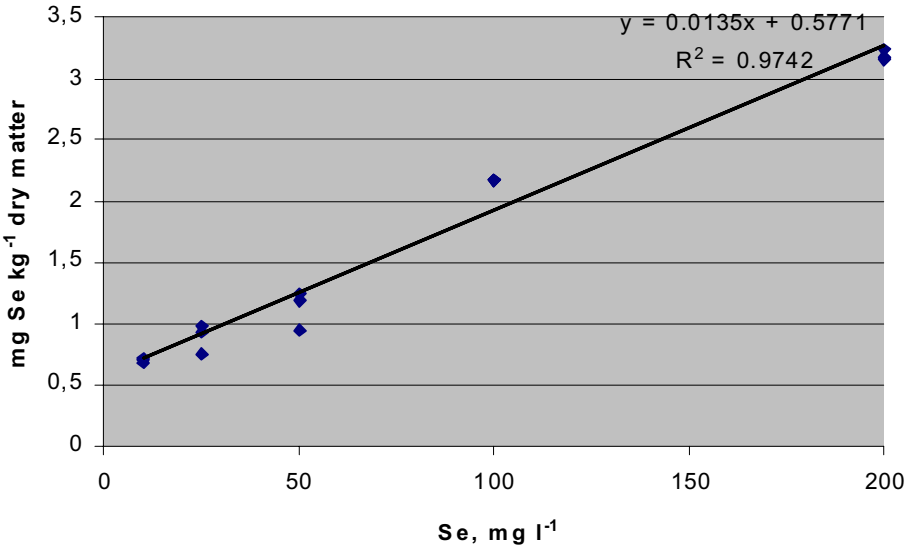

Figure. 3. Total Se concentration in grains depending on Se concentration in soaking solution.

salt solutions. Figures 1 and 2 represent these differences. Comparing the influence of Se^{+4} and Se^{+6}, we can conclude that Se^{+4} does not promote sprouting activity of grains. Only one Se^{+4} concentration of 10 mg l^{-1} gives small increasing of wheat grains sprouting activity, but all other applied concentrations decrease sprouting activity after 24, 72, and 120 hours. A different effect can be observed after wheat grains soaking in sodium selenate solutions. Investigated concentrations of sodium selenate increase the sprouting activity of wheat grains till Se^{+6} concentration of 100 mg l^{-1}. After 120 hours of germinating, the sprouting activity at Se^{+6} concentration of 200 mg l^{-1} is even lower than in the control. These differences certify the literature data that Se as selenate in opposition to Se as selenite is not reduced to elemental Se in the cultural solution and therefore uptake of selenium in the form of selenate is better (Lintschinger et al., 2000).

Since influence of sodium selenite was undistinguished, the further analysis was carried out with wheat grains soaked in different concentration solutions of sodium selenate.

The uptake rates were determined by measuring the total Se concentration in the sprouts after 5 days of germination in sodium selenate containing solutions, because it is known that selenium accumulation is more affected by root uptake than by imbibition (Lintschinger et.al, 1997). Therefore a long germination period is required for better enrichment.

The obtained results are shown in Figure 3. Data shows that wheat is active in selenium uptake during soaking. The content of selenium in the grains increases several times compared with selenium concentration in the grains before soaking. It could be explained by the high bioavailability of the wheat. The results suggest that the nutritional value of the grain can be increased by a reasonable addition of Se.

In Figure 3 the total selenium concentration of wheat grains as a function of the concentration of the applied Se solution are presented. Linear correlation can be observed: the correlation coefficient r=0.99, and determination coefficient R^2=0.974.

For comparing the changes in wheat nutritional value due to fortifying of grains with selenium, the content of total protein was determined. Analysis of the obtained results suggests that selenium additive does not influence the total protein significantly – the results vary from 13.64% in control sample to 13.87% in wheat sample with the highest applied selenium concentration (200 mg l^{-1}).

Conclusions

1. Fortifying of wheat grains with microelement selenium is possible during soaking of grains in sodium selenate solutions. The content of total selenium in grains increases 81.5 times after soaking grains in the highest concentration (200 mg l^{-1}) of sodium selenate solution.

2. Sprouting activity of wheat variety 'Zentos' depends on selenium valence and selenium concentration in applied salt solutions. Se^{+4} does not promote sprouting activity of wheat grains in opposition to Se^{+6} which increases sprouting activity till selenium concentration 100 mg l^{-1}.

3. Sodium selenate (Se^{+6}) promotes the germination process better than sodium selenite (Se^{+4}).

4. The content of total protein does not change significantly during soaking of wheat grains in selenium Se^{+6} containing solutions.

References

1. Barclay M.N., MacPherson A. (1992) Selenium content of wheat for bread making in Scotland and the relationship between glutation peroxidase (E.C.1.11.1.9) levels in whole blood and bread consumption. Brit.J.Nutr., 68, pp. 261-270.
2. Combs G.F. (2001) Selenium in global food systems. Brit.J.Nutr., 85, pp. 517-547.
3. Eurola M., Ekholm P., Ylien M., Koisvistoinen P., Varo P. (1990) Effects of selenium fertilization on the selenium content of cereal grains, flour and bread produced in Finland. Cereal Chem., 67, pp. 334-337.
4. Foster L.H., Sumar S. (1997) Selenium in health and disease, a rewiew. Crit.Rev.Food Sci.Nutr., 37, pp. 2111-2285.
5. Lintschinger J., Fuchs N., Moser H., Jäger R., Hlebeina T., Markolin G., Gössler W. (1997) Uptake of various trace elements during germination of wheat, buckwheat and quinoa. Plant Food Hum.Nutr., 50, pp. 223-237.
6. Lintschinger J., Fuchs N., Moser J., Kuehnelt D, Goessler W. (2000) Selenium-Enriched Sprouts. A raw material for fortified cereal-based diets. J.Agric.Food.Chem., 48, pp. 5362-5368.
7. Rayman M.P. (2002) The argument for increasing selenium intake. Proc.Nutr.Soc., 61, pp. 203-215.
8. Rotruck J.T., A.L. Pope H.E. Ganther A.B. Swanson D.C. Hafeman W.G. and Hoekstra (1973) Selenium: Biochemical role as a component of glutathione peroxidase. Science, 59, pp. 125-138.
9. Standman T.C. (1990) Selenium biochemistry. Annual Review of Biochemistry, 59, pp. 111-127.
10. Schrauzer G.N. (2002) Selenium and human health: the relationship of selenium status to cancer and vital disease. The Alltech's 18th Annual Symposium, pp. 263-269.

ANTIRADICAL ACTIVITY OF VEGETABLE OILS

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Abstract

This research presents the antiradical activity and fatty acids changes of vegetable oils. Natural antiradical activity and its changes during storage for one and two years of rapeseed, linseed and hemp oils were determined with 1.1-diphenyl-2-picrylhydrazyl (DPPH). Fresh hemp oil show the higher antiradical activity.
The content of fatty acids of fresh rapeseed, linseed and hemp oils and of the mixture of rapeseed (800 g kg^{-1}) and linseed (200 g kg^{-1}) oils was determined by the method of gas chromatography. After heating the mixture of rapeseed and linseed oils at the temperature of 160-180 °C, changes proportions in saturated and unsaturated fatty acids.
Key words: antiradical activity, fatty acids, vegetable oil, gas chromatography.

Introduction

The content of many widely used oils incompletely matches the needs of food scientists. Often these oils contain insufficient amount of essential polyunsaturated fatty acids (Bluka et al., 2004). During the last years, usage of polyunsaturated oils has increased due to prophylaxis of heart and blood vessel diseases. Therefore it is important to develop production of such oils as linseed, hemp, soy, mustard, corn, and peanut, because they are rich with essential fatty acids. Choise of oils in food market is, supplemented with oils produced in Latvia: linseed oil and hemp oil – oils previously used rarely. These oils contain a significant amount of essential fatty acids (Vucāne et al., 2004)

Polyunsaturated oils easily undergoe oxidation making hydroperoxide. Peroxidation of oils not only lowers the nutritional quality of food, but it is also associated with aging, membrane damage, heart diseases, stroke, emphysema and cancer in living organisms (Abulude et al., 2005). The addition of antioxidants is effective in retaining the oxidation of fats. It is impressive that many substances have been identified that prevent peroxidation of lipids. Some of these componds are synthetic antioxidants, and others occur as natural dietary constituents (Wagner et al., 2000).

Vegetable oils contain tocopheroles with various oxidative and vitamin activity. γ- and σ-tocopheroles have the highest antioxidative activity (Brand-Williams et al., 1995). For example, linseeds contain 0.45 mg kg^{-1} of σ-tocopherole and 29.70 mg kg^{-1} of γ-tocopherole. It means that vegetable oils have their own antioxidative activity. 1.2-diphenil-2-picrylhydrazyl (DPPH) can be used as a free radical to evaluate antioxidative activity of natural oils (Osakada et al., 2004; Tang et al., 2005).

The tasks of this investigation are:

- Compare antiradical activity of different vegetable oils;
- To clarify the content of fatty acids of different vegetable oils;
- Derive oil mixture from 80% rapseed and 20%

Table 1

Samples of vegetable oils (produced in 'Iecavnieks' Ltd)

Code of Vegetable oils	Vegetable oils	Type of oil
A	Hemp oil	cold pressed, fresh
B	Hemp oil	cold pressed, one-year-old
C	Hemp oil	cold pressed, two-year-old
D	Linsed oil	cold pressed, fresh
E	Linsed oil	cold pressed, one-year-old
F	Linsed oil	cold pressed, two-year-old
G	Rapeseed oil	cold pressed, fresh
H	Rapeseed oil	cold pressed, one-year-old
I	Mixture of rapeseed 80% and linseed 20% oil	cold pressed, fresh
J	Mixture of rapeseed 80% and linseed 20% oil	after 4 h heating
K	Mixture of rapeseed 80% and linseed 20% oil	after 8 h heating

linseed oils and determined by the method of gas chromatography fatty acids, too after heating at the temperature of 160-180 °C.

Materials and Methods

The obtained samples of vegetable oils are summarized in Table 1. The oil samples were stored at temperature 4±2 °C.

To increase the content of essential polyunsaturated fatty acids in rapeseed oil, a mixture of fresh rapeseed oil (80%) and fresh linseed oil (20%) was made.

Samples of this mixture were heated at the temperature of 160-180 °C for 4 and 8 hours.

1.1-diphenyl-2-picrylhydrazyl (DPPH) is a stable radical which reacts with hydrogen donors creating 1.1-diphenyl-2-picrylhydrazil. Absorption of about 517 nm is typical for DPPH radicals. Reducing maximum of DPPH the absorption decreases. The antiradical activity of plant oils will be defined after decrease of DPPH absorption in the specified time period.

To define the antiradical activity, the following solution is prepared, 0.00394 g ($1 \cdot 10^{-4}$ M).

DPPH dissolved in 100 mL of 96% ethanol solution, while stirring with magnetic mixer for 4 hours. 0.1 mL of vegetable oil were added to 2.9 mL $1 \cdot 10^{-4}$ M of DPPH ethanol solution. Solution was stirred and thermostated at the temperature of 37 °C. After 30 minutes, absorption was measured at 517 nm (Jenwey 6405 UV/Vis. Spectrophotometer). Then the control was established, namely, 0.1 mL of ethanol were added to 2.9 mL of DPPH ethanol solution and the absorption was read. The obtained measurements are used in calculation of antiradical activity.

Take 0.1 mL of vegetable oil with a pipette and pour into a test-glass, then add 2.9 mL DPPH solution.

The solution was stired and placed in a thermostat for 30 min. at the temperature of 37 °C; absorption was measured at 517 nm.

The antiradical activity of the vegetable oil sample was determined by decrease of DPPH absorption in the specified time period.

The antiradical activity (hereafter ARA) is expressed in percents, how DPPH reacted with vegetable oils:

$$ARA,\% = \frac{(A_{control} - A_{sample})}{(A_{control} - A_{background})} \cdot 100, \quad (1)$$

where

$A_{control}$ - DPPH with ethanol which has reacted in 30 min.;
A_{sample} - DPPH with ethanol which has reacted in 30 min.;
$A_{background}$ - constant 0.09.

Vegetable oils were researched with the method of gas chromatography by LVS EN ISO 5508:1995 in seminal of plants from Latvia flax, hemp, and rapeseed (ISO 5508, 1995).

The content of fatty acids was determined in oil samples by the method of gas chromatography (Shimadzu GC -17A, 2003) with flame ionization detector (FID), column AT-Wax, 50 m, internal diameter-0.25 mm, thickness of immobile phase-0.2 µm.

Each measuring was carried out several times and

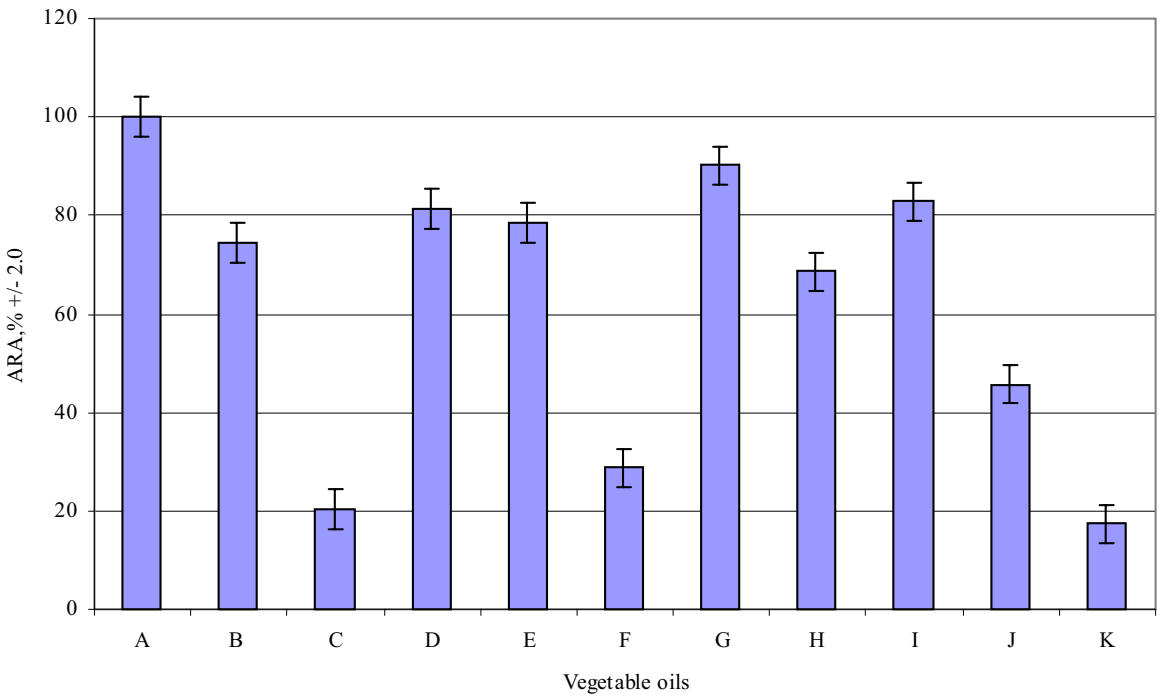

Figure 1. The antiradical activity of vegetable oils.

Table 2

The content of fatty acids in fresh vegetable oils

Fatty acids	Rapeseed oil, % ± 2.0	Linseed oil, % ± 2.0	Hemp oil, % ± 2.0
Myristic C 14:0	-	-	0.25
Palmitic C 16:0	3.84	4.41	10.58
Stearic C 18:0	1.87	3.02	2.30
Oleic C 18:1(9)	60.83	20.42	25.24
Linoleic C 18:2(9,12)	20.98	16.63	43.77
Linolenic C 18:3(9,12,15)	10.33	55.09	17.37
Arachidic C 20:0	0.59	0.14	0.25
Gondoic C 20:1	1.21	0.29	0.24
Behenic C 22:0	0.06	-	-
Erucic C 22:1(13)	0.07	-	-
Other fatty acids	0.12	-	-

then the simple average was calculated.

The data were analyzed statistically by using SPSS for Windows, MS Excel.

Results and Discussion

The results of antiradical activity are summarized in Figure 1.

During storage of oils at the temperature of 4±2 °C for one and two years, antiradical activity of hemp oil decreased correspondingly 1.3 and 4.9 times, of linseed oil-1.0 to 2.8 times, of rapeseed oil after one year storage-1.3 times.

Vegetable oils contain natural antioxidants, but in figure 1 can see that was been oxidative degradation (autooxidation). This autooxidation may be initiated by various agents, such as light, temperature, especially, air oxygen. At the presence of oxygen side products are formed which decreased the quality of oils.

Lipid peroxidation is a free-radical chain reaction process which occurs during autoxidation of unsaturated fatty acids of lipids.

By the method of gas chromatography, fatty acids of rapeseed, linseed, and hemp oil were identified, and their content is shown in Table 2.

The common content of unsaturated fatty acids in linseed oil is 92.43%, in hemp oil – 86.62%, but the content of

Table 3

The content of fatty acids in vegetable oils mixture before and after heating

Fatty acids	Mixture of oils before heating, % ± 2.0	Mixture of oil after 4 h heating, % ± 2.0	Mixture of oil after 8 h heating, % ± 2.0
Myristic C 14:0	-	0.05	-
Palmitic C 16:0	3.01	3.21	4.56
Stearic C 18:0	1.89	1.95	2.09
Oleic C 18:1(9)	52.74	52.51	49.32
Linoleic C 18:2(9,12)	20.22	20.19	18.68
Linolenic C 18:3(9,12,15)	20.51	20.27	20.19
Arachidic C 20:0	0.50	0.49	0.41
Gondoic C 20:1	1.02	1.06	4.75
Behenic C 22:0	0.04	0.27	-
Erucic C 22:1(13)	0.02	-	-
Other fatty acids	0.05	-	-

Table 4

Changes in the proportion of saturated and unsaturated fatty acids in rapeseed and linseed oils mixture after 4 hours and 8 hours of heating at the temperature of 160-180 °C

Vegetable oil samples	SFA : USFA *	USFA decrease , %
Mixture of oils before heating, %	1 : 17.24	-
Mixture of oils after 4 h heating, %	1 : 15.75	8.64
Mixture of oils after 8 h heating, %	1 : 13.16	16.44

*SFA – saturated fatty acid, USFA – unsatured fatty acid

polyunsaturated fatty acids in linseed oil – 71.72%, in hemp oil – 61.14%. So both oils belong to polyunsaturated fats in contrast to rapeseed oils which belong to monounsaturated fats due to the high content of oleic acids – 60.90% accordingly.

Linseed oil is rich of linolenic acid 55.09% which is essential fatty acids for human being. The unsaturated fatty acids are very important for our immune system and help us regulate our blood pressure.

By the method of gas chromatography, fatty acids of rapeseed and linseed oils mixture were identified and their content is shown in Table 3.

In the mixture of rapeseed and linseed oils, the content of polyunsaturated fatty acids increased. For example, the content of linolenic acid increased 2 times compared to its content in rapeseed oil (Tables 2 and 3).

Using the obtained results, it was calculated how the proportion of saturated and unsaturated fatty acids in linseed oil was changing in the process of heating. The results of calculations are summarized in Table 4.

After heating the mixture of rapeseed and linseed oils at the temperature of 160-180 °C for 4 and 8 hours, the content of unsaturated fatty acids decrease. This indicates serious changes-cleavage processes-in the molecules of unsaturated fatty acids.

The greater the degree of unsaturation in a fatty acid (the more double bonds in the fatty acid), the more vulnerable it is to lipid peroxidation (rancidity).

Table 3 and 4 shows that unsaturated fatty acids of lipids during heating was been peroxidation, what decreased the quality of vegetable oil.

Conclusions

The obtained fresh rapeseed, hemp and linseed oils demonstrate the highest antiradical activity, so proving that they contain total natural antioxidants.

During storage of oils at the temperature of 4±2 °C for one and two years, antiradical activity of hemp oil decreases correspondingly 1.3 and 4.9 times, of linseed oil-1.0 to 2.8 times, of rapeseed oil after one year storage-1.3 times.

The common content of unsaturated fatty acids in linseed oil is 91.17%, in hemp oil – 86.62%, but the content of polyunsaturated fatty acids in linseed oil – 71.72%, in hemp oil – 61.14%.

After heating the mixture of rapeseed and linseed oils at the temperature of 160-180 °C for 4 and 8 hours, the content of unsaturated fatty acids decreases. This indicates serious changes-cleavage processes-in unsaturated fatty acids molecules.

References

1. Abulude F.O., Ogunkoya M.O., Eluyode O.S. (2005) Effect of storage on the physicochemical properties of palm oil. Pakistan Journal of Scientific and Industrial Research, Pakistan Council of Scientific and Industrial Research (PCSIR), Karachi, Pakistan: 48: 2, pp. 110-112.
2. Bluka A., Vucāne S., Kūka M. (2004) Исследование качества льняного масла (Research of linseed oil quality). PTF starptautiskā zinātniski - praktiskā konference Pārtikas produktu inovatīvās attīstības tendences, Referāti, Jelgava LLU, pp. 215–218. (in Russian).
3. Brand-Williams W., Cuvelier M.E., Berset C. (1995) Use of a free radical method to evaluate antioxidant activity. Lebensm. WissU.tehnol., vol. 28, pp. 25-30.
4. Osakada, Fumitaka, Hashino, Asami, Kume, Toshiaki, Katsuki, Hiroshi, Kaneko, Shuji, Akaike, Akinori1 (2004) α-Tocotrienol provides the most potent neuroprotection among vitamin E analogs on cultured striatal neurons. Neuropharmacology, Nov, Vol. 47 Issue 6, pp. 904-915.
5. Tang J.L., Faustman C., Hoagland T.A., Mancini R.A., Seyfert M., Hunt M.C. (2005) Interactions between mitochondrial lipid oxidation and oxymyoglobin oxidation and the effects of vitamin E. Journal of Agricultural and Food Chemistry. American Chemical Society, Washington, USA: 53: 15, pp. 6073-6079.
6. Wagner K., Elmadfa I. (2000) Efects of tocopherols and their mixtures on the oxidative stability of olive oil and linseed oil under heating. European Journal of Lipid science and Tehnology, vol. 102, Issue 10, okt., pp. 624-629.
7. Vucāne S., Kūka M. (2004) Changes of UV – absorption by autoxidation of polyunsaturated fats. International research conference The Role of Chemistry and Physics in the Development of Agricultural Technologies, Kaunas, Book of Abstracts, Kaunas, Akademija, pp. 56–57.

VOLATILE COMPOUNDS IN AROMATISED OILS WITH BASIL, OREGANO AND THYME

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Abstract

During processing of aromatized rapeseed oils, volatiles from the added spices migrate in oil and give specific taste and aroma to oils, but there are no investigations about volatile compound migration in oil. The aim of this research was to determine volatile compounds in oils aromatized with basil, oregano, and thyme. In basil 43 volatile compounds, in oregano – 39, and in thyme – 37 volatile compounds were identified. In oil aromatized with basil – 8, in oil aromatized with oregano – 20, and in oil aromatized with thyme 11 volatile compounds were identified. From the total amount of identified compounds in spices, 23-30 % of volatiles found in thyme migrated in oil aromatized with thyme, from oregano in oil migrated 12-15% of volatiles, but from basil in oil aromatized with basil – only 5% of volatiles. More volatile compounds as camphene, α-pinene, and α-thujene migrated in oil better than less volatile compounds like methyl chavicol, and thymol. Migration of the same compound in oil from various spices differed. It could be explained by the location of the volatile compound in plant structure.

Key words: volatile compounds, basil, oregano, thyme, migration, aromatized oil.

Introduction

Basil, oregano and thyme are popular aromatic herbs growing in many regions of the world. Many authors reported the content of volatile compounds in basil (Lee et al., 2005; Barbieri et al., 2004; Diaz-Maroto et al., 2004; Pojjanapimol et al., 2004; Grayer 1996), oregano (Rodrigues et al., 2004; Juliani et al., 2002; Russo et al., 1998), and thyme (Kaloustian et al., 2005; Lee et al., 2005; Santos et al., 2005; Loziene et al., 2003; Pereira et al., 2000). A number of studies showed that basil, oregano and thyme are very variable in chemical composition of essential oils depending on geographical origin, vegetative stage, and used treatment. Spices and herbs are used to enhance the sensory features of food. Aromatization of oils could be one of the ways to expand use of the spices and vegetable oils and also to vary the assortment of oil products. During processing of aromatized rapeseed oils, volatiles from the added spices migrate in oil and give specific taste and aroma to oils.

For detection of volatile compounds in the spices and oils, different methods have been used, e.g. hydrodistillation (Kaloustian et al., 2005; Lee et al., 2005; Loziene et al., 2003), Soxlet extraction (Antonelli et al., 1998), simultaneous distillation-extraction (Barbieri et al., 2004; Diaz-Maroto et al., 2002), and supercritical fluid extraction (Rodrigues et al., 2004; Diaz-Maroto et al., 2002). But some compounds change during those types of extractions, for example, monoterpenes during hydrodistillation and removal of solvent (Diaz-Maroto et al., 2002; Yang et al., 1999). Headspace techniques could be a good option for qualitative analyses, but extraction yields are lower than those achieved using solid extraction. One of the headspace method used for extraction of volatiles in spices and oil is solid phase microextraction (Guillen et al., 2005; Kanavouras et al., 2005; Mildner-Szkudlarz et al., 2003; Jelen et al., 2000). This method was chosen for further research because it was possible to use the same method for spices and aromatized oils.

The aim of this research was to determine volatile compounds in oils aromatized with basil, oregano and thyme.

Materials and Methods

Dried basil, thyme and oregano were purchased from 'Santa Maria' (Tule, Estonia). Aromatized oils were prepared using refined rapeseed oil 'Risso'. Processing of aromatized oils is shown in Figure 1. Two concentrations of spices in oil were tested: 30 g kg^{-1} and 60 g kg^{-1}.

Extraction of volatiles from spices and oils was made using solid phase microextraction (SPME). 1.2 g of basil and oregano, 1.5 g of thyme and 5 g of aromatised oils were weighed in 20 ml vials and capped with a septum (Gerstel). SPME extraction and injection were performed by an MP-2 autosampler (Gerstel). Divinylbenzene/Carboxen/Polydimethylsiloxane (DVB/Car/PDMS) fiber (Supelco Inc., Bellefonte, PA, USA) was used for headspace SPME sampling. SPME parameters: incubation time – 2 min, extraction temperature – 30 °C, extraction duration – 60 min, rotating speed – 250 rpm, agitator on time (s) – 1, agitator off time (s) – 10, desorbtion – 5 min, 250 °C. For the analysis of the spices and aromatised oils, a Hewlett-Packard 6890 GC Plus coupled with a HP 5973 MSD (Mass Selective Detector-Quadrupole type) equipped with a CIS-4 PTV (Programmed Temperature Vaporization) Injector (Gerstel, Mulheim-an-der-Ruhr, Germany), and a EC5-MS capillary column (30 m x 0.25 mm i.d.; coating thickness 0.25 ǵm) was used. Working conditions were: injector – 250 °C; transfer line to MSD – 260 °C; oven temperature start – 35 °C, hold – 5 min, programmed from 35 to 60 °C at 2 °C min^{-1} and from

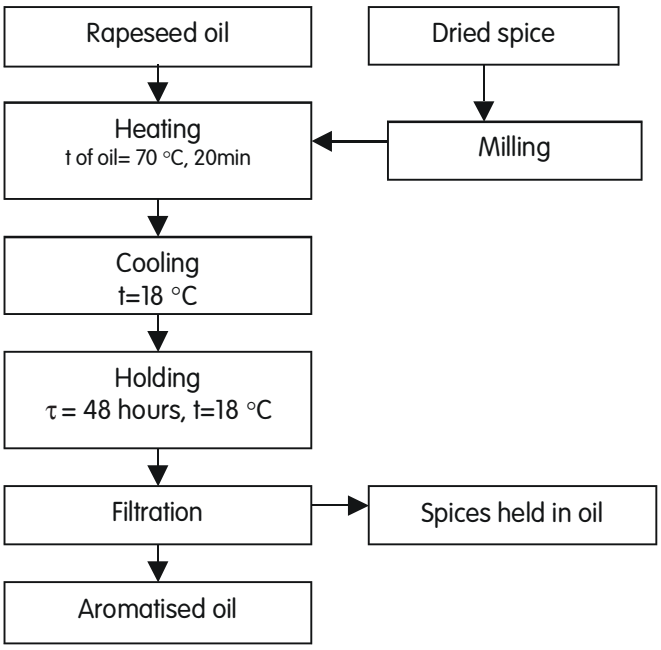

Figure.1. Processing of aromatised oils.

60 to 250 °C at 20 °C min^{-1}, hold 5 min; carrier gas (He) – 1 ml min^{-1}; splitless; ionization EI – 70 eV. Acquisition parameters in full scan mode: scanned m/z 40-200 (0-20 min), 40-400 (>20 min).

Compounds were identified by comparison of their mass spectra with mass spectral libraries (Nist 98 and Wiley 6th), and by calculation of linear retention indexes and comparison with literature data (Adams, 1995). All analyses were made in triplicate. Compounds in tables are shown in the sequence of retention times.

Results and Disscusion

Volatile compounds of basil, oregano and thyme were determined. In the headspace of basil – 43, in oregano – 39, and in thyme 37 compounds were detected (Table 1). The major volatile compounds migrated from spices to aromatized oil: in oil with basil – 8, with oregano – 20, and with thyme 11 volatile compounds were detected (Table 2). Some spice compounds were not identified in aromatized oil, generally the ones forming less than 5% of the total spice volatile composition.

Table 1

Composition of the volatile compounds of spices

Compound	LRI [a] calculated	LRI literature [b]	Composition (%) ± SD		
			Basil	Oregano	Thyme
α-Thujene	925	931	0.12 ± 0.01	**1.38 ± 0.08**	**0.61 ± 0.04**
α-pinene	932	939	**0.40 ± 0.03**	**0.43 ± 0.01**	**0.78 ± 0.02**
Camphene	947	953	n.d.	n.d.	**0.47 ± 0.02**
Benzaldehyde	960	961	0.63 ± 0.02	n.d.	n.d.
Sabinene	971	976	**0.44 ± 0.03**	**3.27 ± 0.08**	0.22 ± 0.02
β-pinene	975	980	**0.65 ± 0.04**	**0.35 ± 0.01**	0.33 ± 0.02
1-Octen-3-ol	979	978	n.d.	0.15 ± 0.01	0.99 ± 0.03
3-Octanone	985	986	n.d.	n.d.	0.28 ± 0.02
Myrcene	989	991	0.66 ± 0.05	**2.69 ± 0.05**	**2.88 ± 0.25**
α-phellandrene	1005	1005	n.d.	**0.48 ± 0.00**	0.23 ± 0.01
Δ-3-carene	1008	1011	0.31 ± 0.02	**0.55 ± 0.01**	0.46 ± 0.03
α-terpinene	1016	1018	n.d.	**2.07 ± 0.05**	**1.48 ± 0.09**
p-cymene	1024	1026	**1.81 ± 0.17**	**19.62 ± 0.12**	**37.27 ± 1.34**
Limonene	1028	1031	**1.64 ± 0.08**	**3.27 ± 0.08**	**3.05 ± 0.11**

Table 1 continuation

1,8-cineole	1031	1033	**4.52 ± 0.18**	**2.05 ± 0.04**	**0.95 ± 0.08**
Z-β-ocimene	1036	1040	n.d.	0.77 ± 0.02	n.d.
E-β-ocimene	1047	1050	n.d.	0.16 ± 0.00	n.d.
γ-terpinene	1058	1062	0.13 ± 0.02	**4.51 ± 0.09**	**6.78 ± 0.19**
cis-sabinene hydrate	1069	1068	0.35 ± 0.01	**3.62 ± 0.01**	0.89 ± 0.03
cis-linalool oxide	1071	1074	0.56 ± 0.02	n.d.	n.d.
trans-linalool oxide	1086	1088	0.50 ± 0.01	n.d.	n.d.
Terpinolene	1087	1088	n.d.	**0.77 ± 0.02**	0.25 ± 0.01
p-cymenene	1089	1089	n.d.	0.30 ± 0.00	0.37 ± 0.01
trans-sabinene hydrate	1102	1097	n.d.	n.d.	**5.07 ± 0.24**
Linalool	1102	1098	**19.02 ± 0. 35**	**7.29 ± 0.14**	n.d.
trans-p-menth-2-en-1-ol	1124	1121	n.d.	0.93 ± 0.01	n.d.
cis-p-menth-2-en-1-ol	1142	1140	n.d.	0.70 ± 0.01	n.d.
Camphor	1146	1143	0.37 ± 0.01	n.d.	0.53 ± 0.01
Borneol	1170	1165	0.25 ± 0.00	n.d.	0.82 ± 0.07
terpin-4-ol	1180	1177	0.99 ± 0.02	**8.13 ± 0.05**	1.3 ± 0.09
α-terpineol	1194	1189	0.67 ± 0.00	**1.94 ± 0.02**	0.3 ± 0.02
Methyl chavicol	1202	1195	**43.11 ± 0.29**	0.8 ± 0.08	0.78 ± 0.10
trans-piperitol	1208	1205	n.d.	0.27 ± 0.00	n.d.
Thymol, methyl ether	1231	1235	n.d.	**4.66 ± 0.05**	3.18 ± 0.09
Carvacrol, methyl ether	1241	1244	n.d.	**8.11 ± 0.12**	2.96 ± 0.12
Carvone	1245	1242	n.d.	0.08 ± 0.00	n.d.
Linalool acetate	1251	1257	0.16 ± 0.00	**10.63 ± 0.11**	n.d.
Z-anethole	1253	1251	0.42 ± 0.02	n.d.	n.d.
Bornyl acetate	1285	1285	0.50 ± 0.01	n.d.	n.d.
E-anethole	1287	1283	2.13 ± 0.16	0.31 ± 0.03	0.45 ± 0.02
Thymol	1290	1290	0.49 ± 0.05	5.27 ± 0.48	**21.07 ± 1.21**
Carvacrol	1299	1298	0.24 ± 0.02	0.51 ± 0.05	1.46 ± 0.10
Z-Methyl cinnamate	1303	1301	1.96 ± 0.12	n.d.	n.d.
Eugenol	1354	1356	1.93 ± 0.11	n.d.	n.d.
α-copaene	1379	1376	0.34 ± 0.01	0.19 ± 0.01	0.24 ± 0.01
E-Methyl cinnamate	1386	1379	4.72 ± 0.43	0.46 ± 0.03	0.36 ± 0.04
β-elemene	1393	1391	0.50 ± 0.02	n.d.	n.d.
Methyl Eugenol	1401	1401	0.40 ± 0.03	n.d.	n.d.
E-caryophyllene	1423	1418	0.64 ± 0.00	2.27 ± 0.06	2.55 ± 0.06
trans-α-bergamontene	1436	1436	5.23 ± 0.02	n.d.	n.d.
α-guaiene	1439	1439	0.37 ± 0.01	n.d.	n.d.
α-humulene	1459	1454	0.21 ± 0.00	0.19 ± 0.00	n.d.
cis-β-guaiene	1492	1490	0.19 ± 0.01	n.d.	n.d.
α-selinene	1498	1494	0.23 ± 0.01	n.d.	n.d.
α-bulnesene	1505	1505	0.20 ± 0.02	n.d.	n.d.
γ-cadinene	1517	1513	1.38 ± 0.04	n.d.	0.19 ± 0.02
Δ - cadinene	1523	1524	n.d.	n.d.	0.26 ± 0.01
cis-calamenene	1525	1521	0.31 ± 0.02	n.d.	n.d.
Spathulenol	1563	1576	n.d.	0.28 ± 0.03	n.d.
Caryophyllene oxide	1588	1581	n.d.	0.52 ± 0.03	0.19 ± 0.00
Cadinol	1639	1640	0.30 ± 0.01	n.d.	n.d.

[a] – LRI – linear retention index
[b] – Adams. 1995
n.d. – not detected

bold – volatile compounds identified in oil aromatized with correspondent spice

The main compounds in basil were methyl chavicol (43 %), followed by linalool (19%), trans-α-bergamontene (5.2%), *E*-Methyl cinnamate (4.7%), and 1.8-cineole (4.5%). Peak areas of other compounds were found in less than 2% of total area. Grayer et al. (1996) reported a similar content of basil, rich in linalool and methyl chavicol. In oil aromatized with basil, main compounds were linalool (35%), methyl chavicol (27%), and 1.8-cineole. The content of volatiles in basil and in oil aromatised with basil differ significantly. Percentage of methyl chavicol in basil was 17% higher than in oil aromatised with basil, whereas percentage of 1.8-cineole was 20% higher in aromatized oil. The major volatile compounds in oregano were p-cymene (19.6%) and trans-sabinene hydrate (12.8%), followed by linalool acetate (9.9%), carvacrol methyl ether, and terpin-4-ol (each 7.5%). In oil aromatised with oregano, p-cymene and trans-sabinene hydrate were the main volatile compounds too, but their percentage was higher than in oregano. The two main compounds of thyme were p-cymene (36.2%) and thymol (20.5%), followed by γ-terpinene (6.6%) and linalool (4.9%). Other compounds were found in less than 3% from the total. These data are similar to literature, and thyme analysed could belong to the p-cymene chemotype containing 32% of p-cymene, 21% of thymol, 9.5% of γ-terpinene, and 2.8% of linalool (Kaloustian, 2005). In oil aromatized with thyme, the main compounds were p-cymene (66%) and γ-terpinene (14.5%). Percentage of thymol in thyme was 20%, but in oil aromatised with thyme only – 2.5-3.6%. Percentages of volatile compounds in basil, oregano, thyme and aromatised oils made using these spices differ significantly (Tables 1, 2). It could be explained by the various migration levels of volatile compounds in oil.

The migration of each compound from spices in oil was expressed by calculating the percentage of volatile compound amount in the aromatized oil versus the volatile

Table 2

Composition of the volatile compounds of the aromatized oils

Compounds	Composition of aromatised oils (%, from total volatile compounds)					
	Oil with basil		Oil with oregano		Oil with thyme	
	30 g kg^{-1}	60 g kg^{-1}	30 g kg^{-1}	60 g kg^{-1}	30 g kg^{-1}	60 g kg^{-1}
α-Thujene	n.d.	n.d.	4.43 ± 0.24	4.25 ± 0.05	0.99 ± 0.12	0.82 ± 0.05
α-pinene	2.39 ± 0.18	2.42 ± 0.09	1.04 ± 0.15	1.00 ± 0.06	1.17 ± 0.04	1.23 ± 0.01
camphene	n.d.	n.d.	n.d.	n.d.	1.02 ± 0.08	0.96 ± 0
sabinene	1.55 ± 0.02	1.45 ± 0.03	6.85 ± 0.12	6.37 ± 0.24	n.d.	n.d.
β-pinene	3.16 ± 0.05	3.05 ± 0.08	0.52 ± 0.09	0.55 ± 0.07	n.d.	n.d.
Myrcene	n.d.	n.d.	1.61 ± 0.19	1.56 ± 0.10	3.11 ± 0.1	2.98 ± 0.29
α-phellandrene	n.d.	n.d.	1.07 ± 0.16	0.94 ± 0.10	n.d.	n.d.
Δ-3-carene	n.d.	n.d.	0.59 ± 0.08	0.62 ± 0.05	n.d.	n.d.
α-terpinene	n.d.	n.d.	4.79 ± 0.09	4.37 ± 0.12	2.99 ± 0.04	2.69 ± 0.27
p-cymene	2.97 ± 0.19	3.1 ± 0.14	32.29 ± 0.26	30.39 ± 0.50	66.06 ± 0.85	65.87 ± 3.08
limonene	3.8 ± 0.24	3.6 ± 0.12	3.28 ± 0.65	3.30 ± 0.09	1.68 ± 0.1	1.85 ± 0.21
1,8 - cineole	23.95 ± 0.2	21.83 ± 1.22	4.43 ± 0.04	6.55 ± 1.87	1.75 ± 0.19	1.78 ± 0.15
γ-terpinene	n.d.	n.d.	8.38 ± 0.18	7.37 ± 0.15	14.47 ± 0.44	14.33 ± 1.23
cis-sabinene hydrate	n.d.	n.d.	4.09 ± 0.21	4.38 ± 0.34	n.d.	n.d.
terpinolene	n.d.	n.d.	1.07 ± 0.04	1.08 ± 0.05	n.d.	n.d.
linalool	35.35 ± 0.76	35.09 ± 0.86	n.d.	n.d.	2.72 ± 0.1	2.59 ± 0.43
trans-sabinene hydrate	n.d.	n.d.	17.99 ± 0.93	18.42 ± 1.05	n.d.	n.d.
terpin-4-ol	n.d.	n.d.	4.58 ± 0.03	5.26 ± 0.10	n.d.	n.d.
α-terpineol	n.d.	n.d.	0.52 ± 0.08	0.74 ± 0.02	n.d.	n.d.
Methyl chavicol	26.85 ± 0.56	29.46 ± 0.32	n.d.	n.d.	n.d.	n.d.
Thymol, methyl ether	n.d.	n.d.	0.55 ± 0.09	0.66 ± 0.02	n.d.	n.d.
Carvacrol, methyl ether	n.d.	n.d.	1.03 ± 0.07	1.19 ± 0.03	n.d.	n.d.
linalool acetate	n.d.	n.d.	0.90 ± 0.02	1.00 ± 0.01	n.d.	n.d.
Thymol	n.d.	n.d.	n.d.	n.d.	2.56 ± 0.28	3.57 ± 0.52

compound amount in an equal amount of dried spices necessary for aromatization (Table 3). From total volatile compounds identified in thyme, in oil migrated 30% (in oil with 30 g kg^{-1} of thyme) and 23% (in oil with 60 g kg^{-1} of thyme) of volatiles. In oil with basil, only 5% from the total amount of identified volatiles migrated in oil. It was due to low migration of the main basil volatiles – metilchavicol and linalool – in oil (Table 3). From oregano in oil migrated 15 % (in oil with 30 g kg^{-1} of oregano) and 12% (in oil with 60 g kg^{-1} of oregano) of volatile compounds. In the tables the identified compounds are presented according to their sequence of eluation. The more volatile compounds eluate first, then follow less volatile compounds. The more volatile compounds – α–thujene α-pinene, camphene – migrated in oil better, whereas migration of less volatile compounds as methyl chavicol and thymol was very low (3-5%).

Migration of volatile compounds depended on the type of spice, for example, from thyme 40% of myrcene migrated in oil, whereas from oregano only 9 % of that compound migrated in oil. It could be explained by the location of the volatile compound in plant structure that could accelerate or reduce migration of compounds in oil. The migration rate of volatile compounds from oregano and thyme in oil was lower with a higher spice additive. But the migration rate of basil volatile compounds did not change with the concentration.

Conclusions

1. In oil aromatized with basil – 8, in oil aromatized with oregano – 20, in oil aromatized with thyme 11 volatile compounds were identified.

2. From the total amount of identified compounds in spices, 23-30 % of volatiles found in thyme migrated in oil aromatized with thyme, from oregano in oil migrated 12-15% of volatiles, but from basil in oil aromatized with basil only 5% of volatiles.

3. More volatile compounds as camphene, α-pinene, and α-thujene migrated in oil better than less volatile compounds like methyl chavicol, and thymol.

4. Migration of the same compound in oil from various spices differed. It could be explained by the location of the volatile compound in plant structure.

Table 3

Percentage of compounds migration from spices in oil

Compounds	% of compounds migration from spices in oil					
	Oil with basil		Oil with oregano		Oil with thyme	
	30 g kg^{-1}	60 g kg^{-1}	30 g kg^{-1}	60 g kg^{-1}	30 g kg^{-1}	60 g kg^{-1}
α-Thujene	n.d.	n.d.	48	38	60	39
α-pinene	30	32	36	29	56	46
camphene	n.d.	n.d.	n.d.	n.d.	81	61
sabinene	18	17	31	24	n.d.	n.d.
β-pinene	25	25	21	19	n.d.	n.d.
Myrcene	n.d.	n.d.	9	7	40	30
α-phellandrene	n.d.	n.d.	32	24	n.d.	n.d.
Δ-3-carene	n.d.	n.d.	16	14	n.d.	n.d.
α-terpinene	n.d.	n.d.	34	26	75	53
p-cymene	8	9	25	19	66	52
limonene	12	12	14	13	21	18
1,8 cineole	27	25	32	39	69	55
γ-terpinene	n.d.	n.d.	28	20	80	62
cis-sabinene hydrate	n.d.	n.d.	17	15	n.d.	n.d.
terpinolene	n.d.	n.d.	21	17	n.d.	n.d.
linalool	10	10	n.d.	n.d.	20	15
trans-sabinene hydrate	n.d.	n.d.	20	17	n.d.	n.d.
terpin-4-ol	n.d.	n.d.	8	8	n.d.	n.d.
α-terpineol	n.d.	n.d.	4	5	n.d.	n.d.
Methyl chavicol	72	81	n.d.	n.d.	n.d.	n.d.
Thymol, methyl ether	n.d.	n.d.	2	2	n.d.	n.d.
Carvacrol, methyl ether	n.d.	n.d.	2	2	n.d.	n.d.
linalool acetate	n.d.	n.d.	1	1	n.d.	n.d.
Thymol	n.d.	n.d.	n.d.	n.d.	5	5

References

1. Adams R. (1995) Identification of essential oil components by gas hromatography/mass spectrometry, Allured Publishing Corporation, Illinois, 469 pp.
2. Antonelli A., Fabbri C., Boselli E. (1998) Modifications of dried basil (Ocimum basilicum L.) leaf oil by gamma and microwave irradiation. Food chemistry, 63, pp. 485-489.
3. Barbieri S., Elustondo M., Urbicain M. (2004) Retention of aroma compounds in dried basil with low pressure superheated steam. Journal of Food Engineering, 65, pp. 109-155.
4. Diaz-Maroto M.C., Perez-Coello M.S., Cabezudo M.D. (2002) Supercritical carbon dioxide extraction of volatiles from spices Comparison with simultaneous distillation-extraction. Journal of Chromatography A, 947, pp. 23-29.
5. Diaz-Maroto M.C., Palomo E.S., Castro L., Vinas M.G., Perez-Coello M.S. (2004) Changes produces in the aroma compounds and structural integrity of basil (Ocimum basilicum L.) during drying. Journal of the Science of Food and Agriculture, 84, pp. 2070-2076.
6. Grayer R.J., Kite G.C., Goldstone F.J. Bryan S.E., Paton A.J., Putievsky E. (1996) Intraspecific taxonomy and essential oil chemotypes in sweet basil. Ocimum basilicum. Phytochemistry, l43, pp. 1041-1047.
7. Guillen M.D., Cabo N., Ibargoitta M.L., Ruiz A. (2005) Study of both sunflower oil and it headspace throught the oxidation process. Occurrence in the headspace of toxic oxygenated aldehydes. Journal of Agricultural and Food chemistry, 53, pp. 1093-1101.
8. Jelen H.H., Obuchowska M., Zawirska-Wojtasiak R, Wasowiez E. (2000) Headspace Soild-phase Microextraction Use for the Characterization of Volatile compounds in Vegetable oils of different sensory quality. Journal of Agricultural and Food chemistry, 48, pp. 2360-2367.
9. Juliani H.R., Simon J.E. (2002) Antioxidant activity of basil. Trends of new crop and new uses, pp. 507-510.
10. Kaloustian J., Abou L., Mikail C., Amiot M., Portugal H. (2005) Southern French thyme oils: chromatographic study of chemotypes. Journal of the Science of Food and Agriculture, 85, pp. 2437-2444.
11. Kanavouras A., Kiritsakis A., Hernandez R.J. (2005) Comparative study on volatile analysis of extra virgin olive oil by dynamic headspace and solid phase micro-extraction. Food chemistry, 90, pp. 69-79.
12. Lee S., Umano K., Shimbamoto T., Lee K.G. (2005) Identification of volatile components in basil (Ocimum basilicum L.) and thyme (Thymus vulgaris L.) leaves. Food chemistry , 91, pp. 131-137.
13. Loziene K., Vaiciuniene J., Venskustonis R. (2003) Chemical composition of essential oil of different varieties of thyme (Thymus pulegioides) growing wild in Lithuania. Biochemical Systematic and Ecology, 31, pp. 249-259.
14. Mildner-Szkudlarz S., Jelen H.H., Zawirska-Wojtasiak R., Wasowiez E. (2003) Application of headspace-solid phase microextraction and multivariate analysis for plant oils differentiation. Food chemistry, 83, pp. 515-522.
15. Pereira S.I., Santos P.A.G., Barroso J.G., Figueiredo A.C., Pedro L.G., Salgueiro L.R., Deans S.G., Scheffer J.J.C. (2000) Chemical polumorphism of the essential oils from populations of Thymus caespititius grown on the island S.Jorges (Azores). Phytochemistry, 55, pp. 241-246.
16. Pojjanapimol S., Chaiseri S. (2004) Heat – introduced changes in aroma components of Holy basil (Ocimum sanctum L.) In: Deibler K., Delwiche J. (eds) Handbook of flavor characterization, Marcel Dekker, New York, pp. 217-230.
17. Rodrigues M.R.A., Krause L.C., Caramao E.B., Santos J., Dariva C., Vladimir J., Oliviera J.V. (2004) Chemical composition and Extraction Yield of the Extract of Origanum vulgare obtained from Sub- and Supercritical CO_2. Journal of Agricultural and Food chemistry, 52, pp. 3042-3047.
18. Russo M., Galletti G.C., Bocchini P., Carnacini A. (1998) Essential oil composition of wild population of Italian oregano spice (Origanum vulgare ssp. hirtum): a preliminary evaluation of their use in chemotaxonomy by cluster analysis.1. Inflorescences. Journal of Agricultural and Food chemistry, 46, pp. 3741-3746.
19. Santos P.A.G., Barroso J.G., Figueiredo A.C., Pedro G.L., Salgueiro L.R., Fontihna S.S., Deans S.G., Scheffer J.C. (2005) Chemical polymorphism of populations of Thymys caespititius grown on the islands Corvo. Flores. Sao Miguel and Terceira (Azores) and on Madeira. Assessed by analysis of their essential oils. Plant Science, 169, pp. 1112-1117.

SHELF LIFE EXTENSION OF FRESH SEA BUCKTHORN BERRIES (*HIPPOPHAE RHAMNOIDES*)

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Abstract

Sea buckthorn berries are one of the most important sources of vitamins, minerals, organic acids, polyphenols and other biologically active substances in human nutrition. The shelf life of fresh chilled berries does not exceed one week.
The venues of research were Fruit and Berry Processing Center of the Dobele Horticultural Plant Breeding Experimental Station and Packaging Material Testing Laboratory of the Faculty of Food Technology, Latvia University of Agriculture, from August until October 2005. Two most popular sea buckthorn cultivars in Latvia – 'Avgustinka' and 'Prozrachnaja' - were used for the study. Sea buckthorn samples were packed in ready-made PET/adhesive/PP containers supplied by 'Huhtamaki'. Gas mixture with initial composition of 10% of O_2, 10% of CO_2, 80% of N_2 and ambient air as control were used. Containers were sealed on the packaging equipment 'TECNOVAC Pratica'. Packed sea buckthorn samples were stored at +4 ± 1 °C temperature for 50 days.
The aim of this study was to clarify the effect of the initial concentration of gas mixture in the package made from plastic of high barrier properties on the quality of fresh sea buckthorn berries during storage time.
The results showed that shelf life of fresh sea buckthorn berries without any significant quality changes can be extended till 30 days by packaging in containers with high barrier properties and air ambiance.
Key words: sea buckthorn, packaging, vitamin C, firmness.

Introduction

Sea buckthorn berries contain functionally active substances that are important for the human body: vitamins, minerals, fibres, organic acids, polyphenols (including carotenoids, especially β- carotene), unsaturated fatty acids, lipids, amino acids etc. (Rongesen, 2005; Kawecki et al., 2004).

It is important to use fresh berries; however their storage time/shelf life is just a few days (Li, 2003). In order to extend the shelf life of the berries it is necessary to choose the most suitable technology for their storage, for example, packing in vacuum, slight vacuum or equilibrium modified gas atmosphere (EMAP). Packing in CO_2 (carbon dioxide) and O_2 (oxygen) gas mixture is one of most convenient methods to store fresh food – vegetables and fruits, thereby extending its shelf life preserving nutritional value (Криворот, 2001; Laurence et al., 1995).

Fruits and berries, being a living biologically active system, continue to respire after they are harvested (Криворот, 2001; Laurence et al., 1995). At the time when fruits and berries are harvested they have the highest quality. Afterwards their quality reduces, especially if the conditions for a proper storage have not been taken into account. The changes in the fruit and berry structure characterize the losses in their quality (Bourne, 2002). Only starting material of high quality is recommend to be packed in modified gas atmosphere (Криворот, 2001; Zomorodi, 1990; Lidster et al., 1988). To extend the shelf life of respiring produce, it is recommended to apply EMAP technology. Temperatures in the range of 0-5 °C have to be chosen for the storage of produce that is pre-packed in the above-mentioned way (Day, 1992). Pre-packing in the equilibrium modified atmosphere packaging considerably extend the shelf life of fruits and vegetables, as it influences biochemical, enzymatic and microbiological changes in them, as well as delays the quality losses. The stability of carotene is changeable and, depending on its quantity and type, it is subject to oxidation processes. Equilibrium modified atmosphere can reduce the oxidative browning and discoloration, the loss of vitamin C and other vitamins, as well as it can delay the changes of consistency in several fruit (Kader, 2001). The content of vitamin C was reduced by high CO_2 concentration in strawberries and blackberries, but only a moderate to negligible effect was found for black currants, red currants, and raspberries (Agar et al., 1997). Successful EMAP technology could be achieved by use of polymer materials with selective gas permeability.

CO_2 is widely used in MAP technology. It has bacteriostatic and fungicide qualities, it protects against mould formation, delays its growth, dissolves well in water and fat by forming carbonic acid. The formation of carbonic acid in a product can cause negligible changes in flavour and it also lowers pH. The gas composition of the pre-packing is chosen by taking into account the variety of the crop, cultivar, degree of ripeness, and scientific studies done so far (Zagory et al., 1988). It is recommended to use 15–20% of CO_2 and 5–10% of O_2 for soft berries such as raspberries, strawberries, and black currants (Mitcham et al., 2000; Grubigh, 1998; Lindster et al., 1988). The identification of the gas composition for optimum packaging for each kind of cultivar and crop is complicated (Day, 1988).

The information on how to prolong the shelf life of fresh sea buckthorn berries by using packing technology of modified atmosphere was not found in literature sources.

The aim of this study was to clarify the effect of the initial concentration of gas mixture in the package made from plastic of high barrier properties on the quality of fresh sea buckthorn berries during storage time.

Materials and Methods

The venues of research were in Fruit and Berry Processing Center of the Dobele Horticultural Plant Breeding Experimental Station and Packaging Material Testing Laboratory of the Faculty of Food Technology, Latvia University of Agriculture, from August until October 2005. Two most popular sea buckthorn cultivars in Latvia – 'Avgustinka' and 'Prozrachnaja' - were used for the study. Fresh sea buckthorn berries were harvested in 'Baltplant' Ltd., Berze district, Dobele region, Latvia. Sea buckthorn samples were packed in ready-made PET/adhesive/PP containers ML 620 by size of 210x148x35 mm (mass in each package was 130± 0.6 g) supplied by 'Huhtamaki'. Gas mixture with initial composition of 10% of O_2, 10% of CO_2, 80% of N_2 and ambient air as control were used. Containers were sealed on the packaging equipment 'TECNOVAC Pratica' with film 'Technopack' PET/adhesive/PP by thickness 64 mm. Packed sea buckthorn samples were stored in 'Comercial Freezer/ Cooler ELCOLD' at +4 ± 1 °C temperature (controlled by MINILog, 'Gresinger electronic') within 50 days.

The analyses were performed after every 10 days. At each time of measurement, two identical packages were analyzed. The results were reported as averages of those two determinations. The quality changes of sea buckthorn berries were characterized by measuring of:

- head space composition – CO_2 and O_2 content, (%) inside each package was analysed by gas analyser OXYBABY® V O_2/CO_2, the measurements were repeated three times;
- firmness – texture was measured with texture analyzer 'UTM' (Ultra Test Mecmesin – basic force gauge BFG 1000 N) as compression force (N m^{-2}) pressing each berry till its skin broke, the measurements were repeated 30 times;
- the content of vitamin C (mg $100g^{-1}$) was determined by using iodometric method.

The data were analyzed statistically by SPSS for Windows and MS Excel, significance level at $P<0.05$.

Results and Discussion

Changes in gas content in the packages

The results were as follows: CO_2 content in the control sample of 'Avgustinka' was 24.7%, but for the berries stored in gas mixture it was a little higher – 27.8% (Figure 1). The CO_2 content in the control sample of cultivar 'Prozrachnaja' berries was 23.2%, whereas stored in MAP it was slightly higher – 25.5%. Consequently, O_2 content of both samples was <1%, which means that packaging in PET/adhesive/ PP containers is potentially harmful for berry quality maintenance.

Significant differences between CO_2 content of samples packed in initial ambient air and gas mixture were not determined during all storage time ($p>0.05$). Comparing both packing environments, after 40 storage days the content of CO_2 was a little higher: for 'Avgustinka' the average value was 30.2%, but for 'Prozrachnaja' – 27.6%, which might be explained with the perishability during the storage time (bitter flavour was felt after opening of the package) as well as connected with difference in the respiratory

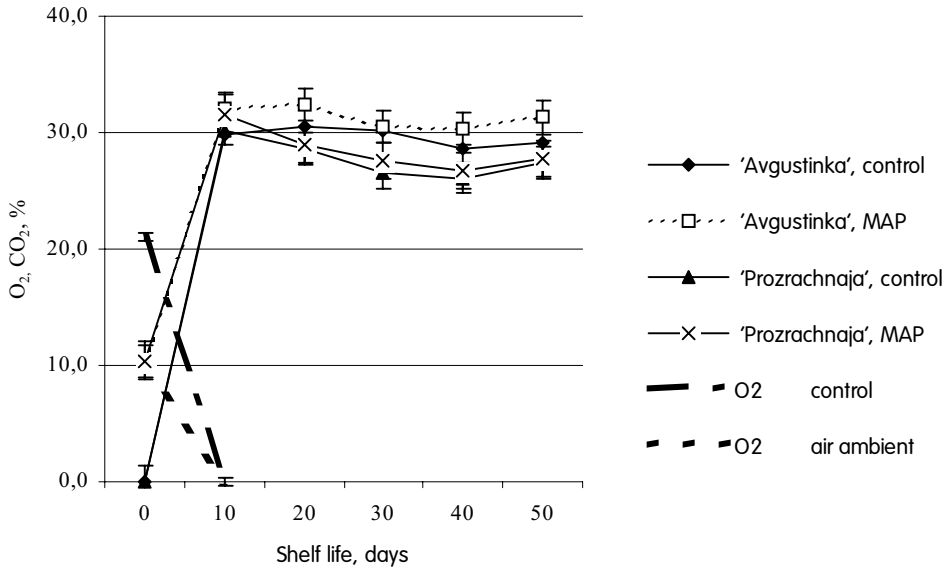

Figure 1. Changes in O_2 and CO_2 content during the storage time.

rate of various berry cultivars. As berries were packed in the containers with high barrier properties, anaerobic conditions were performed within 10 storage days and oxygen content reduced up to zero. In anaerobic conditions, yeasts change glucose into ethyl alcohol and carbon dioxide, but in aerobic conditions they form carbon dioxide and water. It could be considered to be the reason for the increase of CO_2 content in the packaging.

The elevated content of CO_2 as a result of respiration of berries could be one of the main parameters reducing the adequate shelf life of the sea buckthorn berries till 30 days. To extend the shelf life of fresh sea buckthorn berries, special materials with selected barrier properties should be used.

Firmness of berries

Significant differences in the berry firmness of the examined cultivar (respectively 8.2 and 8.0 N m^{-2}) before packaging were not observed. Sea buckthorn berries get softer during their storage time, and after 50 days the skin mechanical resistance for control sample 'Avgustinka' decreased to 6.1 N m^{-2}, but for berries packed in gas mixture – to 5.4 N m^{-2}. Firmness of the control sample 'Prozrachnaja' berries decreased to 4.8 N m^{-2}, but for the sample packed in initially formed gas mixture (10% O_2, 10% CO_2, and 80% N_2) – to 4.5 N m^{-2} (Figure 2). It proves that initial gas composition in packages before storage did not significantly influence the firmness of berries.

The reduction of berry mechanical resistance can be explained by the ripening process. The resistance of plant cells to O_2, CO_2, ethylene and water vapor condensate partial pressure in the packing is dependent on the particular fruit and berry cultivar (Cameron et al., 1982).

Monitoring the mechanical resistance of berries through all the storage time, a significant difference was observed between the cultivars ($p=0.03<0.05$): the firmness of cultivar 'Avgustinka' reduced for about 25%, but that of 'Prozrachnaja' – for about 42%. The obtained results correspond to those mentioned in the literature: the changes of plant cell structure depend on the cultivar, shelf life and ambiance in the package (Cameron et al., 1982). Nevertheless the changes in firmness of berries during the storage time in the examined packaging containers did not depend on the initial ambiance in package: the firmness of the berries studied was mainly dependent on the cultivar.

Changes in vitamin C content

Vitamin C is an important antioxidant that is taken into human body through food. The sea buckthorn berries grown in Latvia contain on average 38.4–71.2 mg 100 g^{-1} of vitamin C, although it depends on various factors (growth place, time of harvest, preservation temperature and others) (Seglina et al., 2004). Scientific studies show that preservation of vitamin C in modified atmosphere packing varies according to the crop type (Agar et al., 1997).

At the beginning of the study, the content of vitamin C in cultivar 'Avgustinka' was 98.77 mg 100 g^{-1} and 66.20 mg 100 g^{-1} in 'Prozrachnaja'. During the first ten storage days, the content of vitamin C increased up to 138.33 mg 100 g^{-1} in the control sample and up to 142.17 mg 100 g^{-1} in MAP packed berries of cultivar 'Avgustinka'. During the first twenty storage days, the content of vitamin C increased up to 90.60 mg 100g^{-1} in the control sample and up to 88.60 mg 100 g^{-1} in MAP packed berries of cultivar 'Prozrachnaja' (Figure 3). The increase in the vitamin content could be explained by the degree of ripeness of the berries. The research concerning changes in vitamin C content in sea buckthorn berries showed its dependence on the harvest time (Antonelli et al., 2005) – when the berries are getting ripe the content of vitamin C increases, but after reaching full ripeness – decreases.

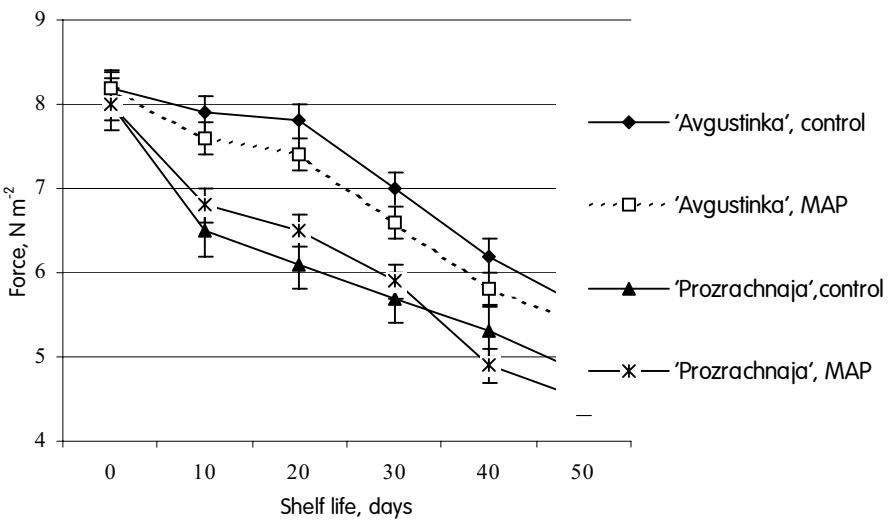

Figure 2. Changes of mechanical resistance of sea buckthorn berries during the storage time.

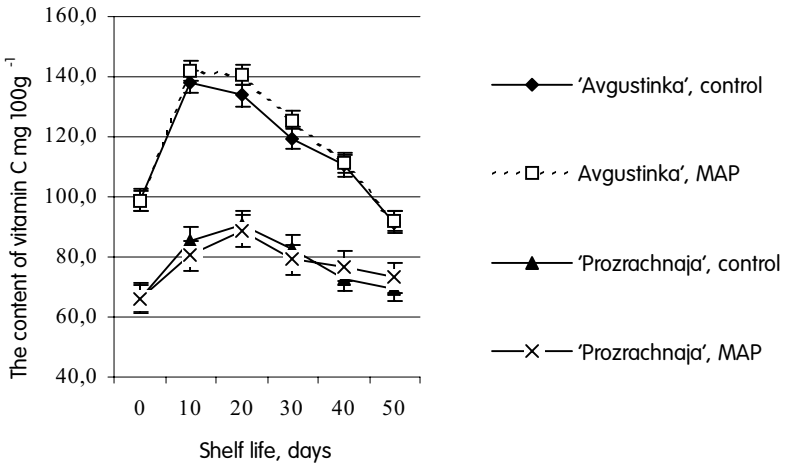

Figure 3. Changes in the content of vitamin C during the storage time.

In our experiments during, the first 10 storage days the increase of vitamin C content in MAP, as well as air ambiance in packed cultivar 'Avgustinka' berries was about 40%, in cultivar 'Prozrachnaja' – about 20%. The overall decrease in vitamin C content at the examined storage period of 50 days in cultivar 'Avgustinka' berries was only about 10%, while in 'Prozrachnaja' no significant decrease was observed.

The obtained results can be compared with those shown in literature data; they prove that the losses of vitamin C during the storage time of sea buckthorn berries depend on their cultivar, gas composition and storage temperature (Agar et al., 199

Conclusions

1. For sea buckthorn berries packed at different initial conditions the changes in CO_2 content at the head space in high barrier property containers observed during the storage time were not significant ($p>0.05$).

2. Monitoring the mechanical resistance of berries through all the storage time, a significant difference was observed between the cultivars ($p=0.03<0.05$): firmness of cultivar 'Avgustinka' reduced for about 25%, but that of 'Prozrachnaja' – for about 42%.

3. The overall decrease in vitamin C content during the examined storage period of 50 days in MAP as well as air ambiance packed cultivar 'Avgustinka' berries was only about 10%, while in cultivar of 'Prozrachnaja' berries significant decrease was no observed.

4. The initial composition of air ambiance at the head space of containers with high barrier properties did not influence the firmness and vitamin C content changes during the storage time.

5. The shelf life of fresh sea buckthorn berries at +4 ± 1 °C without any significant quality changes can be extended till 30 days by packaging in containers with high barrier properties and air ambiance.

Acknowledgements

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References

1. Agar I.T., Streif J. and Bangerth F. (1997) Effect of High CO_2 and Controlled Atmosphere on the Ascorbic and Dehydroascorbic Acid Content of Some Berry Fruits. Postharvest Biol. Technol., 11: pp. 47-55.
2. Antonelli M., Raffo A., Paoletti F. (2005) Biochemical Changes During Ripening of Seabuckthorn (Hippophae rhamnoides) Fruits // Seabuckthorn (Hippophae L.): A Multipurpose wonder Plant, Vol. II (Singh et al., Editor-in-Chief), Daya Publishing House, New Delhi, India, pp. 285-312.
3. Bourne M.C. (2002) Food Texture and Viscosity: Concept and Measurement. Academic Press, pp. 1-32.
4. Cameron A.C. and Reid M.S. (1982) Diffusive Resistance: Importance and measurement in Controlled Atmosphere Storage and Transport of Perishable Agriculture Commodities (eds D.G. Richardson and M. Meherink), Timber Press, Oregon, USA, 171 pp.
5. Day B.P.F. (1992) Guidelines for the Manufacture and Handling of Modified Atmosphere Packed Food Products, Technical Manual No.34, Campden Food and Drink Research Association, Chipping Campden, Glos, UK.
6. Day B.P.F. (1988) Optimization of Parameters for Modified Atmosphere Packaging of Fresh Fruit and Vegetables, CAP '88, Scotland Business Research Inc., Princeton, New Jersey, USA, pp. 147-170.
7. Grubich L., (1998) Berry Cool Tips. University of California – Davis, J. Fruit Grower, June, pp. 8-9.
8. Kader A.A. (2001) Physiology of CA treated produce, 8th International Controlled Atmosphere Research Conference, Rotterdam, Oosterhaven.
9. Kawecki Z., Zalcievicz H., Bienik A. (2004) The common Sea Buckthorn – A valuable Fruit. Journal Fruit and Ornamental Plant Research, vol. 12, pp. 183–195.

10. Laurence L., Joseph A., Lencki R. and Castaigne F. (1995) A Review on Modified Atmosphere Packaging and Preservation of Fresh Fruits and Vegetables: Physiological Basis and Practical Aspects – Part I / J. Packaging Technology and Science Vol. 8, pp. 315-331.
11. Li T.S.C., (2003) Effect of Harvest Date on Fruit and Seed Characteristics of Seabuckthorn. ISSA – Meeting Sea buckthorn – a Resource of Health, a Challenge to Modern Technology. Berlin, Germany, September 2003, pp. 61-62.
12. Lidster P.D., Hildebrand P.D., Bérard L.S., Porritt S.W. (1988) Commercial storage of fruit and vegetables. Agriculture Canada publication 1532/E.
13. Mitcham E.J., Crisosto C.H., Kader A.A. (2000) Strawberry: Recommendations for maintaining postharvest quality. University of California, Davis.
14. Rongsen L. (2005) Biochemical Characteristics of Seabuckthorn (Hippophae L.) Seabuckthorn (Hippophae L.: A Multipurpose wonder Plant, Vol. II (Singh et al., Editor-in-Chief), Daya Publishing House, New Delhi, India, pp. 98-107.
15. Segliņa D. and Skrebele B. (2004) Content of Vitamin C and Carotenoids in Sea Buckthorn (Hippophae Rhamnoides l) Berries. International Scientific Conference Proceedings, Research for Rural Development, Jelgava, LLU, pp. 139-141.
16. Zagory B. and Kader A.A. (1988) Modified Atmosphere Packaging of Fresh Produce /Fd Technolol., 42(9), pp. 70-77.
17. Zomorodi B. (1990) The Technology of Processed / Prepackaged Produce. Preparing the Product for Modified Atmosphere Packaging (MAP), CAP '90, Scotland Business Research Inc., New Jersey, USA, pp. 301-317.
18. Криворот А. М., (2001) Хранение плодов: опыт и перспективы (Fruit storage: experience and aspect). Минск: Полибиг, pp. 13-30; 61-72. (in Russian).

THE CHEMICAL COMPOSITION OF WHEAT BREAD WITH BERRY MARC

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Abstract

The task of the research was to study the chemical composition of seabuckthorn and raspberry marc as well as of high milling wheat bread with berry marc. Wheat bread, i.e. the control sample and the bread samples with 3%, 5% and 7% (from the flour mass) of raspberry and seabuckthorn marc, was baked in the experimental bakery. The content of sugar, fat, protein, fibre and titratable acids was determined by using standard methods. The content of vitamin E, carotene, pectin and phenol compounds was determined by using spectrophotometric method.

The obtained results prove that seabuckthorn and raspberry marc have fibre, fat, sugar, organic acids, carotene, phenol compounds, vitamin E, and pectin. The content of fibre and carotene increased in wheat bread samples when raspberry and seabuckthorn marc was added. Depending on the amount of marc added to the bread, the changes in the content of fat, sugar, and carotene in wheat bread samples were studied. The wheat bread with raspberry and seabuckthorn marc contained vitamin E and phenol compounds.

Key words: berry marc, raspberries, seabuckthorn, wheat bread.

Introduction

Bread provides a human body with more than 40 % of the necessary carbohydrate, 30 % of protein, as well as fiber, vitamins B, and mineral substances. Bread provides a human body with 30% of the energy necessary for a day; this is conclusive evidence that bread cannot be properly substituted with any other human food (Космроāа, 2001).

Statistical data show that the tendency to eat wheat bread is increasing (Consumption of Food Products..., 2004, 2005; Statistical Yearbook…, 2005), therefore it is essential to enrich bread with fibre, vitamins, and mineral substances. Presumably berry marc can be used to enrich high milling wheat bread (marc is a by-product which remains after juice is produced; it is not used any further). After juice is obtained with the pressing method, fibre, sugar, organic acids, pectin and other substances remain in the marc (Вторичные материальные ресурсы..., 1984; Deval, 1996; Morris et al., 1996; Тимофеева, 1996).

Seabuckthorn is one of the most valuable crops. 100 grams of seabuckthorn berries contain 5.7 g of sugar, 2 g of organic acids, vitamins (C, B_1, B_2, B_{12}, E, K), 4.5 g of fat, 2 g of pectin, 35-60 mg of carotene, and mineral substances (Tsybikova et al., 2003).

Lately an importance has been attached to the researches studying the possibilities of using seabuckthorn marc in production of different foodstuffs: in oil production (Koshelev et al., 2003), in juice industrial technology to produce juice and syrup (Тимофеева, 1996; Koshelev et al., 2003), as an additive in dairy products (Терещук et al., 1998), in bread technology dried, and ground marc is added to dough (Koshelev et al., 2003; Tsybikova et al., 2003; Золотарева, 2004; Lõugas et al., 2005).

Raspberries are widely spread and grown all over the world. These berries are popular because of their colour, lovely aroma, juiciness, sapidity, and sweetness (Laugale, 2002).

100 grams of raspberries contain 3-8 g of sugars (glucose, fructose), 0.9–1.4 g of organic acids (malic acid, citric acid, salicylic acid), vitamins (A and B group, P, E, C), 0.5 g of fat, 3.7 g of fibre, pectin, and mineral substances (Strautiņa, 2005). Raspberry marc is not used widely.

In order to determine how the adding of seabuckthorn and raspberry marc influence the chemical composition of wheat bread, the task of the research was to determine the chemical composition of seabuckthorn and raspberry marc as well as of high milling wheat bread with berry marc.

Materials and Methods

Dried raspberry and seabuckthorn marc was made in Dobele Horticultural Plant Breeding Experimental Station (DSIS) pilot plant. When the juice was obtained by using the pressing technology, the marc was dried in a drying oven with forced air circulation; the temperature was maintained fewer than 40 °C until the content of humidity in marc was 9%. Raspberry and seabuckthorn marc was ground in the grinder and sifted.

After the preliminary sensory evaluation of the experimental bread samples the optimum additive of berry marc was determined to be between 3 and 7%. High milling wheat bread samples, i.e. the control sample and the bread samples with 3%, 5% and 7% (of the flour mass) of raspberry and seabuckthorn marc additive, were made and baked in the experimental bakery of S/C 'Dobeles Dzirnavnieks' in accordance with the recipes and technological schemes of the bakery.

The ISO standard methods were used to determine the content of fat ISO 6492, proteins ISO 5983, fibre ISO 5498, and titratable acids ISO 750. Sugar content in the marc was detected by photometric method.

The content of carotene, pectin and phenol compounds was determined using spectrophotometric method, and the content of vitamin E in samples was established by

Table 1

The content of proteins, fibre, sugars, fat, and titratable acids in raspberry and seabuckthorn marc

Samples	Proteins, %	Fibre, %	Sugars, %	Fat, %	Titratable acids, %
Raspberry marc	23.88 ± 0.05	33.61 ± 0.26	12.3 ± 2.0	0.9 ± 0.02	4.8 ± 0.02
Seabuckthorn marc	26.27 ± 0.08	19.55 ± 0.02	4.0 ± 1.0	10.2 ± 1.0	3.9 ± 0.07

modified method based on the extraction of carotenoides with petroleum benzine. The same solvent was used for determination both of carotenoides and vitamin E. The chemical analyses were repeated three times; mean value and standard error was calculated.

The analyses were conducted in the laboratory of the National Diagnostic Centre, Food Control Department (PVD), the Scientific Laboratory of Agronomic analysis at the Latvia University of Agriculture, and in the Biochemical laboratory of DSIS.

Results and Discussion

Juice production by-product – berry marc contains certain amount of valuable ingredients of berries. The research data on content of proteins, fibre, sugars, and fat in raspberry and seabuckthorn marc is compiled in Table 1.

The results show that raspberry marc contains 1.7 times more fibre, 3 times more sugars, and 1.2 times more titratable acids, than seabuckthorn marc. Seabuckthorn marc contains approximately 11 times more fat than raspberry marc.

The obtained results conform to the results described in the literature on the content of fibre (15-20 %), proteins (20-26 %), sugars (2.8-3.9 %), fat (8-12 %), and titratable acids (1.8-3.7 %) in sea buckthorn marc (Deval, 1996; Morris et al., 1996; Тимофеева, 1996).

The content of carotene, phenol compounds, vitamin E, and pectin in raspberry and seabuckthorn marc is presented in Table 2.

The results show that seabuckthorn marc contains 5.5 times more carotene, 2.6 times more pectin, and 1.7 times more vitamin E than raspberry marc. Raspberry marc contains 2.3 times more phenol compounds than seabuckthorn marc.

The previous studies also prove that some amount of carotenes is transferred to berry marc and the amount depends on the berry variety, especially high amount of anthocyanins about 25% from all phenolic compounds is found in a raspberry marc (Тимофеева, 1996, Laugale et al., 2002).

The obtained data allows to assume that adding these juice production by-products (raspberry and seabuckthorn marc) to the bread will enrich its biological and nutritional value.

The content of proteins, fibre, sugars, and fat in the high milling wheat bread control sample and the samples with 3%, 5% and 7% of raspberry marc is shown in Table 3.

The obtained results show that, depending on the amount of raspberry marc added to high milling wheat bread, the content of fibre increases from 2.8 to 5.5 times comparing with the control sample. The content of proteins, sugars, and fat in wheat bread samples does not change substantially.

The content of proteins, fibre, sugars, and fat in wheat bread samples with 3%, 5% and 7% of seabuckthorn marc is shown in Table 4.

The results in Table 4 show that, depending on the amount of sea buckthorn marc added to wheat bread samples, the content of fibre increases from 1.5 to 2.9 times comparing to the control sample. The content of protein in wheat bread increases slightly (1.04 - 1.09 times), but the

Table 2

The content of carotene, phenol compounds, vitamin E, and pectin in berry marc

Samples	Carotene, mg 100 g^{-1}	Phenol compounds, mg 100 g^{-1}	Vitamin E, mg 100 g^{-1}	Pectin, %
Raspberry marc	5.06 ± 0.03	3420.77 ± 6.86	75.6 ± 0.03	0.75 ± 0.06
Seabuckthorn marc	27.83 ± 0.41	1459.23 ± 4.04	131.22 ± 0.05	2.13 ± 0.08

Table 3

The content of proteins, fibre, sugars, and fat in bread samples with raspberry marc

Bread samples	Proteins, %	Fibre, %	Sugars, %	Fat, %
Wheat bread control sample	12.44 ± 0.00	0.42 ± 0.00	3.4 ± 0.1	2.8 ± 0.5
Wheat bread with 3 % raspberry marc	12.45 ± 0.01	1.19 ± 0.04	3.4 ± 0.2	3.2 ± 0.2
Wheat bread with 5 % raspberry marc	12.50 ± 0.06	1.88 ± 0.04	3.5 ± 0.2	3.8 ± 0.2
Wheat bread with 7 % raspberry marc	12.57 ± 0.02	2.31 ± 0.01	3.8 ± 0.2	3.6 ± 0.2

Table 4

The content of proteins, fibre, sugars, and fat in bread samples with seabuckthorn marc

Bread samples	Proteins, %	Fibre, %	Sugars, %	Fat, %
Wheat bread control sample	12.44 ± 0.00	0.42 ± 0.0	3.4 ± 0.1	2.8 ± 0.5
Wheat bread with 3% seabuckthorn marc	12.91 ± 0.0	0.63 ± 0.07	3.6 ± 0.2	3.4 ± 0.1
Wheat bread with 5% seabuckthorn marc	13.22 ± 0.06	1.13 ± 0.04	3.6 ± 0.2	4.0 ± 0.2
Wheat bread with 7% seabuckthorn marc	13.53 ± 0.02	1.23 ± 0.0	3.5 ± 0.2	4.5 ± 0.5

content of fat increases 1.2-1.6 times compared to the wheat bread control sample because sea buckthorn marc has 10.2 % of fat.

The content of carotene, phenol compounds and pectin in wheat bread samples with 3%, 5% and 7% of raspberry marc is shown in Table 5.

The obtained results show that, depending on the amount of raspberry marc added to wheat bread samples, the content of carotene increases from 1.7 to 3 times. Vitamin E was found in the wheat bread samples with 5% and 7% of raspberry marc (0.13 mg 100 g^{-1} and 0.57 mg 100 g^{-1} respectively). Phenol compounds were found in all wheat bread samples with raspberry marc but pectin (0.4 mg 100 g^{-1}) is only in the bread sample with 7% raspberry marc. This is

Table 5

The content of carotene, phenol compounds, vitamin E, and pectin in wheat bread samples with raspberry marc

Bread samples	Carotene, mg 100 g^{-1}	Phenol compounds, mg 100 g^{-1}	Vitamin E, mg 100 g^{-1}	Pectin, %
Wheat bread control sample	0.06 ± 0.01	ND	ND	ND
Wheat bread with 3 % raspberry marc	0.10 ± 0.01	205.21 ± 0.3	Traces	ND
Wheat bread with 5 % raspberry marc	0.16 ± 0.02	314.44 ± 0.2	0.13 ± 0.05	Traces
Wheat bread with 7 % raspberry marc	0.18 ± 0.02	332.11 ± 0.3	0.57 ± 0.04	0.4 ± 0.1

ND - not detected

Table 6

The content of carotene, phenol compounds, vitamin E, and pectin in wheat bread samples with seabuckthorn marc

Bread samples	Carotene, mg 100 g^{-1}	Phenol compounds, mg 100 g^{-1}	Vitamin E, mg 100 g^{-1}	Pectin, %
Wheat bread control sample	0.06 ± 0.01	ND	ND	ND
Wheat bread with 3% seabuckthorn marc	0.45 ± 0.01	75.18 ± 0.2	1.97 ± 0.03	ND
Wheat bread with 5% seabuckthorn marc	0.65 ± 0.02	114.53 ± 0.2	6.37 ± 0.03	Traces
Wheat bread with 7% seabuckthorn marc	0.70 ± 0.02	231.52 ± 0.2	12.43 ± 0.02	0.6 ± 0.1

ND - not detected

because raspberry marc itself contains only 0.75% of pectin substances and if 3 or 5% of marc is added only traces can be detected in bread, but if 7% of raspberry marc is added the product with increased pectin content is obtained.

The content of carotene, phenol compounds, vitamin E, and pectin in wheat bread samples with seabuckthorn marc is shown in Table 6.

The obtained results show that, depending on the amount of seabuckthorn marc added to wheat bread, the content of carotene increases from 7.5 to 11.7 times. There are phenol compounds and vitamin E in all wheat bread samples with seabuckthorn marc but pectin (0.6 mg 100 g^{-1}) is only in the bread sample with 7% of seabuckthorn marc, because only in case if significant amount of seabuckthorn marc (7%) is added pectin can be detected in bread sample (Tsybikova et al., 2003).

Conclusions

1. The results of the raspberry and seabuckthorn chemical analysis show that the highest content of fiber (33.6%) is in raspberry marc, but the content of fat (10.2%), carotene (27.83 mg 100 g^{-1}), vitamin E (131.22 mg 100 g^{-1}), and pectin (2.13 mg 100 g^{-1}) is the highest in seabuckthorn marc.

2. The content of fibre, fat and carotene is significantly increased in wheat bread if seabuckthorn marc is added. Raspberry marc additive increases content of fibre and carotene in wheat bread.

3. The additive of berry marc enriches wheat bread with vitamin E and phenol compouds.The content of vitamin E varies from 1.97 to 12.43 mg 100 g^{-1} in wheat bread with seabuckthorn marc (3%, 5%, 7% of the flour mass) but the content of phenol compounds varies from 75.18 to 231.52 mg 100 g^{-1}.

References

1. Consumption of Food Products (2004) In: Household budget in 2003: Statistical Bulletin (2004) Central Statistical Bureau of Latvia. Riga, 75 pp.
2. Consumption of Food Products (2005) In: Household budget in 2004: Statistical Bulletin (2005) Central Statistical Bureau of Latvia. Riga, 75 pp.
3. Devel C. (1996) Strawberries und Raspberries. In: Edit by Somogyi L.P, Barrett D.M, Hui Y.H. Processing fruits: Science and Technology, Volume 2, Technomic Publishing Company, Inc., Cambridge, pp. 117-155.
4. Koshelev Yu.A., Mirenkov V.A. (2003) Industrial Utilization of Seabuckthorn in Russia. In: Singh V. et al., (eds) A Multipurpose Wonder Plant. Vol.1, Indus Publishing Company, New Delhi 110027, India, pp. 471-474.
5. Laugale V., Streipa M. (2002) Aveņu grāmata. (Raspberry book). Avots, Rīga, 211 pp. (in Latvian).
6. Lõugas T., Veskus T., Martverk K., Täht R., Rada K., Vokk R. (2005) Seabuckthorn and its new fields of use. INTRAD – EFFoST Conference 2005. Session 3- New Approaches in Modelling Real Foods, Reflecting Functionality and Complexity. pp. 719-722.
7. Morris J.R., Striengler K. (1996) Fruit processing. In: Edit by Somogyi L.P, Barrett D.M, Hui Y.H. Processing fruits: Science and Technology, Volume 2, Cambridge, Technomic Publishing Company, Inc., pp. 197 -231.
8. Statistical Yearbook of Latvia 2005. (2005) Central Statistical Bureau of Latvia. Riga, 302 pp.
9. Strautiņa I. (2005) Dārza ogu avīze. (Newspaper on garden berries). Lauku avīze, Rīga, 63 pp. (in Latvian).
10. Tsybikova G.Ts., Tsybikova D.Ts., Dorzhiyeva A.A. (2003) Seabuckthorn (Hippophae rhamnoides L.) Fruit Residue Flour for Production of Quality Food Products. In: Singh V. et al., (eds) A Multipurpose Wonder Plant. Vol.1, Indus Publishing Company, New Delhi 110027, India, pp. 479-482.

11. Вторичные материальные ресурсы пищевой промыщленности образование и использование (1984) Справочник. Москва, Экономика, 323 с. (in Russian).
12. Золотарева А.М. (2004) Перспективы использования модифицированного облепихового сырья (Perspectives to use modified seabuckthorn raw materials) Хранение и переработка сельхозсыря, 9, с. 59 – 62. (in Russian).
13. Кострова И. Е. (2001) Малое хлебопекарное производство. (Bread production in small enterprises) СПб, ГИОРД, 120 с. (in Russian).
14. Терещук Л.В., Павлов С.С., Остроумова Т.А. (1998) Использование продуктов переработки облепихи при выработке молочных продуктов. (The use of seabuckthorn product processed in producing diary products). Хранение и переработка сельхозсыря, 8, 41 с. (in Russian).
15. Тимофеева В.Н. (1996) Использование выжимок облепихи в производстве напитков. (The use of seabuckthorn marc in drink production) Хранение и переработка сельхозсыря, 6, 32 с. (in Russian).

THE CHEMICAL COMPOSITION OF OSTRICH MEAT

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Abstract

Several farmers of Latvia have established ostrich substituting traditional animal growing farms. Ostrich meat is frequently described as a healthy alternative to other meat products. Ostrich, a red meat, is even lower in calories, cholesterol and fat than skinless chicken and turkey, while remaining high in the content of iron and protein.

The aim of the investigation is to evaluate the chemical composition of frozen ostrich meat obtain in Latvia and compare it with other meats.

The samples of meat for experiments were obtained from ostrich meat producers. Moisture content was determined by drying of the samples at 100 °C to a constant weight (ISO 6406). Protein content was determined by Kjeldahl method (ISO 5983). Fat content was determined by Soxlet extraction method (ISO 6492). The calories in different meats were determined by an approved procedure which includes summing of the calories from fat and from protein.

The investigations showed that there were no significant differences between the main components of ostrich meat produced in Latvia and those found in the data in literature. Chemical composition of ostrich meat does not significantly differ from that of other types of meat. The research suggests that ostrich meat can be substituted for beef or chicken in any recipe, including meat-processing products.

Key words: meat, ostrich, chemical composition.

Introduction

The types of meat commonly consumed in different countries are dependent on eating habits and the ability to rear the animals successfully, which is influenced by local climate, geography and economy. Beef, pork, and chicken are the major meats consumed in the world, including Latvia (Sandler et al., 1999).

The ostrich (*Struthio camelus.var domesticus*) is the largest of all birds. It is an important animal in many livestock industries because of its healthy red meat and skin. The ostrich is a relatively new agricultural animal in many parts of the world. Recently there has been a huge interest in ostrich farming for its low fat meat, leather, feathers and eggs. South Africa is the main provider of ostrich meat in the world market. Only young stocks up to 15 month of age are slaughtered for meat export (Girolami, 2003). The latest statistics show that current ostrich meat production is not enough to meet the increasing demand in Europe. Production ability makes ostrich farming an extremely viable and highly economical proposition for developing countries (Jensen, 2004).

Meat is one of most important products of ostrich. It is very popular in European restaurants. It comes in a variety of cuts, including prime steaks, filets, sausages, burgers, stir-fry. It can be substituted for beef, pork, lamb, turkey, or chicken in virtually any recipe.

Ostrich meat is frequently described as a healthy alternative to other meat products. Ostrich, a red meat, is even lower in calories, cholesterol and fat than skinless chicken and turkey, while remaining high in iron and protein.

Chemical composition of processed ostrich products and similar types of commercially available products suggested that processed ostrich products can be formulated to compete successfully with similar types of products derived from other meat species (Fisher, 2000).

Commercial rearing of ostrich meat is new to Latvia. The first several ostriches were bought in Latvia ten years ago. Now the largest ostrich farms are located in the east part of Latvia in Jekabpils region (Horbacuks, 2005; Bundze Zdanovska, 2005).

There have not been carried out studies regarding chemical composition of ostrich meat and processed ostrich products in Latvia.

The aim of our investigation is to evaluate the chemical composition of frozen ostrich meat obtained in Latvia for processing and compare it with other meats.

Materials and Methods

Research was performed at the Faculty of Food Technology and in the Agrochemical Analyses Laboratory of LLU. The samples of meat for experiments were obtained from Latvian meat producers. Ostrich, beef and poultry meat was frozen and stored in a freezer before analysis. Meat samples were ground in food blender to ensure the homogeneous consistence of meat samples for analysis.

Moisture content was determined by drying the samples at 100 °C to a constant weight (ISO 6406). Protein content was determined by Kjeldahl method (ISO 5983). Fat content was determined by Soxlet extraction method (ISO 6492). The calories in different meats were determined by an approved procedure which includes summing of the calories from fat and from protein. The calories from carbohydrates in fresh meat products are assumed as zero. The analyses were carried out in duplicate. The data given here are the mean value of the measurements.

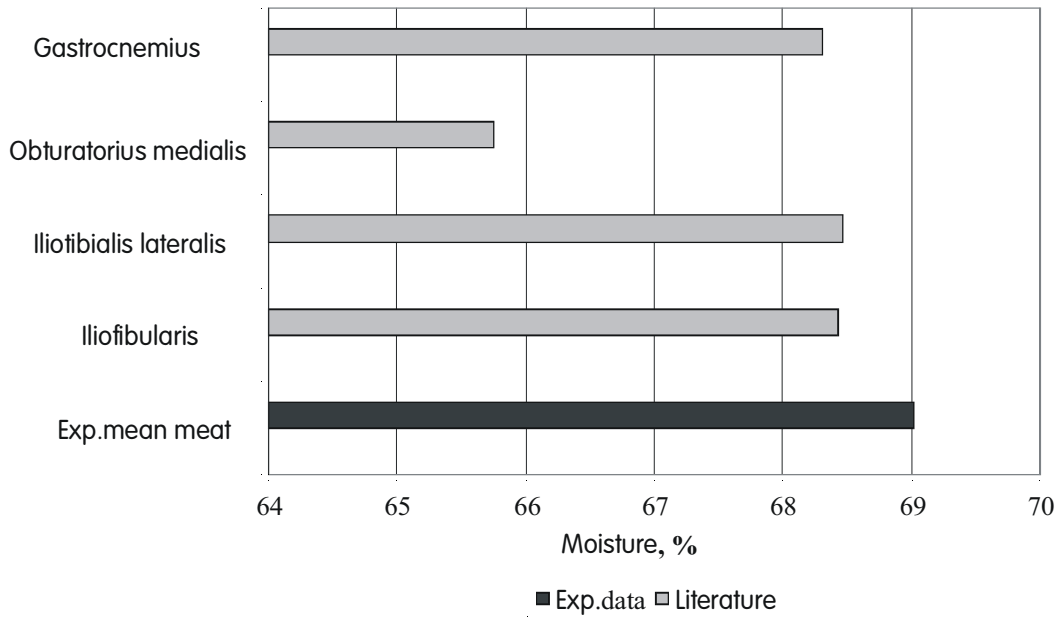

Figure 1. The moisture content in analysed ostrich meat compared with data in literature.

Results and Discussion

Meat tissue composition varies according to differences in species, breeding, and anatomical location of cuts within carcass.

Ostrich muscles ranged in moisture from 65.75 to 68.46% (Ostrich meat industry development, 1994). Moisture content in ostrich meat in different parts of ostrich muscles compared with literature data is showed in Figure 1.

The moisture content of experimental sample of ostrich meat was approximately 69.02 % compared with beef (moisture content 70.61 %) and chicken (moisture content 69.15 %), although some authors indicate that ostrich meat contains a higher amount of water ranging from 75.1 % to 77.7 % (Horbancuks, 2005). The differences in results are not essential compared with data in literature and could be explained by the feed composition, using for ostrich, peace of meat cut.

Meat is a significant source of protein, which is of high biological value. Proteins constitute 16–22 % of skeletal muscle tissue and contain all amino acids. The protein content of different meats and cuts varies inversely with fat content.

The protein content did not differ in wide ranges between beef, ostrich and chicken and literature data and ranged in value from 25.21 % in ostrich to 23.88 % in chicken. It means that it is possible to obtain ostrich meat with a corresponding protein content in Latvia, too (Figure 2).

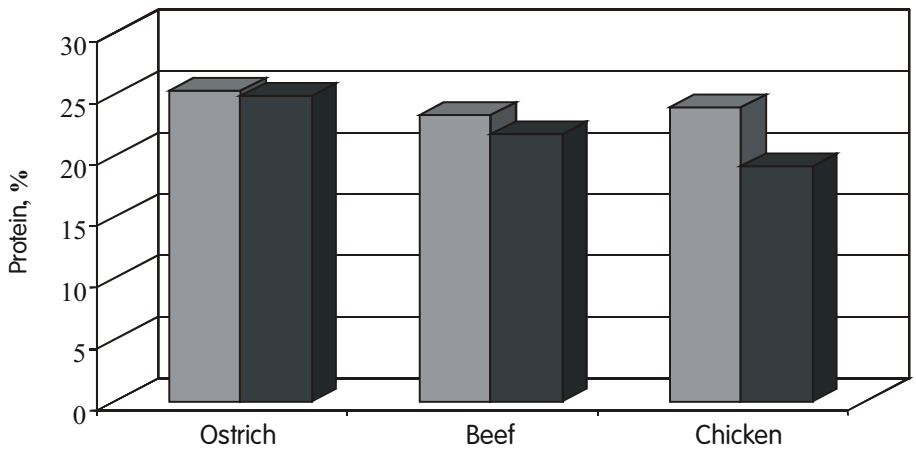

Figure 2. Protein content in ostrich, beef, and chicken meat.

*The source of literature data is Encyclopaedia of Human Nutrition

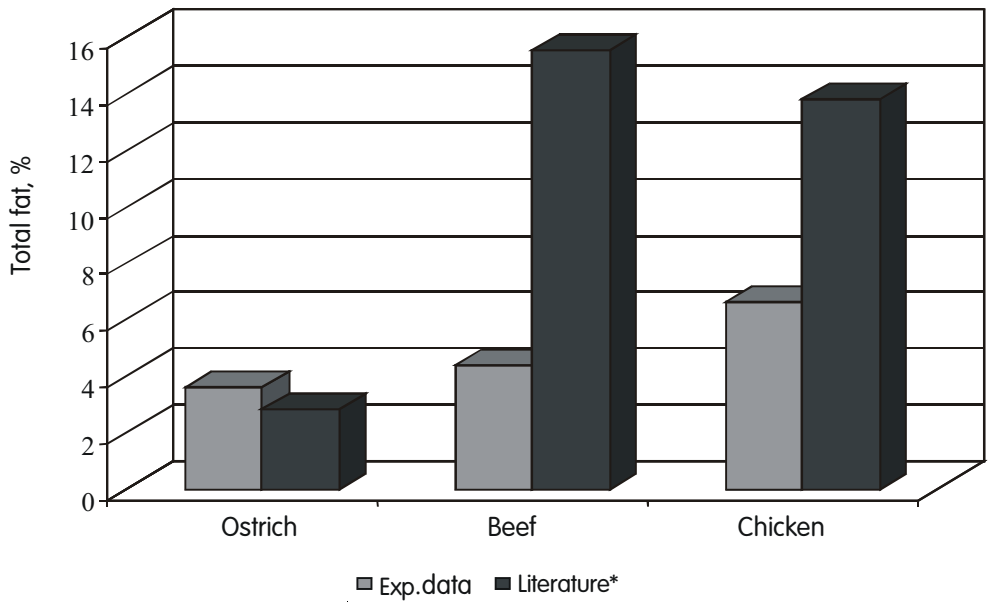

Figure 3. Fat content in ostrich, beef and chicken meat.

*The source of literature data is Encyclopaedia of Human Nutrition

Animal adipose tissue (fat) is composed primarily of neutral lipids and phospholipids. Various lipids forms serve as an energy source for the cells, as a structural and functional component of the cell (Jensen, 2004). Ostrich meat was lower in the total lipids content than the meat cuts from beef and chicken (see Figure 3). If compared the obtained data with literature data, the fat content in experimental ostrich meat samples was higher, but in beef and chicken meat samples - lower. The differences could be explained by the influence of local winter climate, by the feed composition and place of meat cut.

Estimating the amount of calories of different meats, in our case we can observe that ostrich meat has the same energy balance that beef meat (Figure 4). It could explain we used for analyses the lean meat, although the data from literature showed the differences in calories existed between ostrich meat and beef meat. This is also one of the reasons why European consumers prefer meals prepared from ostrich meat and choose as a healthy alternative to other meat products.

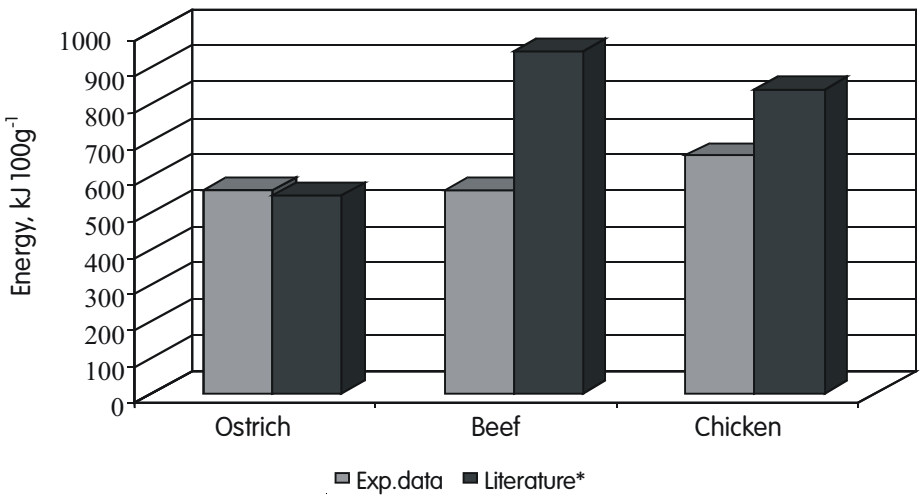

Figure 4. Calories in different meats.

*The source of literature data is Encyclopaedia of Human Nutrition

Conclusions

1. The experimental data showed that no significant differences were observed between the main components of ostrich meat produced in Latvia and those found in the data in literature.

2. The chemical composition of ostrich meat does not significantly differ from that of other meats. It allows concluding that ostrich meat can be substituted for beef or chicken in any recipe including meat processing products.

3. Further investigations are necessary for examination of technological and sensory properties of frozen ostrich meat.

Acknowledgment

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References

1. Bundze Zdanovska I. (2005) Strauskopības attīstība un ražošanas iespējas Latvijas tirgū. (Development of ostrich farming and possibilities of production for Latvian market). Zinātniskais darbs profesionālā pārtikas higiēnas maģistra grāda iegūšanai. LLU, Jelgava, 67 pp. (in Latvian).
2. Edit by Sandler M.J., Strain J.J., Caballero B. (1999) Encyclopaedia of Human Nutrition, T.2, Academic Press, pp. 1272 – 1282.
3. Editor by Jensen W.K. (2004) Encyclopaedia of Meat Sciences, T.1, Academic Press, pp. 185 – 190.
4. Fisher P., Hoffman L.C. and Mellett F.D. (2000) Processing and nutritional characteristics of value added ostrich products. Meat Science, 55, 2, pp. 251-254.
5. Girolami A., Marisco I., D'Andrea G., Braghieri A., Napolitano F. and Cifuni G.F. (2003) Fatty acid profile, cholesterol content and tenderness of ostrich meat as influenced by age at slaughter and muscle type. Meat Science, 64, 3, pp. 309-315.
6. Horbančuks J.O. (2005) Strausi (Ostrich) Rīga, 164 pp. (in Latvian).
7. Ostrich Meat Industry Development (1993, Revised October 1994) Final Report to American Ostrich Association. Available at: http://savell-j.tamu.edu/Ostrich.pdf, 23.06.2006.

DETERMINATION OF TRYPTOPHAN METABOLITES IN PORCINE ADIPOSE TISSUE: A PRELIMINARY REPORT

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Abstract

Tryptophan is a precursor for the production of skatole and indole in the large intestine of pigs. Accumulation of these compounds in adipose tissue causes an objectionable odour in meat from entire male pigs. Potential market impact illustrates the importance in developing an accurate method of determining skatole and indole content in adipose tissue. In the present study, a method is described for determination of skatole and indole concentrations by liquid chromatography combined with mass spectrometry (LC-MS) using atmospheric pressure chemical ionization (APCI). The optimization of chromatographic and APCI conditions is reported. This method showed excellent linearity over the concentration range tested (from 10 to 1000 ng ml^{-1} of liquefied fat for both skatole and indole).
Key words: skatole, indole, adipose tissue, LC-MS.

Introduction

Tryptophan is degraded in the large intestine of pigs with the production of two major metabolites – skatole (3-methylindole, C_9H_9N) and indole (C_8H_7N), which are absorbed through the intestinal walls and further metabolised in the liver. Some amounts of the un-metabolised skatole and indole can accumulate in the adipose tissue causing an unpleasant smell in heated pork products referred to as boar taint. Numerous analytical methods have been developed for the separation and quantification of skatole and indole in biological tissues, including high-performance liquid chromatography (HPLC) (Claus et al., 1993) and gas chromatography (GC) (Jensen and Jensen, 1994). For the determination of skatole in plasma and fat reversed-phase HPLC with fluorescence detector (excitation at 285 and emission at 350 nm) is often used under laboratory conditions (Claus et al., 1993). Currently, a colorimetric method for measuring so called skatole equivalents in fat (Mortensen and Sørensen, 1984) is used in Danish slaughterhouses to identify tainted carcasses. The advantages of this method are speed and simplicity; however, it measures the concentrations of total indolic compounds and does not provide information about the concentrations of individual compounds. Further investigations are required to develop an accurate and sensitive method for the systematic analysis of skatole and indole in porcine tissues. Only a few reports have been published on liquid chromatography - mass spectrometry (LC-MS) analysis of indolic compounds in lung microsomes (Skordos et al., 1998), and to our knowledge no data is available in the literature on the analysis of skatole and indole in adipose tissue by LC/MS. The present report describes a new method for the analysis of skatole and indole with LC/MS. The method was applied for determination of skatole and indole in 10 fat samples, which were also analysed for skatole equivalents by the colorimetric method.

Material and Methods

One hundred µl of liquefied fat was mixed with 1 ml of hexane in a glass tube (16 x 100 mm). Then, 1 ml of acetonitrile: water (3:1) was added to each tube, vortexed and centrifuged for 15 min at 2000 rpm at room temperature. The upper hexane layer was removed, and 200 µl of the bottom layer was transferred to an autosampler vial.

Analyses were performed using an Agilent 1100 LC/MSD system equipped with a gradient quaternary pump, a thermostated autosampler, a thermostated column compartment, a variable UV detector, and a single quadrupole mass analyzer (G1946D). Agilent Chemstation software was used for control of the HPLC system and data processing.

The separation of indolic compounds was performed using a reversed-phase column Genesis C18, 150 mm*4.6 mm i.d.; 4 µm (Jones Chromatography, UK) with a guard column Opti-guard C18, 1 mm (Optimize Technologies, INC, USA) at 23 °C. The injection volume was set at 2 µl with a flow-rate of 0.4 ml min^{-1}, and the thermostated autosampler temperature was set at 8 °C. The UV detector was set at 280 nm. The mobile phase consisted of organic phase (methanol with 10 mM of acetic acid) and aqueous phase (water with 10 mM of acetic acid), operated at a linear gradient. The gradient started at 50% (v/v) methanol with a lag time of 3 min, then raised linearly to 90% methanol over 12 min and was kept constant for 5 min; thereafter it was decreased linearly over 1 min to the initial concentration of methanol that was then applied for 6 min in order to re-equilibrate the column. Under these conditions, indole eluted at 15.8 min and skatole at 18.6 min. A total run time of 27 min per sample was optimal to equilibrate the column and avoid endogenous interfering peaks. When developing the method, other gradient programs were also used.

Atmospheric pressure chemical ionization (APCI) was operated in positive ion mode. For optimizing APCI parameters, flow injection analysis (FIA) was used. A capillary

voltage was set at 3.0 kV with the drying gas temperature at 350 °C and flow rate of 9 L min^{-1}. Nebuliser gas pressure was 30 psi, vaporizer temperature was set at 300 °C and a corona current of 7 µA. Fragmentor potential was set to 90 V for both indole and skatole. During method development, a scan mode in the range of 100-800 m/z was used. Selected ion monitoring (SIM) of protonated molecular ions $[M+H]^+$ was used for quantification of indolic compounds. Automated tuning and mass calibration were performed using an Agilent APCI tuning solution. Mass spectral data as well as the retention times of compounds were used for peak identification.

Quantification was based on an external standard method. A multilevel calibration curve was used in the range of 10, 25, 50, 100, 250, 500, and 1000 ng ml^{-1}. The peak area was plotted against concentration, and least-squares regression analysis was used to fit lines to the data. At this range, the response was linear for both skatole and indole.

Results and Discussion

Optimisation of LC-MS

The nature of organic solvents at a given concentration and pH strongly influence the retention, selectivity and intensity of measured compounds. In the routine HPLC method for screening indolic compounds (Zamaratskaia et al., 2004), the mobile phase contained acetonitrile and phosphate buffer. However, phosphate buffer should not be used in LC-MS technique because of its involatility and suppression of MS signal. In the present study, 10 mM aqueous acetic acid was used as a volatile buffer, and two organic phases, acetonitrile and methanol, were compared. More intense MS signals for skatole and indole were obtained with methanol which was in agreement with common recommendations for APCI. Variation in intensity might be due to the increased ability of methanol for ion charge exchange reactions. During the subsequent analysis, a mobile phase consisting of an organic phase (methanol with 10 mM of acetic acid) and an aqueous phase (water with 10 mM of acetic acid) was used.

Vaporising probe temperature may have a profound effect on signal intensity. In the present study, no significant differences between MS signal intensities were found between temperatures of 300° and 400 °C. This suggests that skatole and indole are both sufficiently ionised in the gas phase and no improvement in volatilisation can be expected with further increase in vaporising temperature. During the final analysis a temperature of 300 °C was used.

Corona currents from 4 to 9 µA were evaluated. At low currents (from 4 up to 6 µA), the responses for skatole and indole were very low. A corona current of 7 V was found to be optimal for analysis of skatole and indole, based on the observation that the peak areas of both compounds increased with increasing corona current up to 8 µA, and then decreased, as shown by FIA.

Capillary voltages of 3000 V and 4000 V were compared with 3000 V being chosen for subsequent analysis since the signals for both compounds were higher at this condition.

The effect of drying gas (N_2) on signal intensity of skatole and indole was studied by varying the gas flow between 5 and 9.0 l min^{-1}. The signal was higher at a flow of 9 l min^{-1} for both investigated compounds.

Nebulizer gas pressure of 30 psi was found to be optimal for the analysis. The increase in the pressure up to 60 psi did not significantly influence the signal.

Matrix effect

The common insight is that the use of LC-MS practically guarantees specificity. Contrary to this belief, a number of recent studies illustrate the need for studies on matrix effect and ion suppression. The matrix components may have an impact on the quantification of the analytes. Matrix effects can both reduce and enhance the MS response of analytes when compared to standards prepared in solvents. Matrix effects can be minimized by more selective extraction as well as by using an internal standard (Matuszewski et al., 2003). Additionally, use of APCI minimizes the risk of matrix effect (Dams et al., 2003) and ion suppression (King et al., 2000). In the present study, extraction with acetonitrile and defating with hexane were performed for preparation of adipose tissue extracts. No MS signal suppression/enhancement could be detected in these extracts, which indicated that the sample pre-treatment used in the present study was suitable for APCI.

Comparison of colorimetric and LC-MS methods

Skatole and indole content was measured in 10 porcine adipose tissue samples using the new LC-MS method. The same samples were analysed by the colorimetric method for skatole equivalents. Additionally, plasma samples from the same animals were taken at the same time as the samples of adipose tissue and were analysed for skatole concentrations by HPLC (Zamaratskaia et al., 2004). Skatole concentration in fat obtained from the two methods was compared. High correlation between the results obtained by these two methods was found (Figure 1). However, the values obtained by the colorimetric method were somewhat higher compared to those obtained by LC-MS due to the low specificity of the colorimetric method. The overestimation of skatole concentrations by the colorimetric method was especially pronounced at low values. The sum of skatole and indole was calculated for each sample and the sum values were plotted against skatole equivalents (Figure 1). The relationship between the sum of indolic compounds, and skatole equivalents was closer (especially for

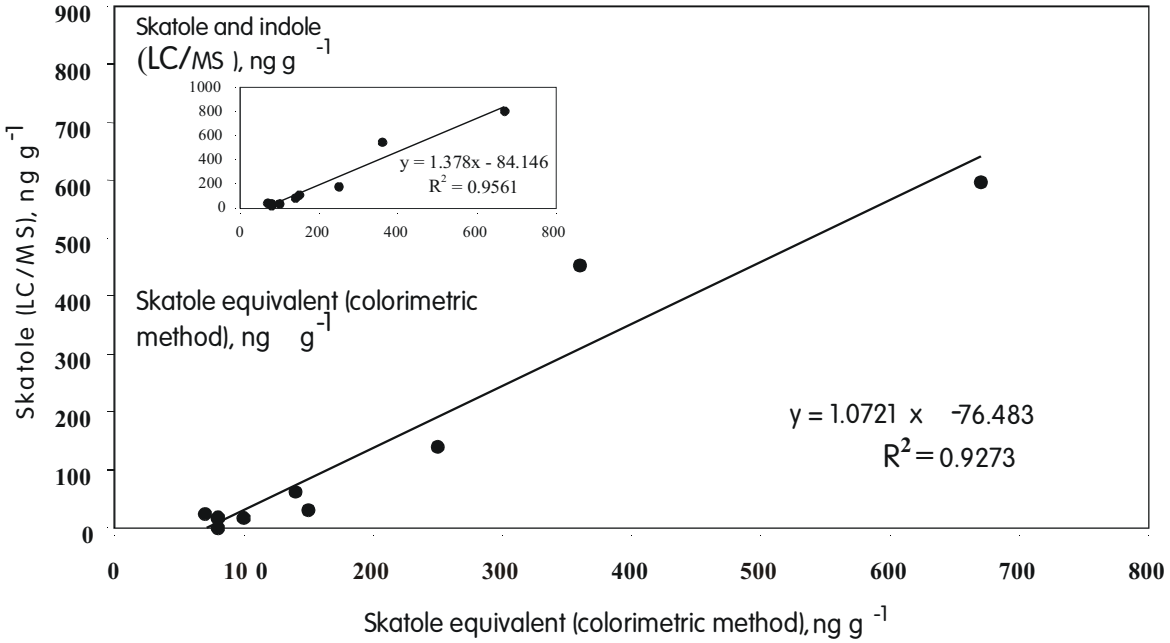

Figure 1. Comparison of the concentrations of indolic compounds in fat measured by colorimetric and LC/MS methods.

low concentrations), but still not perfect, suggesting the presence of other indolic compounds detected by the colorimetric method. Previous investigations identified the presence of indolemethanol, indolepropionic acid, indoleacetonitrile and indolethanol in porcine adipose tissue (Hansen-Moller, 1998), which may contribute to the signal intensity when measuring skatole equivalents by the colorimetric method.

Additionally, the concentrations of skatole in fat obtained by LC/MS and the colorimetric method were compared against plasma skatole concentrations measured by HPLC (Figure 2). The determination coefficient (R^2) between skatole in plasma (HPLC) and fat (colorimetric method) was only 0.276, whereas skatole concentrations in plasma were closely related to skatole in fat as measured by LC-MS (R^2 =0.899).

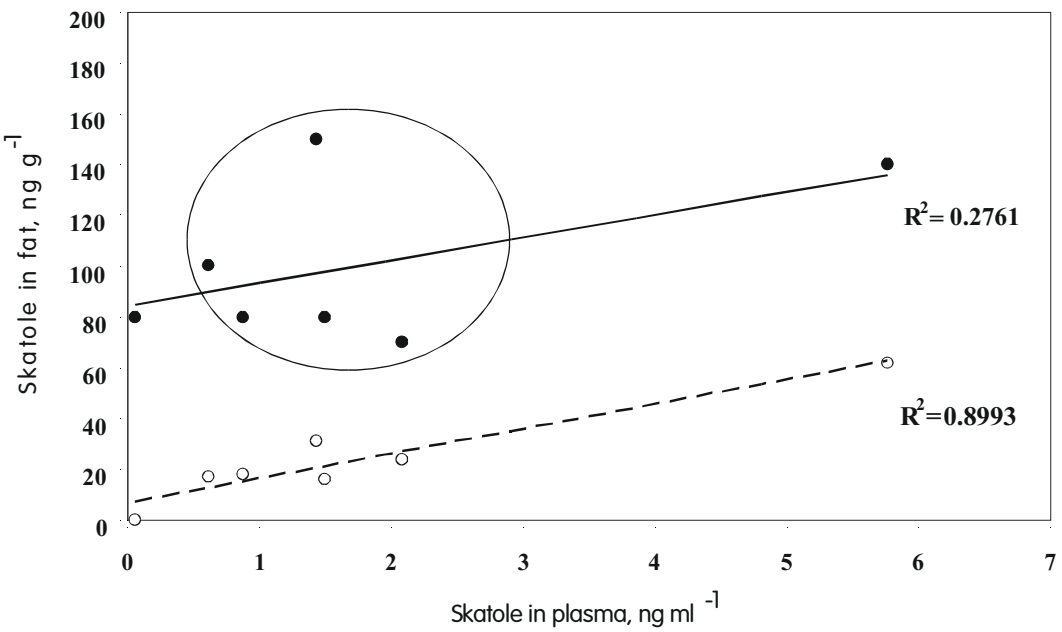

Figure 2. Relationship between skatole concentrations in plasma (HPLC) and skatole concentrations in fat measured by LC-MS (solid dots) and colorimetric methods (open dots). Oval shows the widest dispersion of data.

Conclusions

For the first time, LC-MS has been successfully applied for the separation and quantitative determination of skatole and indole in porcine adipose tissue. However, more detailed method validation is needed if the method is to be set up as a routine.

References

1. Claus R., Dehnhard M., Herzog A., Bernal-Barragan H. and Gimenez T. (1993) Parallel measurements of indole and skatole (3-methylindole) in feaces and blood plasma of pigs by HPLC. Livestock Production Science, 34, pp. 115-126.
2. Dams R., Huestis M.A., Lambert W.E. and Murphy C.M. (2003) Matrix effect in bio-analysis of illicit drugs with LC-MS/MS: influence of ionization type, sample preparation, and biofluid. Journal of the American Society for Mass Spectrometry, 14, pp. 1290-1294.
3. Hansen-Moller J. (1998) Analytical methods for determination of boar taint compounds. In: Skatole and boar taint. Danish Meat Research Institute, Roskilde, pp. 21-40.
4. Jensen M.T. and Jensen B.B. (1994) Gas chromatographic determination of indole and 3-methylindole (skatole) in bacterial culture media, intestinal contents and faeces. Journal of Chromatography B: Biomedical Sciences and Applications, 655, pp. 275-280.
5. King R., Bonfiglio R., Fernandez-Metzler C., Miller-Stein C. and Olah T. (2000) Mechanistic investigation of ionization suppression in electrospray ionisation. Journal of the American Society for Mass Spectrometry, 11, pp. 942-950.
6. Matuszewski B.K., Constanzer M.L. and Chavez-Eng C.M. (2003) Strategies for the Assessment of Matrix Effect in Quantitative Bioanalytical Methods Based on HPLC-MS/MS. Analytical Chemistry, 75, pp. 3019-3030.
7. Mortensen A.B. and Sørensen S.E. (1984) Relationship between boar taint and skatole determination with a new analysis method. In: Proceedings of 30th European Meeting Meat Research Workers, Bristol, UK, pp. 394-396.
8. Skordos K. W., Skiles G.L., Laycock J.D., Lanza D.L. and Yost G.S. (1998) Evidence Supporting the Formation of 2,3-Epoxy-3-methylindoline: A Reactive Intermediate of the Pneumotoxin 3-Methylindole. Chemical Research in Toxicology, 11, pp. 741-749.
9. Zamaratskaia G., Babol J., Andersson H. and Lundström K. (2004) Plasma skatole and androstenone levels in entire male pigs and relationship between boar taint compounds, sex steroids and thyroxine at various ages. Livestock Production Science, 87, pp. 91-98.

CHANGES OF PH IN BEER DURING MANUFACTURE PROCESS

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Abstract

The possibility to use cranberry juice for acidification of water in the process of beer making instead of traditionally used acidifiers is researched in this work. The output of malt extract received from cranberry juice with acidity regulator is 21.84%. Physicochemical parameters of mash and beer have been defined. The developed method is recommendable for beer production at small enterprises and in home environment.

Key words: malt, beer, pH, cranberries.

Introduction

Beer is usually prepared from water, barley malt, hop, and yeast. The solution of drink received in the result of multiform chemical and fermentative processes is complicated – it contains about 400 various substances (Heyse, 1995). Therefore, even negligible indentions from traditional production technologies affect some specific chemical or biochemical processes and result in alteration of beer quality, making it better or worse (Narziβ, 1995).

One of the most important processes in beer fermentation is the process of mash recovery. Mash raw material – malt - is currently a standard quality commercial product and many of beer manufacturers prefer to choose any kind of malt from the wide range of offered products instead of getting it themselves.

On the first stage of malt getting – the process of mashing – the factors that affect the output of malt extract are the quality of water, medium pH and temperature, as in this period the biochemical processes carry on (Varnam, Sutherland, 1994). In the process of mashing, it is important to provide the optimal conditions for starch hydrolysis enzymes α-amylase and β-amylase activity. The largest α-amylase activity was stated when medium pH was 6.0-5.8, but β-amylase - 5.4–5.6. Because of that this process is commonly carried out when the mash pH is between 5.4 and 5.8 (Kunze, 1998).

Normally, mash medium pH is higher and an optimal pH is obtained by adding phosphoric, lactic acids or gypsum or *Lactobacillus delbrueckii* to the mixture. The option of specific additive is defined by the quality of used water. In most cases, medium pH regulator is lactic acid which reacts with calcium hydrogen-carbonate and forms calcium lactate which substantially affects activity of enzymes (Меледина, 2003).

The purpose of this research is to find out the possibility to substitute phosphoric acid for other organic acids which are in berry and fruit juices.

Materials and Methods

In the experiment, the malt and ready beer acquired in laboratory conditions.

Three series of experiments were accomplished changing the water pH and acidificators was:

- raw water mixed with malt,
- water acidulated with cranberry juice mixed with malt,
- water acidulated with phosphoric acid mixed with malt.

Materials:

1. Light malt.
2. 'Līvu' source water: Ca^{2+} - 50-75 mg L^{-1}, Mg^{2+} - 10- 25 mg L^{-1}, SO_4^{2-} - 5-20 mg L^{-1}, Cl^- - 5-15 mg L^{-1}, Fe^{2+} - 0.01-0.05 mg L^{-1}.
3. Beer yeast.
4. Phosphoric acid.
5. Cranberries.

Methods:

Physicochemical indications of ready beer – output of malt extract, content of ethanol and density - were been defined by beer analyzing system 'Anton Paar beer Alcolyzer Plus' analyzer, but color, bitter substances and VDC - with spectrophotometer 'Jenway' UV/VIS 6400/6405.

Content of wort extract analyzed with beer analyzing system 'Anton Paar beer Alcolyzer Plus' analyzer.

The mash and wort samples were analyzed potentiometrically at the Department of Chemistry of the Faculty of Food Tehnology, LLU, by employing the WTW pH meter (pH 538) with electrode (Sen Tix 97T), using the AOAC 945.10 method.

Mashing conditions are standardized (Figure 1):

Results and Discussion

In the first case, by mixing non-acidulated water with malt, the medium pH decreased for 1.3 units. In further stages, pH changes were insignificant (Figure 2): at the end of the process, the mash pH was 6.02, so the medium acidity (pH 5.4–5.8) necessary for optimal activity of amylase was not achieved. The output of extract matters relatively was the lowest (Table 1).

For regulation of medium acidity, the phosphoric acid, which reacts with hydrogen-carbonates existing in water, was used. However, in this case, a continuous increasing

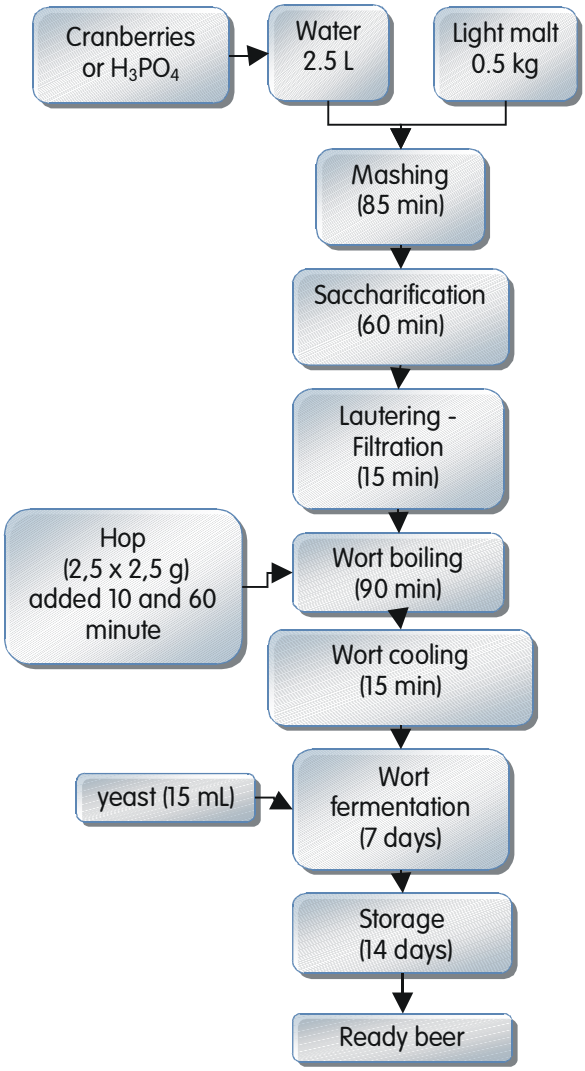

Figure 1. The scheme of the technological process of beer production.

of mash pH was observed. It may be explained by cooperation of phosphoric acid and phosphate with malt extract matters, for instance, amino acids, phosphates, and others. The results of our experiment show that using phosphoric acid as a regulator of acidity, it should be periodically added during the whole process of mashing, which is technologically troublesome.

Beeries and fruits content different organic acids, so them be a possible acidulate leaven agent. For this presumption was testet cranberries. Well-known that 100g cranberries containt 1g citric acid, 1g malic acid and 1g quinine acid (Ruciņš, 2000).

Mixing water, acidulated with cranberry juice (pH 5.64), with malt, the medium pH at all mashing stages was changing very insignificantly and it may be practically considered as constant. In reaction with citric acid, malic acid and quinine acid existing in cranberries, calcium and magnesium hydrogen-carbonates of water were divided this creating salts of relevant organic acids. The practically constant mash pH could confirm that these salts do nor react with extract components. The high output of extract (21.8%) show that it's became absolute saccarification. Cranberry juice as acid regulator is not technological for malt mashing in industrial conditions. However, producing beer in small food production enterprises, e.g., objects of country tourism or in home environment, neither lactic nor phosphoric acids are available. In such production conditions, fruit or berry juice may be used as leaven acidity regulator, such as cranberry, currant, lemon, etc.

To decrease the pH of 200 mL of water which initial pH is 7.0–7.6 up to 5.6, 2.3-2.5 mL of cranberry juice should be added.

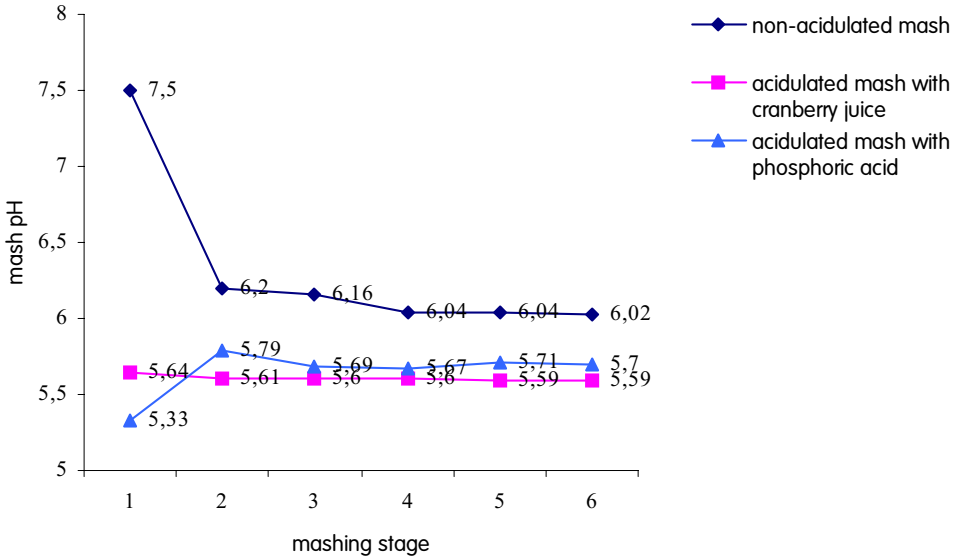

Figure 2. Water and mash pH: for water (1), mixing in (2), albumen pause (3), maltose pause (4), 1st sugaring (5), 2nd sugaring (6).

Derivation beer in a labaratory show variety results. Mash acidulated with phosphoric acid shows in a ready beer the neare results as is in brewery produced beer. Ready beer from mash acidulated with cranberry juice shows very highe original extract, strange color and highe density. This beer color schows, that it's derivate darke beer, but beer was producing from ligh malt. Cranberry juice is influence on beer color in masching process, like dark malt, and it can add in strong beer.

Vicinal diketon (diacetyl, 2.3-pentanedione) content of beer from non – acidulated mash is very highe 1.07 mg L^{-1}. The diacetil flavor threshold is 0.05 – 0.10 mg L^{-1}, and 2.3-pentanedione near 1.0 mg L^{-1}, this mean that beer from non – acidulated mash is appreciable flavor in a buttery and honey like aroma (Fix, 1993).

Conclusions

1. In malt mashing processes water acidulated traditional agents can changed with cranberries juice.

Table 1

Physicochemical indicators of the beer production process

Indicators	Mash		
	Acidulated with cranberry juice	Non-acidulated	Acidulated with phosphoric acid
Mash strained pH	5.59 ± 0.02	6.02 ± 0.02	5.71 ± 0.02
Wort after boiling pH	5.44 ± 0.02	6.02 ± 0.02	5.50 ± 0.02
Wort after main fermentation pH	4.15 ± 0.02	3.92 ± 0.02	4.35 ± 0.02
Original extract, % Plato	21.84 ± 0.03	14.27 ± 0.03	12.47 ± 0.03
Alcohol, %	8.88 ± 0.01	3.77 ± 0.01	5.21 ± 0.01
Color, EBC	18.3 ± 0.1	13.2 ± 0.1	6.0 ± 0.1
Bitterness, BU	23.1 ± 1	20.4 ± 1	20.5 ± 1
VDC*, mg L^{-1}	0.32 ± 0.01	1.07 ± 0.01	0.34 ± 0.01
Density, g/cm^3	1.02304±0.00001	1.02737±0.00001	1.00873±0.00001

Vicinal diketon content

2. Mixing water acidulated with cranberry juice (pH 5.64) with malt, medium pH at all mashing stages is changing very insignificantly and it may be practically considered as constant.

3. With acidity regulator cranberry juice is acquired 21.84% malt extract, which is valuated a high.

4. Acidulated method with cranberries is recommendable for small food production enterprises and home environment.

References

1. Fix G. (1993) Diacetyl: Formation, reduction and control. Brew. Tecn. 1(2), pp. 3-12.
2. Heyse K.U. (1995) Handbuch der Brauerei – Praxis (Handbook of brewery – praxis). Hans Carl, Nürnberg, 547 pp. (in German).
3. Kunze W. (1998) Tehnologie brauer und mälzer (Brewery and malt technology), VLB, Berlin, 910 pp. (in German).
4. Narziβ L. (1995) Abriβ der Bierbrauerei (Description of brewery), Ferdinant Enke Verlag, Stuttgart, 397 pp. (in German).
5. Ruciņš M. (2000) Bioloģiski aktīvo savienojumu kombinēšana ogu un augļu pārstrādes produktos (Combination of biological active components in processing products of berries and fruits). LLU PTF zinātniski paraktiskā konference '21.g.g. Kopā ar zinātni un praksi'. Referāti, Jelgava, pp. 51-54. (in Latvian).
6. Varnam A.M., Sutherland J.P. (1994) Beverages, tehnology, chemistry and microbiology, Chapman&Hall, London, 464 pp.
7. Меледина Т.В. (2003) Сырье и вспомогателъные материалы в пивоварении (Raw materials and helpmate materially in brewery). Профессия, Санкт-петербург 304 с. (in Russian).

APPLICATION OF QUANTITATIVE RISK ASSESSMENT IN CATERING AREA

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Abstract

Company – oriented risk analyses is the necessary precondition to establish, validate and improve HACCP procedures in catering enterprise. In catering area no microbiological criteria exist for ready-to-eat food in both European and Latvian level. The objective of the study was to apply risk assessment approach to evaluate microbiological risks during food preparation processes in school catering establishments. The aim of the author's research was to assess the level of microbiological contamination of food as well as the changes of microbial contamination during technological processing of food to motivate the necessity for controlling of food contamination levels in frame of HACCP procedures. It was concluded that no significant risk in consumption of cooked minced meat food if cooking temperature is adequate and food is stored at correct temperature after cooking. The storage of salads in ambient air temperature causes a significant increase of bacterial contamination due to high initial contamination level that may create a serious risk in case of pathogenic bacteria. On the basis of research it was concluded that microbiological investigation should be a recommended way to test step-by step the performance of technological processes because the hygiene situation is specific to each catering establishment and safety of the end-products may vary considerably. Microbiological testing of food and environmental samples could be a helpful tool for development and validation of HACCP procedures to assess potential risks and to establish critical limits for managing of technological steps in school food service area.
Key words: risk assessment, catering in schools, HACCP, microbiological criteria.

Introduction

The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations have recognized the importance of the development of risk-based approaches for the management of public health risks for hazards in food. The Joint FAO/WHO Expert Consultation on the Application of Risk Analysis to Food Standards Issues held in 1995 defined risk analyses as a process composed of three components: risk assessment, risk management and risk communication (WHO, 1995a; WHO, 2000).

The new European regulation on hygiene of foodstuffs states seven HACCP principles that food business operators shall put in place, implement and maintain in order to assure permanent HACCP procedures (The European Parliament and the Council, 2004). Hazard identification is the first step in HACCP principles application in every food establishment to prevent or eliminate hazards or to reduce them to acceptable levels. Hazard identification is the base for identifying critical control points and for implementation of effective monitoring procedures as well as for establishing procedures to verify effectiveness of hazard controlling measures. According to European General Food Law risk means a function of the probability and severity of an adverse health effect consequential to a certain hazard (The European Parliament and the Council, 2002). It is recognized that three interconnected components of risk analysis provide a systematic methodology for the determination of effective, proportionate and targeted measures and actions to protect consumer health (The European Parliament and the Council, 2002). In the risk assessment phase scientific and quantitative tools are advised and increasingly intensively applied (FAO, 2004).

Company – oriented risk analyses is the necessary precondition to establish, validate and improve HACCP procedures in catering enterprise. In catering area no microbiological criteria exist for ready-to-eat food in both European and Latvian level, and establishment of internal control criteria should therefore be a relevant component of general HACCP procedure.

Materials and Methods

The objective of the study was to examine microbiological risks during food preparation processes in school catering establishments. Technological processes of salad and minced meat food preparation was investigated to compare microbiological risks in chilled food and cooked food preparation chain. In total 30 food and 10 environmental swab samples were taken in five different schools in Jelgava city and 120 microbiological analyses of food and environmental swab samples were performed in Jelgava district Veterinary laboratory. To investigate the technological chain of minced meat food preparation four sequential pork food samples were taken in each school: a raw pork meat sample, a semi-finished raw minced pork product, and two ready-to-eat pork food samples after thermal processing. One of the ready-to-eat pork food samples was left in ambient air temperature in laboratory conditions to imitate frequent practice in schools during hot food storage. To investigate the technological chain of raw vegetable salad preparation two samples of ready-to-eat cabbage - carrot salad made with vegetable oil were taken in each school. One of the salad samples was left in

ambient air temperature in laboratory conditions to imitate frequent practice in schools during storage of chilled food. All pork food samples and cabbage – carrot salad samples were tested for the total plate count and the *Enterobacteriaceae* and *Staphylococcus aureus* bacteria count. In addition, two environmental swab samples were taken in each school: one swab sample from employee's hands engaged in salad preparation and second – from grate used in vegetable crushing. All swab samples from human hands and kitchen inventory (grate) were tested for the total plate count, presence of *Escherichia coli* group bacteria and *Staphylococcus aureus* bacteria count.

To detect the total plate count the microbiological testing was performed in compliance with LVS EN ISO 4833:2003 standard method, using PCA (Plate Count Agar) media and incubation temperature +30 °C for 72 hours. For determination of *Enterobacteriaceae* bacteria count in food samples testing was performed in compliance with ISO 21528-2:2004 standard method, using VRBG (Violet Red Bile Glucose) Agar media and incubation temperature +37 °C for 24 hours. To verify characteristic bacteria colonies, N-agar (Nutrient agar) plates were used and incubation was performed at +37 °C for 24 hours as well as the oxidase test was performed. *Staphylococcus aureus* bacteria in food were determined in accordance with LVS EN ISO 6888-1:1999/A1:2003 standard method, using Baird – Parker Agar plates. After incubation at 37 °C for 24 hours typical bacteria colonies were marked and incubation was continued at 37°C for another 24 hours. The identification of coagulase-positive *Staphylococcus* was performed by incubation of typical and untypical bacteria colonies in Nutrient Broth (brain – heart broth) at 37 °C for 24 hours and by subsequent adding of 0.1 ml of broth to 0.3 ml of rabbit's plasma. Plasma coagulation was tested after incubation at 37 °C for 6 hours and finally after 24 hours to conclude about coagulase – positive *Staphylococcus* presence.

The *Escherichia coli* group bacteria in swabs from human hands and kitchen inventory – grate were detected according to the working procedure VVMDC–T-012-010.2-2000 of the Food and Veterinary Service National Diagnostic Center, using incubation in Brilliant – Green Bile Lactose Broth at +37 °C 24 hours. In case of gas formation a sequential cultivation on differential and selective culture medium for the detection of enteric microorganisms (Endo Agar) was performed at + 37 °C 24 hours. Gram – staining technique and microscoping procedure was used for typical bacterial colonies.

Staphylococcus aureus in swabs was detected according to the working procedure VVMDC–T–012–010.5–2000 of the Food and Veterinary Service National Diagnostic Center, using incubation in 6.5% saline broth at +37 °C 24 hours and sequential incubation on Baird – Parker Agar plates at +37 °C 48 hours. Peptone Yeast Extract Agar plates were used for conformation of *Staphylococcus aureus* colonies at 37 °C 24 hours. Gram – staining technique and microscoping procedure was used for typical bacterial colonies. Catalase test was performed at 37 °C 24 hours to determine the ability of *Staphylococcus* to coagulate rabbit's plasma.

Microsoft Excel computer program was used to obtain quantitative risk assessment and to interpret results of investigation in a graphical way. To demonstrate microbiological contamination of food and environmental samples in graphical way catering establishments were numbered according sample taking sequence (No.1 to No.5).

Risk analyses

Industry is responsible for the quality and safety of the food it produces (WHO, 1998). Microbial risks are considered to be a much larger and more immediate problems to human health than risks associated with chemicals in food - there might be a significant increase of microbial contamination due to replication of microorganisms under favourable environmental conditions (WHO, 1995a). It is recognized that complete freedom from risks is an unattainable goal. A risk analysis is widely recognized as the fundamental methodology for development of food safety standards through the selection and implementation of appropriate measures (FAO, 1997).

Microbiological risk analysis is a process consisting of three components: risk assessment, risk management, and risk communication (WHO, 1999). In practice, risk analysis operates as a non-linear process (FAO, 2004):

- First, a given hazard is identified and a risk profile is developed to guide decisions on how to proceed
- Second, a risk assessment is undertaken according to guidelines established during the preceding step
- Third, the results of the risk assessment are used to select and implement risk management options, and to accomplish risk communication.

It is generally assumed that zero risk is not achievable because a single pathogen has some probability of causing illness under certain circumstances. It is assumed that a single level exists above which the risk is unacceptable and below which the risk is acceptable. The availability of quantitative information on risks allows the identification of food safety objective to allow the use of different technologies to achieve the safe level. The challenge for risk management is to reduce risk as low as reasonably achievable (WHO, 2000). Risk management includes policies, actions and choices to reduce risk and protect public health. The fact that a risk analysis is being done often reflects a prior judgement that some person or group should take action to reduce the likelihood or severity of harm.

It is recognized that individual food enterprise may act

as both a risk manager and risk assessor. Initial identification of food safety problems is a risk management function. It is important to clarify the problem or issue, identify risk management goals and to perform subsequent risk assessment to provide information and to manage the food safety issue afterwards. Ranking of the particular food safety issue for risk management priority is essential to estimate a relative impact of different hygiene interventions for reduction of food safety risks to consumers (WHO, 2000).

Quantitative risk assessment

Food will always present some minimal biological risk and the task of food handlers is to maintain the level of risk at minimum, considering practical and technological constraints. Risk assessment is the process that is used to quantitatively or qualitatively estimate and characterize risk (WHO, 1999). Risk assessment is a process that can include a variety of models to reach conclusions (WHOa, 1995).

Historically, microbiological food safety issues have been considered too complex to establish quantitative safety limits based on a risk assessment (WHO, 1999). Today microbiological risk assessments may be useful tool in hazard analysis as a basis for determining which hazards need to be addressed in the HACCP procedure.

The safety of food products on a consumer's plate depends largely on the way they have been produced. Certain hygiene rules have been established to ensure that safe methods of food production are used (Meulen B. et al., 2004). The General Food Law states that food business operators must ensure adherence to law and imposes a general responsibility to assure that only safe food is sold to consumers. This implies a general risk for food business operators to provide safe food handling practices during food preparation steps and to ensure that food is not injurious to consumer health (The European Parliament and the Council, 2002).

Quantitative risk assessment is used to aid in decision making for managing certain risks (Luning et al., 2006). Risk assessment is a key element to establish standards, guidelines and recommendations for food safety to enhance consumer protection. Initial contamination of the raw materials, the methods of food processing and distribution, the level of sanitation and production process control as well as preparation steps like food cooking and holding are factors that influence the safety of ready-to-eat food. The role of food handler as source of contamination, the amount of hand contact with food, and the potential impact of time/ temperature parameters on bacterial survival or growth are other important factors that must be considered during risk assessment (WHO, 1999).

The objective of a quantitative risk assessment is to derive a mathematical statement on the levels of microbiological contamination during food processing steps as well as on impact of different food processing methods on overall contamination of food. Because the strict measurement of microbial risks during food preparation usually is not possible, possible outcomes can be estimated using quantitative data models. Risk assessment is a key to developing practical and credible food safety procedures. Risk assessment techniques can be applied to determine significance of hazards and to evaluate risk management strategies (WHO, 1995a).

The primary objective of microbiological risk management is to optimise necessary interventions to prevent and control microbiological risks. Risk assessment should be designed to identify the stage in food chain where the interventions will be most effective to reduce contamination of food. Quantitative methods of risk assessment should be developed for biological hazards to optimise and improve the application of HACCP system (WHO, 2000).

1995a HACCP approach

It is generally recognized that microbiological safety of food is assured by application of good hygiene practice during food processing and distribution as well as by application of the HACCP principles. HACCP is a preventive system that is based on process control and therefore is more effective than end-product testing. Hazard analyses identifies potential hazards in raw materials or during food handling processes to decide which hazards are significant and need to be included in HACCP plan (FAO, 1997).

Hazard identification is the first step both in risk analyses processes and in development of HACCP procedures. The level of microorganisms in food is dynamic – it can be kept low with time/temperature control but it can increase with improper food storage temperature or due to cross-contamination of food from other foods, utensils, and equipment or human hands. The effects of processing - hygienic design of premises, organisation and observation of technological process, identification of utensils and other working surfaces, cleaning and disinfection measures, time/ temperature control arrangements are important factors to decrease microbial contamination of food. Qualitatively foods can be categorized according to the likelihood of initial contamination, support of microbial growth, potential for contact with human hands or subject to heat processing (WHO, 1999).

HACCP is a system that identifies specific hazards and preventive measures for their control and the seven principles of HACCP form a framework for developing HACCP procedure that must be specific to food product and food production line. The determination of potential hazards which are essential to control involve a risk based hazard assessment to provide input into HACCP plans (WHO, 1995b).

Bacterial populations are dynamic and may increase or decrease dramatically in food matrices during food processing and storage. HACCP approach includes the

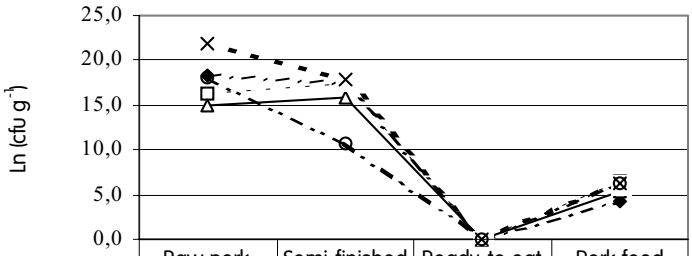
development of processes and procedures, the application of which eliminates hazards or reduces them to acceptable levels. There is a little quantitative data to link specific procedures with potential biological hazards in catering area. The information on food hazards during food handling processes is essential to compare risks and to assure validation of HACCP procedures as well. Systematic evaluation of the impact of sanitary measures or food processing technology on reducing or eliminating risk is recommended for optimisation of food handling processes. Information gained in the risk assessment process may be useful for validation of effectiveness of food safety assurance system (WHO, 2000).

Establishing of specific microbiological criteria for food is often difficult and therefore the critical issue is not to prevent certain microorganisms in food, but to control the survival and growth of them in food in order to minimize potential risk (FAO, 1997).

Results and Discussion

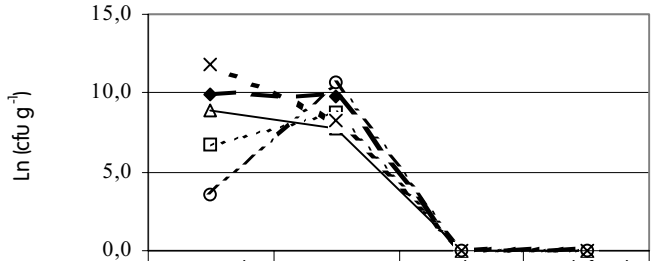
The results of the research indicate that the total plate count decreases considerably from 10^7-10^9 cfu g^{-1} to less than 10 cfu g^{-1} during the thermal processing of minced meat food. If cooked minced meat food after preparation was stored at room temperature for 2 hours, the total plate count reached 7.3×10^1 to 0.6×10^3 cfu g^{-1} in different food samples (Figure 1). *Enterobacteriaceae* were not found in cooked food samples (Figure 2). *Staphylococcus aureus* was found in one raw pork sample and one semi-finished minced pork sample, but was not found in any ready-to-eat food sample (Figure 3).

The results suggested that the total plate count in cabbage - carrot salad made with vegetable oil was between



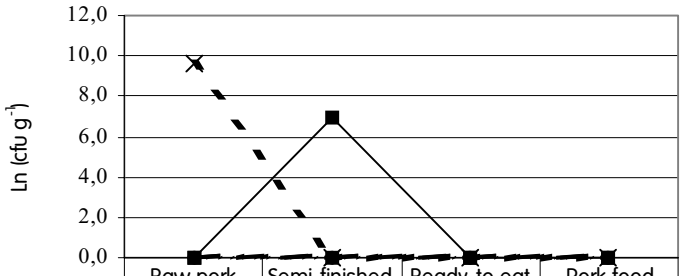
	Raw pork meat	Semi-finished minced pork	Ready-to eat pork food	Pork food after 2 hours
No.1	18,3	17,4	0,0	4,3
No.2	16,2	17,4	0,0	6,4
No.3	14,9	15,8	0,0	5,4
No.4	21,8	17,9	0,0	6,3
No.5	18,0	10,7	0,0	6,2

Figure 1. Changes of Total Plate Count During Preparation of Pork Food.



	Raw pork meat	Semi-finished	Ready-to eat pork	Pork food after 2
No.1	10,0	9,8	0	0
No.2	6,7	8,8	0	0
No.3	8,9	7,8	0	0
No.4	11,8	8,3	0	0
No.5	3,6	10,7	0	0

Figure 2. Changes of *Enterobacteriaceae* Count During Preparation of Pork Food.



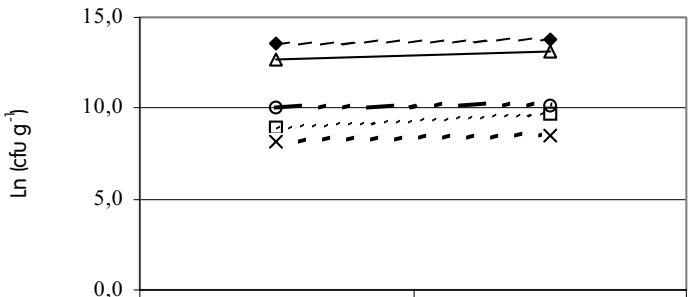
	Raw pork meat	Semi-finished minced pork	Ready-to eat pork food	Pork food after 2 hours
No.1	0,0	0,0	0,0	0,0
No.2	0,0	0,0	0,0	0,0
No.3	0,0	6,9	0,0	0,0
No.4	9,6	0,0	0,0	0,0
No.5	0,0	0,0	0,0	0,0

Figure 3. Changes of *Staphylococcus aureus* Count During Preparation of Pork Food.

$3.6x10^3$ cfu g^{-1} and $7.6x10^5$ cfu g^{-1} after salad preparation and increased to $4.7x10^3$ cfu g^{-1} and $9.6x10^5$ cfu g^{-1} after storage of salads in ambient air temperature for two hours (Figure 4). The *Enterobacteriaceae* count in salads was between 0 cfu g^{-1} to $7.7x10^3$ cfu g^{-1} after preparation and 0cfu g^{-1} to $1.7x10^4$ cfu g^{-1} after storage of salads in room temperature (Figure 5). *Staphylococcus aureus* was present in large amount ($1.1x10^3$ cfu g^{-1}) after storage of salad sample from school kitchen No.5 in ambient air temperature for 2 hours (Figure 6).

The total plate count both on grate and human hands was high and altered greatly in school kitchens (Figure 7). *Escherichia coli* group bacteria were detected in swabs from the surface of clean inventory – grater in school kitchen No.2 and No.4. *Escherichia coli* group bacteria were found in swab sample from human hands in school kitchen No.1, No.2 and No.4. It suggests that in case of kitchen inventory *Escherichia coli* group bacteria positive samples constituted 40% of total sample amount, but in case of human hands – 60% of total sample amount when presence of *Escherichia coli* group bacteria was detected. *Staphylococcus aureus* bacteria were present in large amount (1100 cfu g^{-1}) after storage of salad sample from school kitchen No.5 in ambient air temperature for 2 hours. The finding suggests about unsuitable cleaning – disinfections measures regarding to human hands and/or kitchen inventory, subsequent cross-contamination of salad ingredients during technological processing as well as about rapid multiplication of *Staphylococcus aureus* due to incorrect storage temperature. The research suggests that taking and analysing of single heterogeneous food samples not always characterizes the actual hygienic status food and/or technological process.

The results indicate that raw pork meat and semi-finished minced pork product contains a large number of



	Raw vegetable salads	Salads after 2 hours
No.1	13,5	13,8
No.2	8,9	9,7
No.3	12,7	13,1
No.4	8,2	8,5
No.5	10,0	10,2

Figure 4. Changes of Total Bacteria Count During Preparation of Vegetable Salads.

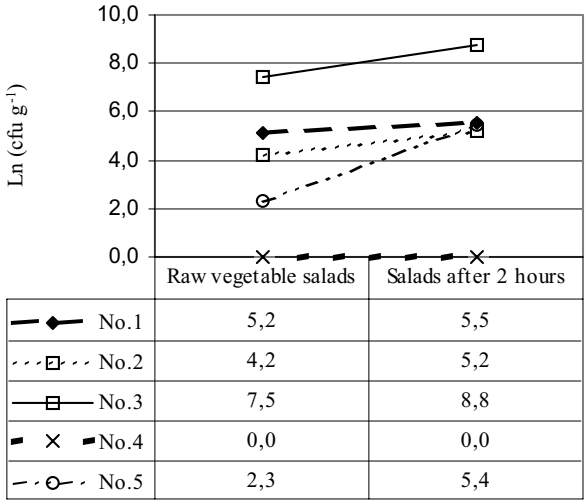


Figure 5. Changes of *Enterobacteriaceae* Count During Preparation of Vegetable Salads.

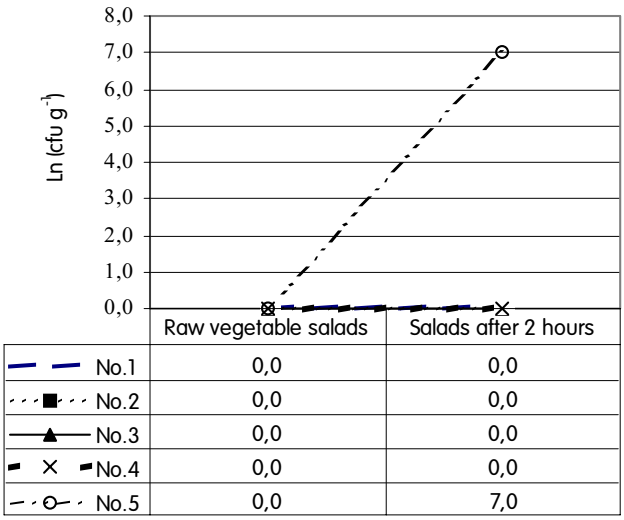


Figure 6. Changes of *Staphylococcus aureus* Count During Preparation of Vegetable Salads.

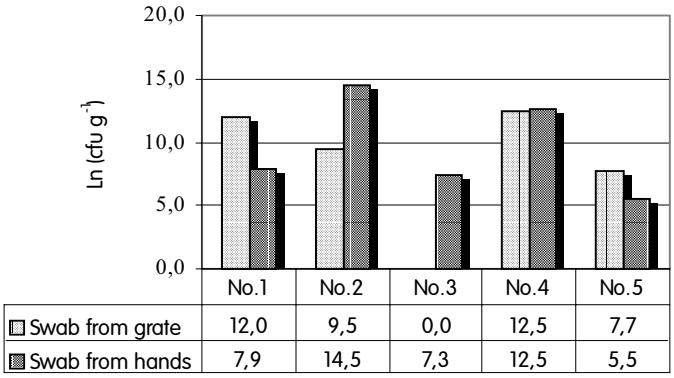


Figure 7. Total Plate Count in Swab Samples.

bacteria cells including *Enterobacteriaceae* that decreases considerably during food thermal processing. It can be concluded that there is no significant risk in consumption of cooked minced meat food if cooking temperature is adequate and food is stored at correct temperature after cooking. Storage of cooked food at room temperature for two hours induced some recovery and growth of bacteria; nevertheless, *Enterobacteriaceae* and *Staphylococcus aureus* were not found in cooked food samples.

Cleanliness both of kitchen inventory for food cold processing and human hands can affect considerably the total plate count in ready-to-eat salads as well as the *Enterobacteriaceae* count and *Staphylococcus aureus* count bacteria in salads. Different contamination levels of kitchen inventory and human hands suggest that the objects that come into contact with food comprise a great risk during salad preparation because the contamination level of them is hard predictable. Regular testing of environmental swab samples can therefore be a helpful tool for improvement of hygiene procedures because of absence of direct critical control points in salad preparation chain. The increase of the total plate count and *Enterobacteriaceae* count in salads was faster than in cooked meat products when food was stored in ambient air temperature for two hours. The general assumption about potentially safe storage of cooked food in ambient air temperature till four hours cannot be applicable for salads due to higher initial contamination level of salad components. Microbiological investigation should be a recommended way to test step-by step the performance of technological processes because the hygiene situation is specific to each catering establishment and safety of the end products may vary considerably. It should be suggested that main problems in school catering sector are not related to big financial investments but rather to adequate competence of food service personnel and hygienic food handling practices.

Conclusion

1. Research on risk assessment demonstrates that adequate thermal processing eliminates food safety risk during preparation of cooked pork food. However, storage of cooked food at ambient air temperature already after two hours induces growth of bacteria that can comprise a significant risk in case of survival of pathogenic bacteria.

2. Research on risk assessment indicates that preparation of salads comprises a food safety risk due to potential cross-contamination of salad components coming into contact with human hands and/or kitchen inventory. Storage of salads at ambient air temperature already after two hours induces a significant increase in Enterobacteriaceae count and *Staphylococcus aureus* count if these bacteria are present in salads.

3. The results of microbiological investigation of swab samples indicate that visually clean kitchen inventory and human hands can be contaminated with considerable amount of bacteria, including *Escherichia coli* group bacteria, if cleaning – disinfection measures are not adequate.

4. Microbiological assessment of food and environmental samples could be recommended as a helpful tool for risk management activities in frame of HACCP procedure to assess potential risks and to establish critical time – temperature limits for technological processes as well as to assess cleaning – disinfection efficiency in catering establishments.

Acknowledgments

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References

1. Codex Alimentarius Commission (1999) Principles and Guidelines for the Conduct of Microbiological Risk Assessment, CAC/GL-30, 6 p. Available at: www.codexalimentarius.net/download/standards/357/CXG_030e.pdf, 17.03.2006
2. European Parliament and Council (2002) Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Available at: http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_031/l_03120020201en00010024.pdf, 17.03.2006.
3. European Parliament and Council (2004) Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. Available at: http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/oj/2004/l_226/l_22620040625en00030021.pdf, 17.03.2006
4. FAO (1997) Risk Management and Food Safety: Report of a Joint FAO/WHO Consultation, Rome, Italy, 27 pp.
5. FAO (2004) FAO Expert Consultation on Food Safety: Science and Ethics, Rome, Italy, 32 pp.
6. Luning P.A. et al. (2006) Safety in the Agri-Food Chain, Wageningen Academic Publishers, the Netherlands, 684 pp.
7. Meulen B. et al. (2004) Food Safety Law in European Union, Wageningen Academic Publishers, the Netherlands, 270 pp.
8. WHO (1995)a The Application of Risk Analysis to Food Standards Issues: Report of the Joint FAO/WHO Expert Consultation, Geneva, 39 pp.
9. WHO (1995)b The Application of Risk Communication to Food Standards and Safety Matters: a Joint FAO/WHO Expert Consultation, Geneva, 31 pp.
10. WHO (1999) Risk Assessment of Microbiological Hazards in Foods: Report on the Joint FAO/WHO Expert Consultation, WHO, Geneva, 23 pp.
11. WHO (2000) The Interaction Between Assessors and Managers of Microbiological Hazards in Food: Report of a WHO 5th Expert Consultation, Geneva, 23 pp.

VETERINARY MEDICINE SCIENCES

FUNGI IN MINK FEED AND ORGANS

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Abstract

The research of feed components of minks (frozen fish and meat offal, dried haemoglobin, dried protein, wheat, barley, wheat and barley meal), and ready-mixed mink feed were investigated by mycological method in Sabouraud's Agar and Czapek Agar. The mycological examination of mink feedstuffs veriffed its contamination with *Acremoniella atra, Alternaria spp., Aspergillus spp., Aureobasidium pullulans, Candida spp., Chaetomium spp., Cladosporium spp., Coremiella cubispora, Crysonilia sitophila, Curvularia spp., Fusarium spp., Gliocladium spp., Moniliella acetoabutans, Mortierella spp., Mucor spp., Penicillium spp., Sporothrix cyanescens, Stemphylium spp., Trichophyton terrestre, Zygosporium masonii,* and *Wangiella spp.* Mycological examination of the mink liver, lungs and kidneys showed contamination with *Acremonium spp., Actinomyces israelli, Arthrographis kalrae, Aspergillus spp., Aureobasidium pullulans, Candida spp., Chaetomium spp., Cladosporium bantianum, Cladosporium sphaerospermum, Conidiobolus coronatus, Curvularia spp., Emmonsia spp., Fonsecaea pedrosoi, Geotrichum candidum, Mucor spp., Penicillium spp., Scedosporium prolificans, Sporothrix cyanescens,* and *Wangiella spp.*
Key words: mink, feed, fungi.

Introduction

At present animal diseases such as mycoses (mycopathies) caused by fungi are considered as one of the most essential urgent issues of veterinary medicine in the world. As the possible reasons for the increase of the number of mycopathies in animals the researchers consider the immunity reducing factors – environmental pollution, the use of plant protection chemicals and fertilizers in a variety of branches of crop production as well as the administration of broad scale antibacterial preparations in the practice of veterinary medicine. Mycoses are caused by the use of feedstuffs infected by fungi (Спесивцева, 1964; Кузнецов, 2001).

A prerequisite of successful development of fur-farming branch is the safety and quality of animal feed that affects directly the herd health. It is determined by the fur-bearing animal keeping and feeding pecularities – great animal density in a small territory, preparation of mixed feed on the spot in the farm kitchen, high protein concentration of animal origin and fat content in the mixed feed, and the use of thermally unprocessed products of animal origin for preparing the mixed feed (Перельдик et al., 1981).

It has been reported (Juokslahti, 1978; 1979) on the bacteriological examinations of the ready-mixed feed and feed components, however, there are no data on the feedstuffs mycological contamination and its effect on the fur-bearing animal body. The data about the effect of farm animal feed mycological contamination on the animal health are still incomplete (Саттон et al., 2001).

Feedstuffs of the plant origin (cereals and rough forage) contain broad spectrum of microorganisms (bacteria, fungi). A reservoir of fungi in nature is the soil. Part of the fungi existing in the soil gradually move to the overground parts of the plants – stalk, leaves, and then to the seeds. Part of the fungi (facultatives) continues to develop also after the plant destruction thus affecting the quality of produce of crop production during its storage (Кузнецов, 2001).

In Latvia, investigations have been carried out on the spread of fungi in the feedstuffs of farm animals and on the negative effect of mycological agents on the semen quality (Емельянов, 1990), but there are no investigations on their effect on the mink body.

This investigation is based on a hypothesis that in the feedstuffs, besides the bacteriological contamination, the presence of fungi is possible that causes disturbances of development in minks, their death and essential economic losses in the branch development due to diseases.

The objective of this research was to establish the distribution of fungi genera in the parenchymal organs of minks and their possible relation with feedstuffs.

Materials and Methods

The mink feed specimens and clinical material were collected on four fur-bearing animal farms in various regions of the Republic of Latvia. Mycological inoculation of feed and parenchymal organ specimens was carried out in the Laboratory of Microbiology of the Research Institute of Biotechnology and Veterinary Medicine 'Sigra', LLU in 2004 and 2005 from July to December.

To detect the fungal effect on the mink body, 34 dark brown minks at the age of seven months without clinical signs of any disease were selected by random on the Latvian fur-bearing animal farms. After parenteral euthanasia of the selected animals (Jepsen et al., 1981) with 1 ml of ditilin solution (10 g per litre of water), pathoanatomical necropsy

was performed and inner organs (liver, lungs, kidneys) were sampled.

Sabouraud's agar was used as a primary isolation medium for the fungal cultures from the mink internal organs specimens. A small surface of the changed tissue was burned on a flame, and small pieces of tissue from the middle were cut out by sterile scissors. The tissue cuts were used for a stripe-like inoculation onto media (Спесивцева, 1964) or they were placed on the agar surface (4-5 small tissue pieces in size of 0.5 cm X 0.5 cm (Quinn et al., 1994).

Feedstuffs for mycological examination were sampled by a random selection: 11 specimens were collected from ready-mixed feed, six – from frozen pig and cattle offal (lungs, larynx, trachea, fat, cattle forestomachs), three – from frozen fish offal, two – from dried haemoglobin, two – from bone meal, two – from dried protein, three – from cereal bran, six – from barley/wheat meal, and eight specimens from barley/wheat cereal feed.

Mycological inoculates from 43 specimens of the mink feed and their components were cultured on Sabouraud's and Czapek media. The preparation of specimens and dilution series was done in compliance with the standart ISO 7954:1987 „Determination of the number of yeasts and moulds in animal feed".

All mycological inoculates on Petri plates were incubated in thermostat for 4 weeks at the temperature of +26 °C, but some cultures, when transfered onto blood agar medium, were incubated 7-10 days at +37 °C (Quinn et al., 1994; Кузнецов, 2001).

The microscopic identification of the isolated fungi was carried out at the Mycology Department of the Laboratory of the Plant Quarantine Organisms according to the conventional methods (Саркисов et al., 1953; Kwon-Chung et al., 1992; Bridson, 1993; Larone, 1995; Кириленко, 1997; Ulloa et al., 2000; Саттон et al., 2001).

Results and Discussion

Many species of fungi causing illnesses (mycoses) are moulds. In immunosuppressive animals, microscopic fungi can disseminate in the organism (Кузнецов, 2001). A summary of the identified fungi from the mink tissue (liver, kidneys, lungs) in this investigation is given in Table 1.

Disseminated infection agents *Aspergillus spp.* and *Candida spp.* (Саттон et al., 2001) were isolated from the animal liver, lungs, and kidneys. Kuznecov (Кузнецов, 2001) also confirms that *Aspergillus spp.* cause dystrophic changes in the liver as well as inflammation of the urogenital and respiratory system. Macromorphology of the two above mentioned genera, however, was different. Colonies of *Candida spp.* were small, creamy, smooth, while *Aspergillus spp.* colonies were comparatively fast growing, wide, with white, blueish or greenish mycelium.

As to the lungs, *Conidiobolus coronatus* was isolated, the colony of which was flat, yellowish brown with a white reverse side. Sporangiophores with large round spores were seen. Other authors (Kwon-Chung et al., 1992) also have reported to have isolated this fungi from dogs and horses where it had caused nasal mucous membrane infections.

Table 1

Microscopic fungi in the mink organs

Microscopic fungi	Liver	Lungs	Kidneys
Acremonium spp.	-	-	+
Actinomyces israelli	+	-	-
Arthrographis kalrae	+	-	-
Aspergillus spp.	+	+	+
Aureobasidium pullulans	+	-	-
Candida spp.	+	+	+
Chaetomium spp.	+	-	-
Cladosporium bantianum	-	-	+
Cladosporium sphaerospermum	+	-	-
Conidiobolus coronatus	-	+	-
Curvularia spp.	-	-	+
Emmonsia spp.	+	-	-
Fonsecaea pedrosoi	-	+	-
Geotrichum candidum	-	-	+
Mucor spp.	-	+	-
Penicillium spp.	+	+	-
Scedosporium prolificans	+	-	-
Sporothrix cyanescens	+	-	-
Wangiella spp.	+	-	-

The second representative in the lungs was *Fonsecaea pedrosoi* that had black colonies with a velvety mycelium. At the ends of conidiophores, the primary conidia were separating from which the secondary ones were formed additionally. Conidia were of dark shade.

Acremonium spp., Cladosporium bantianum, Curvularia spp., and *Geotrichum candidum* were isolated from the kidneys. *Curvularia spp.* colonies averse and reverse were black, but conidiophores were septate and brown. The conidia had 3 crosswalls with a tannish shade. Although scientists (Cattoh et al., 2001) consider *Curvularia spp.* as widely distributed phytopathogens they can cause a disseminated infection. Carter and Chengappa (1993) have also reported on diseases in horses, cattle, dogs, and cats caused by this agent.

The microscopic fungus *Geotrichum candidum* causes an uncommon disease (geotrichosis) in cattle, dogs, poultry and other species, and most often involve bronchi, lungs, and kidneys. Although the infection is disseminated, usually one or several organs are affected (Carter et al., 1993). Within the framework of this investigation, *G. candidum* was isolated only from the kidneys, and it had a glabrous or yeastlike form without conidiophores, but the vegetative hyphae were breaking up into fragments (artrospores). Carter and Wise (2004) also confirmed that the *G. candidum* glabrous form is the only one most often associated with geotrichosis.

The liver is the most important organ of metabolism in the animal body of which most of the fungi types were isolated. *Arthrographis kalrae* colonies were slowly growing with a light brown shade. Micromorphologically colourless arthroconidia were observed. Tewari and Macpherson have also found that *A. kalrae* possess dimorphism, and they are pathogenic for mice (Kwon-Chung et al., 1992).

Chaetomium spp. colonies were cottony, white or tannish. The hyphae were septate with large, oval, dark brown ascospores. Sutton et al. (Cattoh et al., 2001) have also indicated that *Chaetomium spp.* can be the cause of systemic mycoses.

Table 2

Microscopic fungi in the ready-mixed mink feed and raw materials

Microscopic fungi	Ready-mixed feed	Cereal meal	Cereals	Bran	Pig meat offal	Fish offal	Dried protein
Acremoniella atra	-	-	+	-	-	-	-
Alternaria spp.	-	+	+	-	-	-	-
Aspergillus spp.	+	+	+	+	+	+	+
Aureobasidium pullulans	+	-	+	-	-	-	-
Candida spp.	+	+	+	+	+	-	-
Chaetomium spp.	+	-	+	-	-	-	-
Cladosporium bantianum	+	-	-	-	+	-	-
Cladosporium herbarum	+	+	+	-	-	-	-
Cladosporium sphaerospermum	+	+	+	-	-	-	-
Coremiella cubispora	-	-	+	-	-	-	-
Crysonilia sitophila	-	+	+	-	-	-	-
Curvularia spp.	+	+	+	-	-	-	-
Fusarium spp.	+	+	+	-	-	-	-
Gliocladium spp.	-	-	+	-	-	-	-
Moniliella acetoabutans	+	+	+	-	-	-	-
Mortierella spp.	+	+	+	-	-	-	-
Mucor spp.	+	+	+	-	-	-	+
Penicillium spp.	+	+	+	+	+	+	+
Sporothrix cyanescens	+	-	-	-	+	-	-
Stemphylium spp.	+	-	-	-	+	-	-
Trichophyton terrestre	+	-	-	-	+	-	+
Zygosporium masonii	-	+	+	-	+	-	-
Wangiella spp.	+	-	-	-	+	-	-

The above mentioned scientists (Саттон et al., 2001) have described *Sporothrix cyanescens* as a thermotolerant type with white, velvety colonies and a tannish reverse side. Micromorphologically it was detected that just after every conidiophore separation conidia collections followed.

Wangiella spp. macroscopically were characterised as black, slowly growing colonies, but conidiophore cells were slender, thin, with a typical tapered and elongated end.

Although several researchers (Kwon-Chung et al., 1992; Кузнецов, 2001) have isolated fungi from the internal organs of farm animals, there are no data in literature confirming the isolation of microscopic fungi genera from the tissue of the mink internal organs found in this research.

The agents of systemic mycoses are spread in the environment, and animals are mainly infected by ingestion (Quinn et al., 1994). The results of mycological examination of the ready-mixed mink feed and its components showed evidence of their contamination with fungi (Table 2).

Table 2 shows that the fungi found in cereals and meal (*Alternaria spp., Aspergillus spp., Aureobasidium pullulans, Candida spp., Chaetomium spp., Cladosporium herbarum, Curvularia spp., Coremiella cubispora, Crysonilia sitophila, Fusarium spp., Gliocladium spp., Moniliella acetoabutans, Mortierella spp., Mucor spp., Penicillium spp., Zygosporium masonii*) in literature are described as widely spread environmental contaminants (Kwon-Chung et al., 1992; Кузнецов, 2001; Саттон et al., 2001).

Acremoniella atra were characterised by white cottony colonies. Macromorphologically, one brown conidium on each of the conidiophores was seen. The conidia had a thick, smooth membrane.

From the members of *Cladosporium spp.* in cereals C. *herbarum* and *C. sphaerospermum* were found. *Cladosporium herbarum* had an olive-black colony. The conidiophores were segmented and pigmented, but the conidia were brown, elliptical with a rounded end. The third member of *Cladosporium spp.* - *C. bantianum* - was isolated from offal and redy-mixed feed. *C. bantianum* was isolated also from the kidneys, however, morphologically it was different. *C. bantianum,* found in the mink feedstuffs, colonies had a tree-like conidial structure. The conidia and conidiophores were dark.

Also, *Coremiella cubispora* colonies were black, but very small and solid. It was observed that the characteristic dark square-shaped arthroconidia were changing with colourless cells.

The fungi, found in meal and cereals, were also isolated from the ready-mixed mink feed with the exception of *Acremoniella atra, Alternaria spp., Coremiella cubispora, Crysonilia sitophila,* and *Zygosporium spp.*

The obtained results show evidence that *Aspergillus spp., Aureobasidium pullulans, Candida spp., Chaetomium spp., Cladosporium spp., Curvularia spp., Fusarium spp., Moniliella spp., Mortierella spp., Mucor spp.,* and *Penicillium spp.* were not inactivated during the thermal processing at + 90 °C. So, this research confirms the data, reported by Kuznecov (Кузнецов, 2001), that the fungal spores can survive high environmental temperature.

During this experiment, the fungi of *Aspergillus spp., Candida spp., Cladosporium bantianum, Penicillium spp., Sporothrix cyanescens, Stemphylium spp., Trichophyton terrestre, Zygosporium masonii,* and *Wangiella spp.* were found in the pig meat offal, which confirms the possibility, similarly to Kuznecov's (Кузнецов, 2001) data, of slaughtering to be contaminated with fungi.

Aspergillus spp. and *Penicillium spp.* fungi were found in the fish offal used on the farm. There are no literature data about the above mentioned fungi presence in fish offal, although researchers (Перельдик et al., 1981) have pointed out that contamination with *Aspergillus spp.* and *Penicillium spp.* is possible due to dissatisfactory hygienic conditions of premises and equipment when products get into contact with contaminated surfaces. Whereas Moeller reports on fish contamination with the fungi of *Wangiella spp.* (Moeller, 2006) which was not confirmed by this study.

Among all types of microscopic fungi found as the result of this investigation (see Tables 1 and 2), 39 % consisted of *Dematiaceous* group fungi (*Alternaria spp., Aureobasidium pullulans, Chaetomium spp., Cladosporium spp., Curvularia spp., Fonsecaea spp., Scedosporium spp., Stemphylium spp., Zygosporium spp., Wangiella spp.*) (Ulloa et al., 2000; Kwon-Chung et al., 1992). The common feature of these fungi is the presence of melanin in the cell wall. Other researchers (Жданова et al., 1990) have proved that the presence of melanin pigment affects essentially endurance of these cells against the influence of environmental moisture, temperature and radiation of the sun as well as provides vitality in the surroundings with insufficient amount of nutrients. In addition, when in a body, the dark pigmented microscopic fungi containing melanin has an increased endurance against the body immunity protective factors. It is possible that one of the reasons why in 42 % of cases exactly *Dematiaceous* group fungi were isolated from the mink parenchymatous organs during this investigation.

Conclusions

1. The microscopic fungi such as *Fusarium spp., Aspergillus spp., Aureobasidium pullulans, Sporothrix cyanescens, Mucor spp., Penicillium spp., Chaetomium spp., Trichophyton terrestre, Mortierella spp., Candida spp., Cladosporium spp., Curvularia spp., Wangiella spp., Moniliella spp.*, and *Stemphylium spp.* were found in the ready-mixed mink feed, as obviously the conventional

thermal processing of animal feed at the temperature + 90 °C is unsufficient to inactivate agents causing mycoses.

2. In the mink lung specimens the following fungi were found: *Aspergillus spp., Penicilium spp., Candida spp.*, *Conidiobolus coronatus, Fonsecaea pedrosoi,*and *Mucor spp.*; in the liver specimens there were *Actinomyces israelli, Arthrographis kalrae, Aspergillus spp., Aureobasidium pullulans, Chaetomium spp., Cladosporium sphaerospermum, Emmonsia spp., Penicilium spp., Candida spp.*, *Scedosporium prolificans, Sporothrix cyanescens,* and *Wangiella spp.*, but in the kidney specimens *Acremonium spp., Aspergillus spp, Candida spp.*, *Cladosporium bantianu, Curvularia spp.,* and *Geotrichum candidum* were isolated.

3. The obtained results show evidence that there could be a link between the spread of mycological agents in the mink feed and their presence in the mink parenchimatous organs.

References

1. Bridson E. (1993) The oxoid vade-mecum of microbiology, Pub. by Unipath Ltd, Basingstoke, pp. 85–128.
2. Carter G.R., Chengappa M.M. (1993) Microbial diseases. A veterinarian's guide to laboratory diagnosis, Iowa State Press, Ames, 293 pp.
3. Carter G.R., Wise D.J. (2004) Essentials of veterinary bacteriology and mycology, Iowa State Press, Ames, 276 pp.
4. Jepsen O.R., Poulsen F.S., Jorgensen G. (1981) Collection of blood, sedation and anaesthesia in mink. Nordisk veterinaermedicin, Suppl.1, pp. 9-13.
5. Juokslahti T. (1978) Bacteriological quality of ready-mixed mink feed in Finland. Acta veterinaria scandinavica. V.19 (4), pp. 520-534.
6. Juokslahti T. (1979) Bacteriological quality of raw materials used in Finnish mink feed. Acta veterinaria scandinavica. V.20 (4), pp. 562-571.
7. Kwon-Chung K.J., Bennett J.E. (1992) Medical mycology. Lea & Febiger, Philadelphia, 826 pp.
8. Larone D.H. (1995) Medically important fungi. A guide to identification. Third ed., ASM Press, Vashington, 261 pp.
9. Moeller Jr.R.B. (2006) Fungal diseases of fish: http://www.aquaworldnet.com/dbws/mycotic.htm – accessed on 17.02.2006.
10. Quinn P.J., Carter M.E., Markey B.K., Carter G.R. (1994) Clinical veterinary microbiology, Wolfe Pub., London, pp. 368–375.
11. Ulloa M., Hanlin R.T. (2000) Illustrated Dictionary of Mycology. APS Press, St. Paul, Minnesota, 445 pp.
12. Емельянов А.В. (1990) Оценка и отбор быков-производителей на устойчивость к болезням (Assessment and selection of breeder bulls in relationship with endurance toward diseases). Диссертация на соискание ученой степени доктора сельскохозяйственных наук. Сигулда, pp. 16-262. (in Russian).
13. Кириленко Т.С. (1997) Атлас родов почвенных грибов (Atlas of soil fungi). Наукова лумка, Киев, 122 po. (in Russian).
14. Кузнецов А.Ф. (2001) Ветеринарная микология (Veterinary mycology). Лань, Санкт-Петербург, 410 pp. (in Russian).
15. Перельдик Н.Щ., Милованов Л.В., Ерин А.Т. (1981) Кормление пушных зверей (Feeding of fur-bearing animals). Колос, Москва, 305 pp. (in Russian).
16. Саркисов А.Х., Капустин В.Ф., Квашнина Е.С., Королева В.П. (1953) Атлас грибов патогенных для сельскохозяйственных животных и птиц (Atlas of pathogenic fungi concerning agricultural animals and birds). Государственное издательство с-хозяйственной литературы, Москва, 158 pp. (in Russian).
17. Саттон Д., Фотергилл А., Ринальди М. (2001) Определитель патогенных и условно патогенных грибов (Guid to clinically significant fungi). Мир, Москва, 454 pp. (in Russian).
18. Спесивцева, Н. А. (1964) Микозы и микотоксикозы (Mycoses and mycotoxicoses). Колос, Москва, pp. 3–473 (in Russian).
19. Жданова Н.Н., Василевская А.И. (1990) Таксономическая значимость некоторых хемотаксономических признаков у почвенных меланинсодержащих микромицетов (Taxonomic significance of certain chemototaxonomic characters in soil melanin-containing micromycetes). Тезисы докладов I Всесоюзного совещания, Киев, 16-18 мая 1990 г., pp. 23-26. (in Russian).

FOREST SCIENCES

FOREST CLEAR-CUT MAPPING IN LATVIAN AND ESTONIAN BOUNDARY AREA WITH LANDSAT THEMATIC MAPPER SATTELITE IMAGES

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Abstract

The most obvious application of satellite images in forestry is identifying forested areas and generating forest maps with particular emphasis on identifying temporarily non-forested areas and mapping forest clear-cuts. The aim of this paper was to investigate the influence of attributes, describing forest clear-cut patch size, patch shape, and habitat conditions on classification results and map forest clear-cuts in Latvian and Estonian boundary area. The satellite images used were medium spatial resolution Landsat Thematic Mapper satellite images made in plain snow cover conditions in late winter. The boundary area was represented by Alūksne region in Latvia and by Võru county in Estonia. Clear-cut areas as changed areas in forests were discerned from non-changed areas with image differencing method that has proved itself as one of the most often used methods in land use and land cover change detection.
Key words: remote sensing, forest change detection, clear-cuts.

Introduction

Remote sensing generally means a process of collecting information about an object or phenomenon without a direct contact with it. One of the most important tasks of remote sensing is monitoring of the environmental changes. Causes of these changes can be natural as well as anthropogenic, or may be a combination of the two (Mas, 1999; Coppin et al., 2004; Lunetta et al., 2004). The most acute land use and land cover changes are commonly associated with human land-use activities. In forested areas the most remarkable change caused by human activity is forest clear-cutting. Mapping of forest clear-cuts has proved to be one of the most effective applications of satellite images in natural resources monitoring (Cohen et al., 1998; Holmgren et al., 1998; Song et al., 2003).

Many change detection methods have been developed to detect changes for the certain time period with remote sensing data. Pairwise image comparison methods have been a more widely used technique in change detection studies. According to the literature the most often-used change detection method, which also gives the most accurate results, is an image differencing method (Coppin et al., 2004). It involves subtracting one date of imagery from a second date that has been precisely registered to the first. This would result in a dataset in which positive and negative values represent areas of change and values close to zero represent no change.

This study had two main objectives. The first aim of the study was to investigate the influence of attributes, describing clear-cut patch size, patch shape, and habitat conditions on classification results of medium spatial resolution Landsat Thematic Mapper (TM) winter satellite images. The second aim was to map forest clear-cut areas in Latvian and Estonian boundary area with Landsat TM images using image differencing method.

Materials and Methods

The study area chosen for this work is located in a boundary area between Latvia and Estonia. Alūksne region represents the boundary area in Latvia and Võru county represents the boundary area in Estonia (Fig. 1).

Alūksne region is situated in the Northeast of Latvia. The total area of Alūksne region is 2243 km^2 and forests cover 57.1% of the region area (Alūksne rajons, 2006). The total national area of forests for Latvia is 2.9 million hectares. State-owned forests cover 50%, privately owned forests - 43% and forests of other ownership - 7% of the total forested area (LVM, 2006).

Võru county is situated in the Southeast of Estonia. The total area of Võru county is 2305 km^2 and forests cover 50% of the county area (Võru maakond, 2006). Almost half of Estonian land area or 2.2 million hectares is covered with forest. Nearly half (40%) of Estonian forests belong to the Estonian state (RMK, 2006). The average rate of clear-cutting observed throughout Estonia during the past 10 years is approximately 1% of forested area per annum (Ministry of the Environment, 2006).

The images used were medium spatial resolution Landsat TM winter images. The three satellite images used were from March 11, 1993, March 19, 1996 and February 24, 2005 with pixel resolution 30 m on ground. Winter in boreal and hemi-boreal latitudes is the season with the greatest target to background contrast on predominantly two-class images composed of forest and non-forest classes. Thus

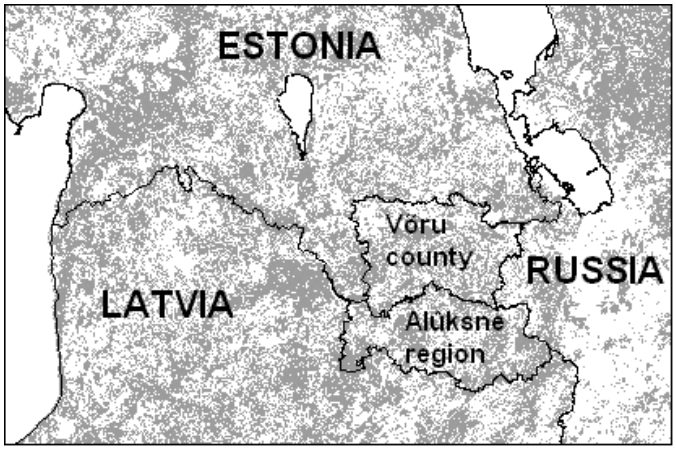

Figure 1. The study area: Alūksne region in Latvia and Võru county in Estonia. (The forest map derived from Landsat Thematic Mapper satellite images is used as a background). (Peterson, 2003).

the classification accuracy in discerning forest and non-forest is higher when using winter images.

Supplementary to the satellite images the Estonian Basic Map and the respective Basic Map orthophotos in scale 1:10 000 covering the area of Võru county were used for satellite image registration and clear-cut boundary verification. Latvian Base Map in scale 1:50 000 was used for image registration.

The data set derived from the longer time interval covered by the satellite images, from 1996 till 2005, was used to investigate the influence of clear-cut attributes on classification results. The data set derived from the shorter time interval covered by the satellite images, from 1993 till 1996, was used for clear-cut mapping in the Latvian and Estonian boundary area.

Spatial analysis and image processing of satellite images was performed with geographic information system software packages: Idrisi Kilimanjaro, MapInfo Professional, and CartaLinx.

Clear-cut detection in state-owned forests was performed using forestry database data and vector format forest stand maps of Antsla, Misso, Roosa, and Võru state forest districts in Estonia.

Forestry database records and stand boundaries were considered as the reference data set. Satellite image classification was aimed to match with high thematic and locational accuracy the reference data set.

Image differencing method that involves subtracting an earlier date image from a later date image was used for detecting clear-cuts (Fig. 2). Images were transformed to the same brightness scale before subtraction. The images were adjusted to compensate for differences in solar illumination and atmospheric transparency conditions at different dates of image acquisition.

The statistical analysis for the investigation of attributes describing clear-cut patch size, patch shape and habitat conditions on classification results of clear-cut area determination was performed with Võru forest district database in Estonia. A set of forest clear-cut attributes was derived from the database and from satellite images. The attribute CLEAR-CUT AREA - 'clear-cut area in the forestry database' - was considered the true value representing a clear-cut area. This true value was used to derive another attribute AREA DIFFERENCE - 'the relative difference of a clear-cut area classified from a satellite image to the area represented in the forestry database'. The mean brightness of clear-cut pixels in a difference image represents an attribute MEAN BRIGHTNESS - 'the arithmetical mean of clear-cut patch pixel values on the difference image'. The attributes FOREST BOUNDARY - 'the relative boundary length of a clear-cut patch with forest' and CONIFEROUS BOUNDARY - 'the relative boundary length of a clear-cut patch with coniferous forest' describe the neighbours of the clear-cut patches. The attribute CLEAR-CUT AGE - 'the age of a clear-cut' - represents the time in years passed since clear-cut logging till the acquisition of the second image of the image pair. The attribute CLEAR-CUT SHAPE - 'clear-cut area to perimeter ratio' - is denoted to describe the shape of clear-cut patches. While the two satellite images in the image pair have been acquired several years apart, one clear-cut patch in the respective difference image may contain more than one adjoining clear-cuts cut in different years. Therefore a categorical attribute MANY NEIGHBOURS - 'a patch of one or several cut blocks' - describes whether a clear-cut patch is cut in one single year or the patch is formed of adjoining clear-cuts logged in different years. The attribute HABITAT TYPE - 'habitat type group' - depicts the site conditions for forest regeneration; nomenclature follows Paal (1997).

The evaluation of the effect of forest clear-cut param-

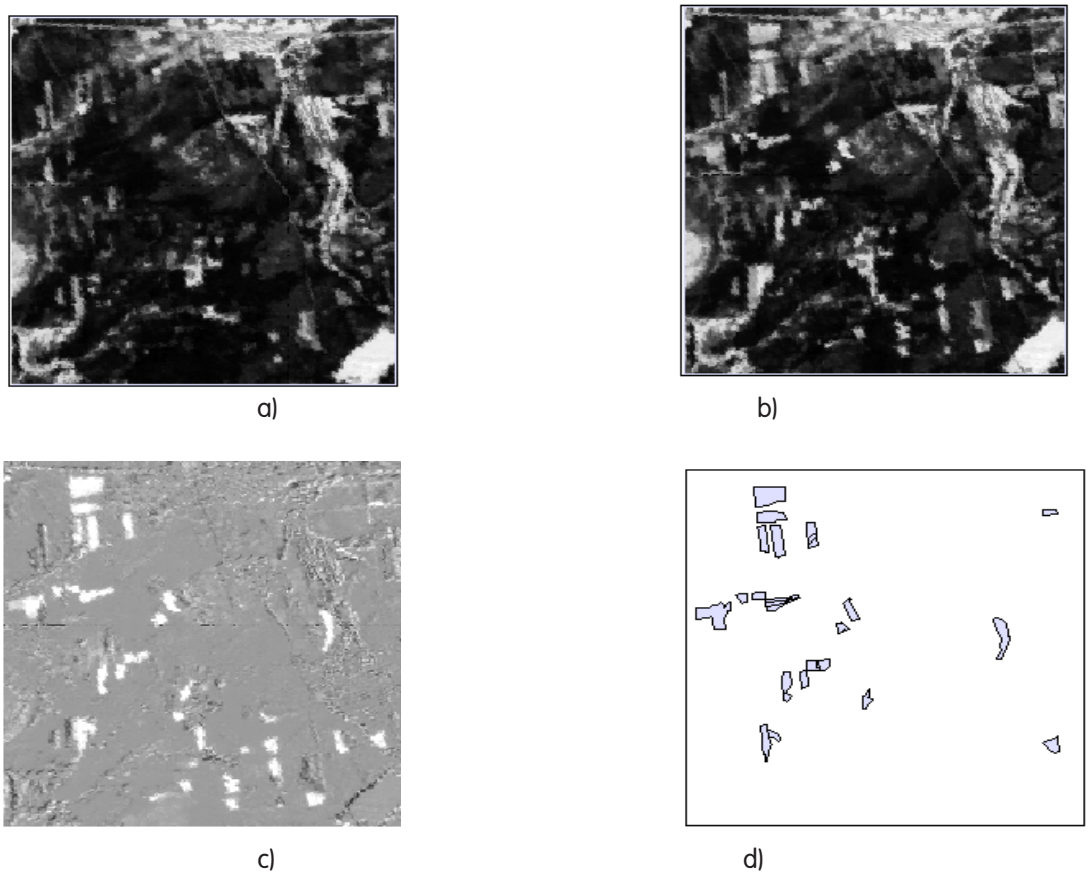

Figure 2. Image differencing was used for clear-cut detection. Two images, an earlier date image a) (here 1993 image, a subset is shown) and a later date image b) (here 1996 image) were used in the image differencing. Bright patches on the difference image c) represent areas of significant change, mostly clear-cuts from 1993 till 1996. The difference image is classified into two classes: clear-cuts and areas of no change to match the reference data set of forestry database clear-cuts, d).

eters on the relative difference of a clear-cut area classified from a satellite image to the area represented in the forestry database was performed using regression analysis. The statistical treatment was performed with SAS package (2002).

Clear-cuts in the Latvian and Estonian boundary area were defined from the difference image as significantly changed areas. Changes were considered significant if they exceeded some threshold value. The threshold value was initially defined from frequency distribution of difference image pixels values for subsets of the satellite image area - for each forest district. The threshold value was defined to match the total area of clear-cuts classified from the satellite image to the total area of clear-cuts in a forest district cut from 1993 till 1996. With the respective threshold value averaged over subset areas, the difference image was classified into two classes: class 0 denoting the areas of no-change representing pixel values lower than the threshold value, and class 1 denoting areas of significant change - clear-cuts in forests having pixel values higher than the threshold value in the difference image.

The commission errors of 'false clear-cuts' were removed with post-classification image treatment. A minimum area threshold was set for significantly changed patches to be recognized as clear-cuts. The decision rules found appropriate in Võru county were applied also to Alūksne region in Latvia.

Results and Discussion

A forest clear-cut map of Latvian and Estonian boundary area representing clear-cut activity from 1993 till 1996 was created as the result of spatial analysis of Landsat TM satellite images. Alūksne region represented the Latvian side and Võru county represented the Estonian side in the boundary area.

The total area of clear-cuts classified in the Võru county area was 1144 ha, of which 1039 ha was cut in state-owned forests and 105 ha in private-owned forests during this relatively short time interval. The average cutting rate was 0.5% per annum of the total state-owned forest area and 0.07% per annum of the private-owned forest area in Võru county. During the observed period forest clear cutting was concentrated mainly into state-owned forests.

Table 1

The results of multiple regression analysis of the effect of forest clear-cut parameters on clear-cut patch area determination from a satellite image

Attribute	Estimate	P-value
intercept	-0.0661	0.4980
clear-cut area*[1]	-0.0212	0.0606
mean brightness [2]	-0.0087	< 0.0001
forest boundary [3]	0.3761	< 0.0001
coniferous boundary [4]	0.0990	0.0108
clear-cut age [5]	0.0032	0.4405
clear-cut shape [6]	0.1736	0.0104
many neighbours [7]	0.0211	0.5622
dry boreal forest type	-0.0194	0.6584
fresh boreo-nemoral forest type	0.0330	0.5406
fresh boreal forest type	-0.0386	0.4061
drained peatland forest type	0.0093	0.8443
Adjusted R-square	0.3958	
Standard Error	0.1786	
Model significance probability	< 0.0001	

[1] clear-cut area - clear-cut area in the forestry database;
[2] mean brightness - the arithmetical mean of clear-cut patch pixel values on the difference image;
[3] forest boundary - the relative boundary length of a clear-cut patch with forest;
[4] coniferous boundary - the relative boundary length of a clear-cut patch with coniferous forest;
[5] clear-cut age - the age of clear-cut, represents the time in years passed since clear-cut logging till the acquisition of the second image in the image pair;
[6] clear-cut shape - clear-cut area to perimeter ratio;
[7] many neighbours - a patch of one or several cut blocks, describes whether a clear-cut patch is cut in one single year or the patch is formed of adjoining clear-cuts logged in different years.

The total area of clear-cuts classified in the Alūksne region area for the time period from 1993 till 1996 was 3130 ha. The average cutting rate was 0.8% per annum of the total forest area in Alūksne region.

The results of the statistical analysis of the influence of clear-cut patch attributes on classification results of clear-cut area determination are presented in Table 1.

A statistically significant linear relation exists between AREA DIFFERENCE ('the relative difference of a clear-cut area classified from a satellite image to the area represented in the forestry database') and attributes describing clear-cut patch size, patch shape and habitat conditions (model significance probability is close to zero). The regression model describes almost 40% of the relative difference in a clear-cut patch area determination from medium resolution satellite images compared to the patch area in the forestry database (adjusted R-square is 0.39). This is a quite common result when forestry database data are used to explain radiance differences measured from satellite images. The results of the analysis show that on the average it is possible to predict the area of a single clear-cut with an accuracy of one fifth to one sixth of the respective database value in the case when the attribute values are known (standard error is 0.17). The results of the statistical analyses show also that the strongest influence on classification results have the mean brightness of the clear-cut area in the difference image and the relative boundary length of a clear-cut patch with forest (p-value is close to zero). Minor influences have the factors 'the relative boundary length with coniferous forest' and 'clear-cut area to perimeter ratio' (p-value is 0.01). The average age of clear-cut (i.e. years passed since clear-cut logging) and habitat type group showed no statistically significant influence on classification results (p-value exceeds 0.05).

The influence of the factor MEAN BRIGHTNESS – ('the arithmetical mean of the pixel values of a clear-cut on the difference image') on AREA DIFFERENCE ('the relative difference of a clear-cut area classified from a satellite image to the area represented in the forestry database') is demonstrated in Figure 3. For better visual representation the clear-cuts are divided into three size groups: small, average, and large clear-cuts. This grouping was done according to the 0.25- and 0.75-quantile values in the frequency distribution.

The regression line shows a decreasing trend. The factors AREA DIFFERENCE and MEAN BRIGHTNESS have an inverse relationship. This means that in case when the total area of classified clear-cuts is matched to the total area

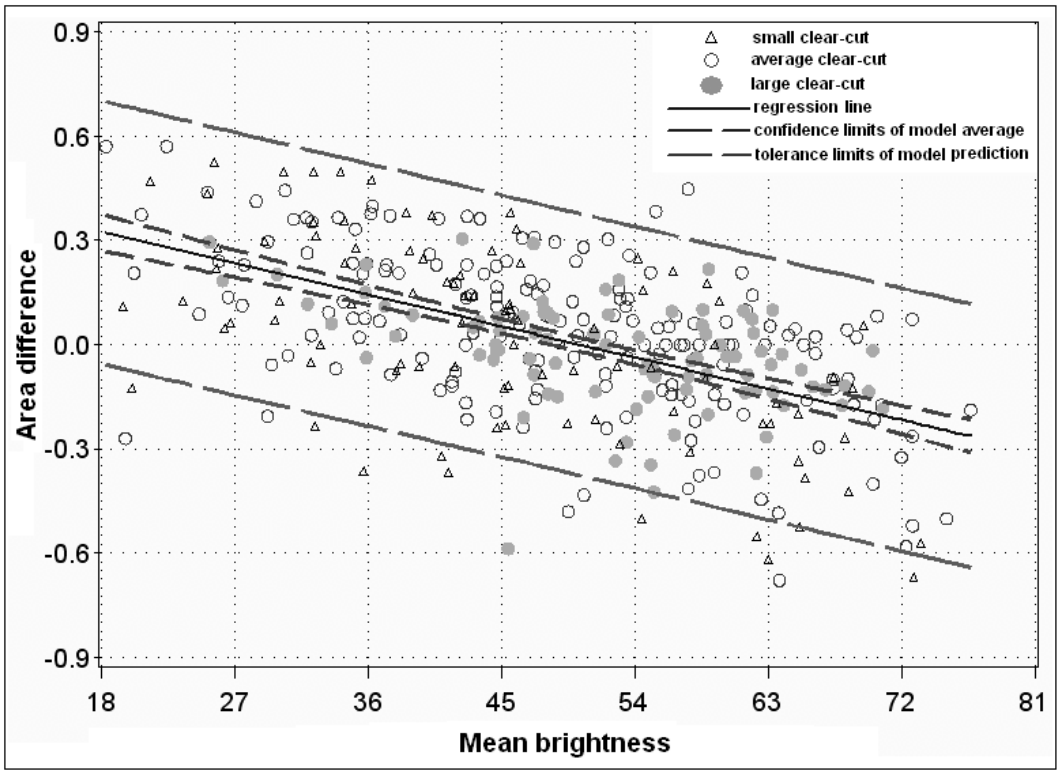

Figure 3. A pairwise relationship between MEAN BRIGHTNESS and AREA DIFFERENCE.

of clear-cuts in the database the area of brighter clear-cuts in the difference image is underestimated and the area of darker clear-cuts is overestimated.

Conclusions

The statistical analysis was performed with a data set derived from a medium resolution Landsat TM difference image. The data set represented forest clear-cuts that were compared to the same clear-cuts in the forestry database. The results showed that the image classification results are influenced by clear-cut attributes describing the mean brightness of clear-cut patch pixels on the difference image, the relative boundary length of a clear-cut patch with forest, the relative boundary length of a clear-cut patch with coniferous forest and an attribute describing the clear-cut shape e.g. clear-cut area to perimeter ratio.

A map of forest clear-cuts in the Latvian and Estonian boundary area for the time period from 1993 till 1996 was created and an estimate for clear-cut area in the neighbouring regions was derived.

References

1. Alūksnes rajons (Alūksne region). (2006) Vispārīgā informācija. Available at: http://www.aluksne.lv/rajons/visp_info.htm 03.05.2006 (in Latvian).
2. Cohen W.B., Fiorella M., Gray J., Helmer E., Anderson K. (1998) An efficient and accurate method for mapping forest clearcuts in the Pacific Northwest using Landsat imagery. Photogrammetric Engineering and Remote Sensing, vol. 64, no. 4, pp. 293–300.
3. Coppin P., Jonckheere I., Nackaerts K., Muys B., Lambin E. (2004) Digital change detection methods in ecosystem monitoring: a review. International Journal of Remote Sensing, vol. 25, no. 9, pp. 1565–1596.
4. Holmgren P. and Thuresson T. (1998) Satellite remote sensing for forestry planning – a review. Scandinavian Journal of Forest Research, 13, pp. 90–100.
5. Lunetta R.S., Johnson D.M., Lyon J.G, Crotwell J. (2004) Impacts of imagery temporal frequency on land-cover change detection monitoring. Remote Sensing of Environment, 89, pp. 444–454.
6. LVM (Latvijas Valsts Meži). (2006) Forest resources. Available at: http://www.lvm.lv/eng/our_forests/ 03.05.2006
7. Mas J.F. (1999) Monitoring land-cover changes: a comparison of change detection techniques. International Journal of Remote Sensing, vol. 20, no. 1, pp. 139–152.
8. Ministry of the Environment (Keskkonnaministeerium). (2006) Aastaraamat Mets 2005 (Forest Yearbook 2005). Keskkonnaministeerium, Metsakaitse- ja Uuenduskeskus, Tartu, pp. 50–64. (in Estonian).
9. Paal J. (1997) Eesti taimkatte kasvukohatüüpide klassifikatsioon (Classification of Estonian vegetation site types). Keskkonnaministeeriumi Info- ja Tehnokeskus, Tallinn, 297 pp. (in Estonian).

10. Peterson U. (2003) Forest mapping for Eastern Baltic region with Landsat Thematic Mapper winter images. In Research for Rural Development. Conference Proceedings, Jelgava, Latvia, pp. 189–192.
11. RMK. (2006) State Forest Management Center. Available at: http://www.rmk.ee/pages.php3/0201, 03.05.2006
12. SAS Institute Inc. (2002) SAS/STAT User's guide, Version 9.1. SAS Institute Inc., Cary, NC.
13. Song C. and Woodcock C.E. (2003) Monitoring forest succession with multitemporal Landsat images: factors of uncertainty. IEEE Transactions on Geoscience and Remote Sensing, vol. 41. No. 11, pp. 2557–2567.
14. Võru maakond (Võru county). (2006) Arvud ja faktid. Available at: http://www.werro.ee/stat/index.html, 03.05.2006 (in Estonian).

CHANGE OF FOREST LAND USE – PROBLEMS, LOSSES, VALUES

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Abstract

Forests and possibilities for forest land use have always played a very significant role in Latvia, gathering important experience in the course of time that can be analysed and used to improve the existing laws and regulations on the basis of the acquired results. The territory is characterised by a high percentage of forest coverage and its potential to increase up to two thirds of the terrestrial area of the country. In the current economic, social and ecological situation it is important to provide a scientific explanation for the future fluctuations of forest resources balance due to natural and artificial transformation of lands – what is discussed in this article.
Key words: natural forest, values of natural forest environment, change of land-use type.

Introduction

Considering the high percentage of forest coverage in the country – 45.0% (Latvijas zemes balance, 2005), very often in order to advance the rural development, the need arises to change the forest land-use type or to transform the current land-use type into another types, e.g. construction, building of roads, watercourses and quarries, and for other purposes. However, most often the designed plans in rural areas fail to materialise because the state has set very strict restrictions on land transformation – a complicated process for obtaining a permit and a high price for elimination of 'natural forest environment' due to transformation.

Neither the Latvian Forest Law, nor other regulations, nor explanatory dictionaries give a complete explanation and definition of 'natural forest environment'. Natural is pristine, primary, produced by nature, basically not human-affected, intact. Latvia's forests are semi-natural because they all are more or less affected by human-induced actions. Along with the elimination of the forest, the forest environment and its values are also destroyed, therefore it is very important to define – which of these values are so significant that their disappearance would incur substantial losses to the community in general and would entitle the state to require compensation. The discussion of these questions and development of methodology for calculation of losses is the aim of this paper.

Materials and Methods

Natural or 'primary' forests have natural forest environment with its inherent structural elements. As a result of transformation, the forest is eliminated. Forest environment is destroyed along with the elimination of a forest, but natural forest environment is destroyed along with the elimination of a natural forest – i.e. natural processes in a forest stand, irrespective of its stage of development, are disturbed as a result of human-induced actions to such a state that they cannot regenerate themselves to the previous level, thus the balance between a specific substance, material, biological organism, entirety of living creatures, which is characterised by mutual interaction of the elements of this entirety and the interaction of various separate entireties, is disturbed, the natural composition of tree species and features of development are modified, what leads to an artificial creation of a new ecosystem that does not comply with the definition of a natural forest.

Referring to the agreement of international organisations on principles of defining natural forests, in our country national parks and forests within the area of restricted-access zones of specially protected territories and micro-reserves with the area of 20,000 ha, i.e. % of the total forest coverage (UN-ECE/FAO Temperate and Boreal forest resources assesment, 2000) correspond to that description. Any kind of land transformation is prohibited in the largest part of these territories, however, in the light of the fact that there might be exceptions – based on a one-time decision by the Cabinet of Ministers – the amount of losses to be compensated for elimination of natural forest environment should be determined, and as large as appropriate, because it implies particularly high responsibility to the community.

The entirety of various forest products and qualities make up the value of forest environment. The literature provides different principles of grouping and distinguishing these values, e.g. division of basic functions of the forest into four large groups: regulation of biosphere processes; preservation of biological diversity; generation of biomass and social functions (Saliņš, 2002). The forest has an invaluable ecological value as it helps preserve the diversity of nature. The forest is a natural habitat for many populations of plants and it gives shelter and protects flora and fauna that cannot develop in clearings. The forest plays a very important role in climate regulation, in stabilisation of the balance between oxygen and carbon dioxide in the atmosphere, in purification of the air from dust and other harmful additions. The forest provides a healthy environment for humans and preconditions for agricultural production. The forest also fulfils serious social, hygienic, recreational and cultural heritage functions. It is very difficult to

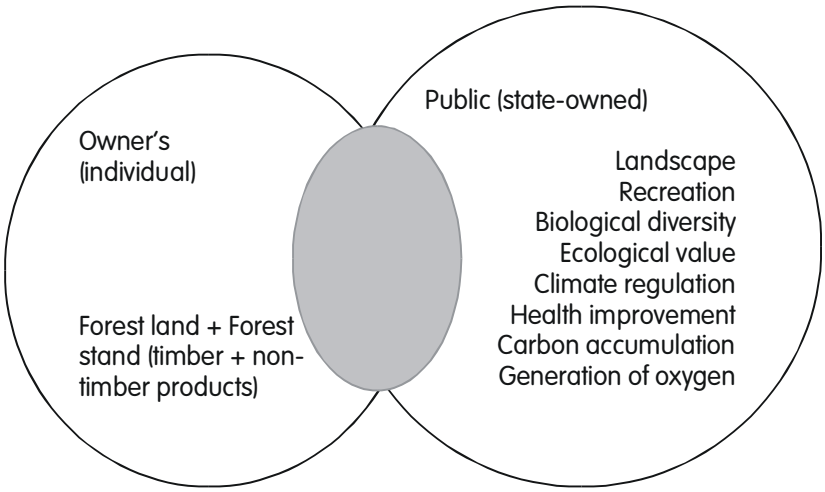

Figure 1. Division of forest values according to the types of interests.

establish unequivocally what are these values that would have to be compensated. For instance, for one forest owner a forest stand would be valuable due to its timber-producing qualities, someone else would perceive it as a security guarantee for the future, others like to walk in the forest and breathe their 'own' oxygen or pick up berries and mushrooms, while some other owners may perceive their forest as a burden because it is a specially protected nature object that they possess – do not possess (Figure 1). In my opinion, the interests of the community are defined by means of laws and regulations, thus, there are specially protected nature territories designated in Latvia irrespective of their ownership type where there are various prohibitions and restrictions set on economic activities. Thus, the economic activities are restricted on 25% of the entire territory of state-owned forest lands and in the remaining forests restrictions apply to 14% of the territory. The complete prohibition of forest management activities in state-owned forests is applied to 5.5% and in the remaining forests – to 0.2% of the area (Statistika par aizsargājamajām teritorijām, 2005).

On 25 January 2005 the State Land Policy Co-ordination Board was established under the guidance of the Ministry of Justice. The ministry was assigned with a task to include 11 organisations in the Co-ordination Board, i.e. Ministry of Defence, Ministry of Economics, Ministry of Finance, Ministry of Transport, Ministry of Environment, Ministry of Agriculture, Ministry of Regional Development and Municipal Affairs as well as the State Land Service. All these involved institutions have common tasks aimed at development of regulatory acts on land policy and policy planning documents and encouragement of research and efficient application of the acquired results in design of the State's land policy (Valsts zems politikas koordinācijas padomes nolikums, 2005). So far new regulations or political decisions have not been made. The prospective types of land use have not been assessed and there is no single model for future development of Latvia's land resources. Until now only a pilot project of the Land Policy developed in 2003 under the guidance of the State Land Service, which defined the basic guidelines for the Common Land Policy and included main tasks and action lines along with the policy results and their performance figures (Saliņš, 2002), has been publicly available. This document emphasises that the Land Policy within the framework of the State's policy focuses on economic growth, social justice and political stability. The Land Policy includes all aspects of land-use and associated processes ensuring access to practical benefits from land resources while observing safety requirements set by the State and reconciling the interests of the State, community and landowners. The land is treated as a resource and a subject to ownership.

The aim of the Land Policy is to create political, legal, social and economic provisions in order to secure immovable properties established as a result of reforms and increase their value that would at the same time encourage preservation of land and other resources, their sustainable use and increase of the yield (Vienotas zemes politikas pamatnostādnes, 2003).

To achieve the set aims a number of preconditions must be observed, starting with the provision that all landowners must be entitled to equal rights and obligations – in line with the Forest Law. Not less important is the requirement to facilitate the diversifying of rural economy and improvement of the living standard of rural communities introducing various activities that would lead to more thorough use of lands while preserving the valuable agricultural and forest lands of national importance. I would like to

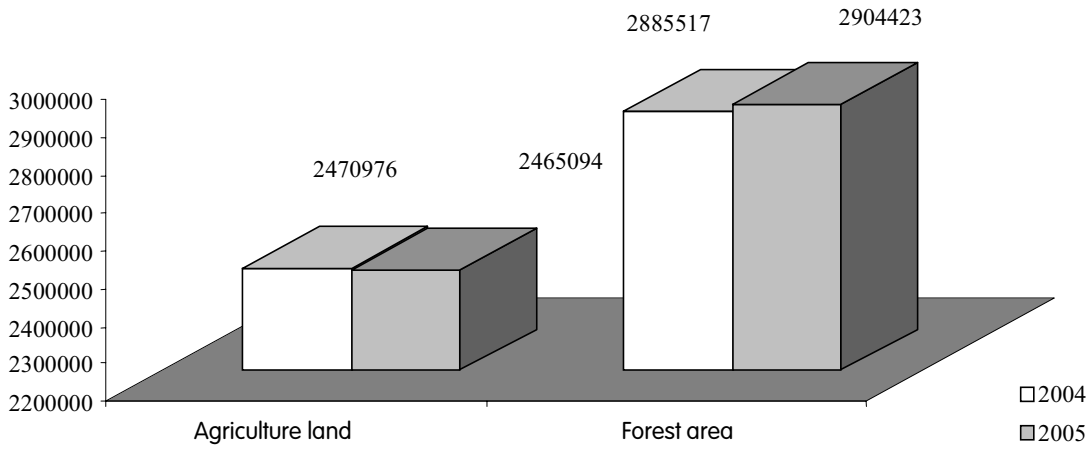

Figure 2. Changes in area of agricultural and forest lands.

underline the role of municipalities in the design of territorial planning and economically feasible utilisation of the existing territory, setting a purpose of use for each immovable property.

Over the last century not only the forest landscape but also Latvia's natural rural landscape has changed (Lauksaimniecības zemju apmežošana, 2004) due to the increase of forest coverage – natural overgrowing of agricultural lands as well as artificial afforestation. According to the latest data of Latvia's land balance, forests cover 45% of the territory, agricultural lands – 38.2%. Analysing the changes which occurred last year in a more detailed way, it can be concluded that the area of agricultural lands diminished by 5,900 ha but the area of forest lands increased by 18,900 ha (Figure 2) (Vienotas zemes politikas pamatnostādnes, 2003). The forest has been artificially planted in the area of two thousand hectares (Meža ieaudzēšana, 2005).

About 0.5 million ha (18%) of agricultural lands are not used for agricultural purposes (Neizmantotās lauksaimniecības zemes apskats, 1999). The neglected areas overgrow with weeds and shrubs, they lose fertility and their landscape value. The natural transformation of agricultural lands increases – they overgrow, turn into swamps. The estimates of the Latvian State Institute of Agrarian Economics show that it is necessary to utilise about 1-1.2 million ha of agricultural lands (i.e. approx. the half of the existing total area) in order to ensure the production of food products for domestic consumption as well as to meet the EU quota for agricultural products (Vienotas zemes politikas pamatnostādnes, 2003). It means that it is necessary to find a solution for rational utilisation of the rest of the agricultural lands.

So that not to diminish the importance of the forest in preservation of environment and its particular role in national economy, the aim was set in Latvia's forest policy (Latvijas mežu politika, 1999) – to prevent the diminishing of the existing forest land area through the application of restrictions on transformation of forest lands. To achieve this aim, under the Forest Law (Meža likums, 2000) the Regulations of the Cabinet of Ministers (Meža zemes transformācijas noteikumi, 2004) have been adopted laying down provisions for forest land transformation and the procedure for obtaining a permit for forest land transformation as well as the procedure for calculation and compensation of state-incurred losses due to transformation. Nothing shows that the area of forest lands decreases due to transformation (Figure 2), it is just the opposite. Every year this balance is positive.

In order to implement the provisions of the forest policy, it is prohibited to transform forest lands in a number of specially protected nature territories and micro-reserves. Thus, the basic requirements of the forest policy are already being implemented.

Also comparing human activities it can be concluded that people are more interested in forest planting than in elimination of forest environment (Figure 3). The State support policy plays a very important role here along with the high price for transformation of forest land. Irrespective of that there are no substantiated studies giving evidence of malicious acts or intentions of landowners where the obtaining of a permit serves as pretence for ill-intentioned elimination of the forest.

So that to get a clearer idea about possible losses caused by the prospective transformation, we must follow the tendencies. In the beginning it is essential to identify the size of the area transformed every year – in what territories and for what purposes. Not less important are studies about the level of knowledge of forest owners about forest management and nature protection issues. We are interested in data acquired after the adoption of the Forest Law therefore the results of the last five years are analysed.

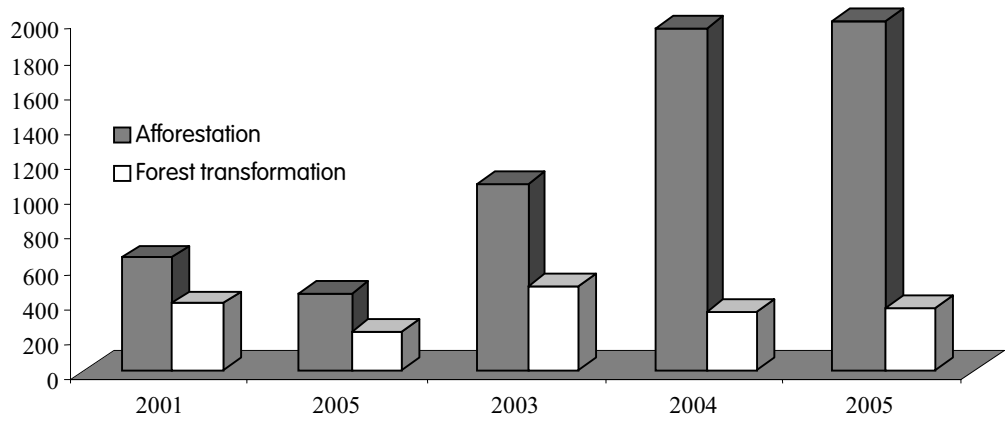

Figure 3. The number of transformations on agricultural and forest lands.

Thus, since the adoption of these regulations, the number of issued transformation permits has doubled, yet the area basically does not increase in size (Figure 4). The rise in the number of issued permits is insignificant in comparison with the growing increase of losses to be compensated to the State in order to carry out some of the projects in the forest owner's property. Consequently, the implementation of various projects is limited and the economic development is impeded. Thus, the estimated losses in 2001 because of the elimination of natural forest environment constituted LVL 383, and in 2005 – LVL 4,006 on average per one hectare.

The large number of transformations performed for construction purposes as well as unsubstantiated transformation of forest lands into agricultural lands. Analysing the purposes of transformation in a more detailed way it has to be concluded (Figures 5 and 6) that on average the construction on agricultural lands is carried out on ten times larger areas than on forest lands, besides, forests are planted more than eliminated. Thus, the previously expressed concerns are not substantiated. According to the experts, by annulment of the large payments for forest transformation, the number of permits obtained for construction would increase, yet not the area, calculating per one case. It can be explained by the fact that very often, also today, people request a construction permit for a much larger area but fell trees and eliminate forest environment only as much as it is needed for the real construction of structures and buildings. There is a tendency to build a house in the forest or near the forest but not in the open space. Obviously, it is a serious matter of taste.

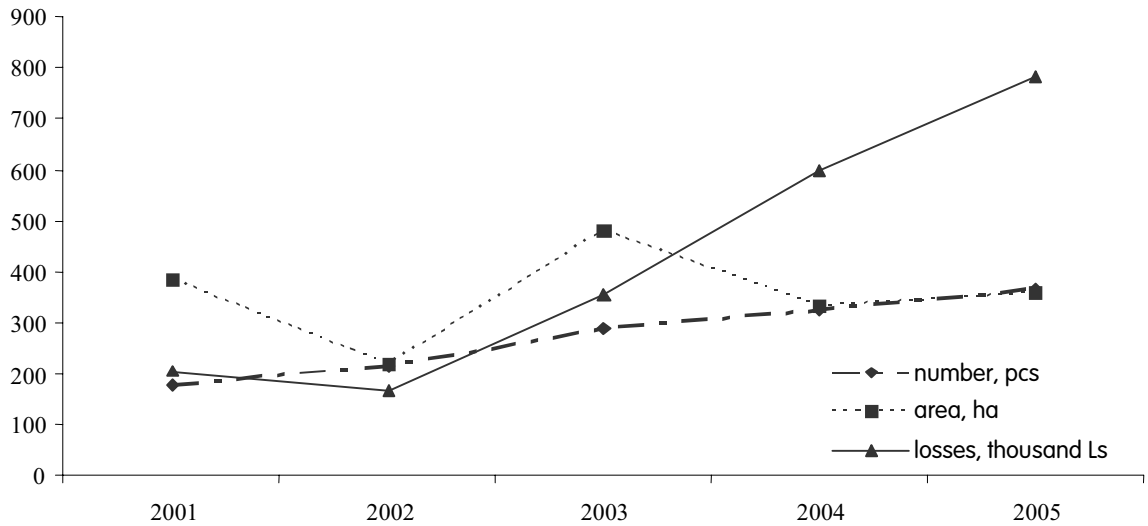

Figure 4. The number of issued forest land transformation permits, area, losses, 2001-2005.

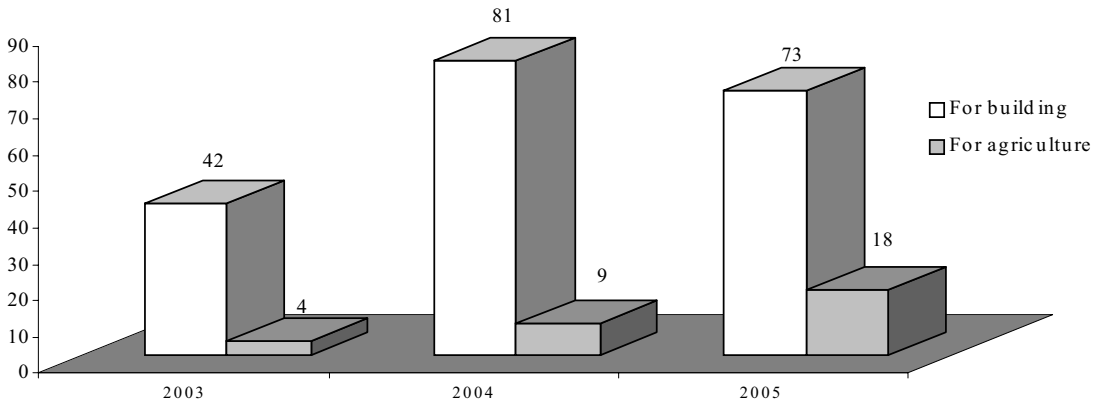

Figure 5. The number of issued transformation permits for forest lands.

Results and Discussion

Referring to the above analysed statistical data and studies, it can be concluded that people most often afforest former agricultural lands as well as build farms or private houses on agricultural lands. The most demanded forest lands for construction are situated in Riga region where the area of one building plot is considerably smaller than on agricultural lands. Quarries cover the largest transformed areas on forest lands as their appearance is directly related to the real elimination of forest lands and utilisation of subterranean depths. Forest areas increase in size more rapidly than they decrease due to transformation; it is related both to natural forest regeneration and implementation of forest plantation projects. The state also carries out special training and educational programmes to educate forest owners. Every year the number of duly regenerated areas increases, though mostly because of natural regeneration, however, owners are getting accustomed to the fact that a forest growing cycle does not end with the harvesting, and a certain 'full stop' can be put only when the harvested plot is counted into the forest covered area. Although it only superficially characterises the attitude to their property of the present forest owners, certain improvements and change of the attitude in a positive direction can be observed.

In order to implement the provisions of the forest policy regarding the prevention of diminishing of forest areas, the forest plantation on former agricultural lands is being financially supported. To ensure compliance with the requirement for restrictions on transformation, it is prohibited to transform forest lands in some of the specially protected nature territories and micro-reserves. In this way the requirements of the forest policy are met and it is important to revise other existing norms that have become obsolete as according to Solvita Āboltiņa, Minister for Justice – 'the State is for people, and not people for the State'. Thus, it would be possible to arrange the data of both State Land Service and State Forest Service what would in turn facilitate the attraction

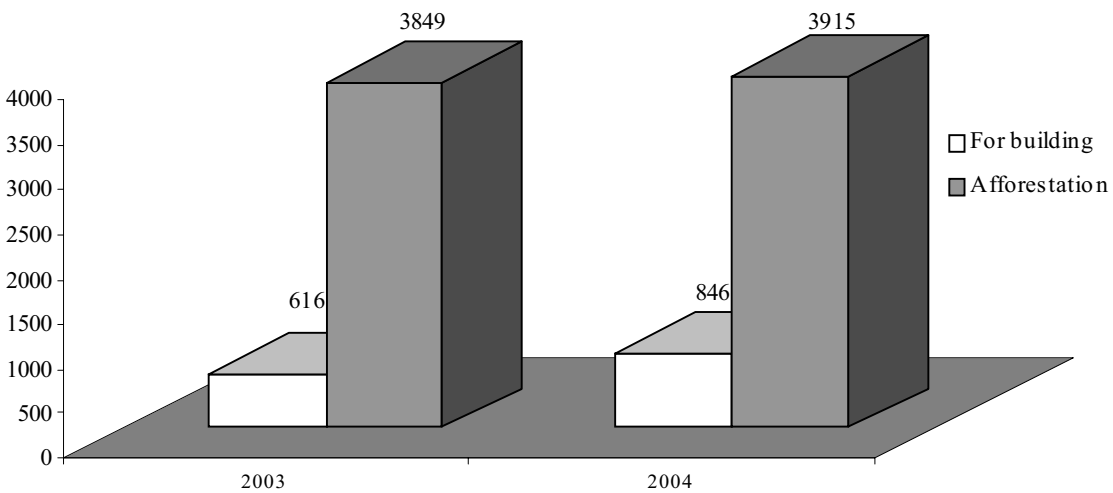

Figure 6. The number of issued transformation permits for agricultural lands.

of investments and economic growth in the rural areas and would give the owners larger freedom of action to manage their properties in the best possible way, as it is in other EU states. After coming into force of each new law or regulation the community needs an 'adaptation' period. During this time people try to understand its essence, adjust to the new regulation and think about the necessity and consequences of their actions.

Recommendations for calculation of state-incurred loses.

1. Losses for elimination of natural forest environment must be compensated only in natural forests. As natural forests are limited access zones of specially protected nature territories and micro-reserves where transformation is prohibited, but in practice there are exceptions – if the transformation is accepted by the decision of the Cabinet of Ministers then regardless of the purposes and conditions of the transformation, the losses must be estimated and compensated. In other cases no damages or losses must be estimated and compensated, one must pay only for obtaining a transformation permit according to the price list of appropriate institutions.

2. Losses for elimination of natural forest environment must be compensated only in natural forests. Although natural forests are limited access zones of specially protected nature territories where transformation is prohibited, in practice there are exceptions - if they are accepted by the decision of the Cabinet of Ministers. The Cabinet of Ministers has so far accepted only those projects where special easements can be applied, i.e. the losses are not to be compensated to the state because of the significance of the project to the community. Consequently, it should be assessed whether to maintain valid the existing easements for special transformation purposes and conditions or not. In other cases – in semi-natural forests the compensation has to be paid to the state for the incurred losses due to the transformation but not for the elimination of natural forest environment. In this process the state loses an area of forest land therefore a performer of transformation must compensate the future losses incurred to the state, i.e. the sum that would cover costs of transformation of agricultural lands into forest lands and planting of forests, adding the costs of seedlings, planting, and tending for the first three years. It complies with the current requirements owing to the subsidies for afforestation of agricultural lands. This way the state can channel money to the special budget, which is used for issue of investments and subsidies – for afforestation of agricultural lands.

If the initiator of transformation is not the owner of the land, he/she agrees on the amount and form of compensation with the owner of the land assuming third party liability. In other cases landowners have a right to choose freely for what purposes they want to use their forest property unless there are other restrictions on economic activities for this particular property due to its special status (nature protection or territories of national or international significance), and if it does not contradict the territorial planning. There might be a provision that forest lands may be transformed into another land-use type if the property historically consists only of this forest land and as such it has not been created artificially – separating or dividing forest land a year prior to the coming into force of this regulation. A year is a sufficient time period because of the usual procedure of development and adoption of regulations of the Cabinet of Ministers in the Republic of Latvia. In such case before obtaining a permit for forest land transformation, a special utilisation plan for a forest land must be developed, which would include digital maps with a descriptive substantiation part. Owing to the digital map it could be easily, and what is most important – electronically, processed in all state institutions. It could be compared with the municipal, regional, detail and territorial planning. It would ensure an easy assessment whether the transformed territory merges into the landscape, and whether it belongs to some of the special zones or protected territories.

In this case the obtaining of a transformation permit would still be a time-consuming and complicated process that would retain its serious nature and the initiator of the transformation will be obliged to consider the necessity and usefulness of transformation. The transformation permit will have to be issued together with the construction licence, contrary to the existing practice when the construction licence is issued prior to the transformation, then the building is constructed, and after several years it turns out that the land-use type was not changed and the transformation permit was not obtained.

3. According to a similar issuing scheme of transformation permits, an appropriate sum will have to be paid for transformation of semi-natural forests in line with the draft of the Regulations of the Cabinet of Ministers No.VSS-1885 TA-417 developed by the Ministry of Environment. This method of calculation is based on the assessment of assortment yield of each forest stand and the expected income after the final cut in each concrete case, and the total market value of assortments is estimated, then the costs of forest regeneration, tending are subtracted from this amount. These sums should be paid into the special budget, which is intended for payment of such compensations. Thus, the inaccuracies related to the calculation principle of the relative values of one hectare could be avoided not only in the appendices of the existing transformation regulations but also the problem of lack of money necessary for the payment of compensations could be solved.

4. The performer of transformation may choose – to

compensate the losses or to set up a new specially protected nature territory (SPNT) or micro-reserve – 'victim of transformation' or other. The elaborated 'transformation plan' should include 'the object of change' which would be excluded from the economic activities and where all requirements applicable to the limited access territories of the SPNT would be observed – i.e. economic activities will never be performed there in future. This forest stand must be as similar to the transformed area as possible, considering all results and elements of the survey. Thus, natural forest environment may appear after a prolonged period of human inactivity.

Conclusions

- During last five years the area of forest lands increases more rapidly than it decreases
- The area of neglected agricultural lands increases but the Latvian land policy has not yet been adopted
- Agricultural lands are transformed for construction purposes more often than forest lands
- The level of forest owners' education and awareness increases every year
- The procedure for obtaining of transformation permits must be complicated, but the procedure for calculation of losses must be simplified
- The current amounts of losses to be paid must be reduced
- The paid money must be directed to special budgets that are intended for provision of subsidies, investments, state aid and compensations to forest owners

References

1. Latvijas mežu politika (Latvian Forest Policy). (1999) VMD, - Rīga, 1999, 16 pp. (in Latvian).
2. Latvijas zemes bilance (Latvia's Land Balance). (2005) VZD, Available at: http://www.vzd.gov.lv/index.php?s=7&sub=165&rec=384, 09.03.2006. (in Latvian).
3. Lauksaimniecības zemju apmežošana (Afforestation of Agricultural Lands). (2004) WWF Pasaules dabas fonds Latvijas programma. – Rīga: WWF, 29 pp. (in Latvian).
4. Meža ieaudzēšana (Aforestation of agricultural land). (2005) VMD, Available at: http://www.vmd.gov.lv/?sadala=146, 09.03.06. (in Latvian).
5. Meža likums (Forest Law). (2000) Latvijas Vēstnesis. Nr.98/99. 13.03.2000. (in Latvian).
6. Meža zemes transformācijas noteikumi (Regulations on Forest Land Transformation). (2004) MK noteikumi Nr.806 Latvijas Vēstnesis, (in Latvian).
7. Neizmantotās lauksaimniecības zemes apskats (Survey of Neglected Agricultural Lands). (1999), VZD, Available at: http://www.vzd.gov.lv., 09.03.06. (in Latvian).
8. Saliņš Z. (2002) Mežs – Latvijas nacionālā bagātība (Forest- Latvia's national wealth). – Jelgavas tipogrāfija, 35. pp. (in Latvian).
9. Statistika par aizsargājamajām teritorijām (Statistics on Protected Territories) (2005) VMD, Available at: http://www.vmd.gov.lv/?sadala=296, 09.03.06. (in Latvian).
10. UN-ECE/FAO Temperate and Boreal forest resources assesment 2000. Terms and definitions, (2000) European communities, Roma
11. Valsts zems politikas koordinācijas padomes nolikums (By-law of the State Land Policy Co-ordination Board). (2005) MK noteikumi Nr.71, TM, Latvijas Vēstnesis, 25.01.2005 (in Latvian).
12. Vienotas zemes politikas pamatnostādnes (Guidelines of Common Land Policy). (2003), VZD, Rīga, 23 pp. (in Latvian).

INVESTIGATIONS OF GREY ALDER (*ALNUS INCANA* (L.) MOENCH) BIOMASS

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Abstract

In the time of the decrease of global fossil resources storage wood, pulp has an increasing importance as a heat energy source. In Latvia, grey alder stands occupy 189.9 thousand ha with a total growing stock of 31.1 mil. m^3. So far in most of cases grey alder is estimated as a low value tree species, because tree dimensions do not to allow obtain a significant proportion of timber quality wood. The increasing fuel shortage has caused the need for growing gray alder as a bio energy supply. Grey alder has not been analyzed intensive until now, therefore the aim of the investigation is to estimate the stand productivity and or above ground biomass; that could serve as a background for recommendations to establish grey alder stands for energy-wood production.

Grey alder biomass is dependent on wood density, but density – on wood moisture. The average newly felled grey alder wood density in April is 0.76 ± 0.011 g cm^{-3}, but absolutely dry wood density for trees felled in October, the average value of absolutely dry wood is 0.46 ± 0.005 g cm^{-3}, which is 1% more than in the spring, but these relationships are not significant Relative moisture demonstrates water content in newly felled wood. Its average value is 54.7 ± 0.5% in April and 53.5 ± 0.5% in October.

Empirical formulae are worked out for absolutely dry stem and branch biomass dependent on stem diameter.

Key words: grey alder, stand, stem volume, biomass.

Introduction

Grey alder *Alnus incana* (L.) Moench stands in Latvia take up to 6.9% or 189.9 thousand ha from the total forest area (Meža statistika, 2005). In the last 15 years, increasing areas are left for natural regeneration. These areas are frequently regenerated by grey alder. From the perspective of energy wood production, it is important to develop the methods for estimation of above ground biomass. That is one of the purposes of this investigation.

In Latvia there are optimal conditions for grey alder, that's why they are widely spread. Grey alder regeneration is successful both with seeds and root or stump shoots. The occurrence of grey alder in a number of forest types gives evidence that it can adapt to different soil conditions. Grey alder can grow in clay, sandy-clay and peat also in alluvial soils close to rivers. In fertile moraine clay and alluvial soils, it builds up the I – II yield class closed stands with high productivity (Avotiņš, 1962). Grey alder stands in rich deciduous forest type *Aegopodiosa* are highly productive. To grow theses stands can be an additional target of forest management (Bušs, 1981). Grey alder that a grove in low fertility, sandy soils often is in the form of bushes, not a single-stem tree (Kundziņš, 1937). Shoots from the grey alder stumps form coppice forests.

Coppice forests are an old form of forest management. Using shoots, wood production is faster when the area is regenerated from seeds. There are no high requirements for wood quality in this form of forest management (Kundziņš, 1937). Grey alder needs to be grown in pure stands due to their short rotation. Admixture with other tree species cannot increase the stand productivity, but only creates difficulties in thinning and use. Grey alder management is of low cost, simple, and safe (Mangalis, 2004).

In coppice forests grey alder reaches the dimensions suitable for fuel-wood at the age of 10-15 years. In this period 100 m^3 of fuel-wood can be obtained from one ha. It is not useful to continue to grow the stand up to 30 years, since the wood volume increment is lessening (Bušs, 1996). At the age of 25 years, grey alder yield can be more than 200 m^3 ha^{-1}. Other tree species require 3-4 times longer period to reach the same volume. The previously specified final cutting (rotation) age for grey alder is 31 year, which is a considerably shorter period than for other tree species (Lange, et al., 1978). In fertile soils (stand yield class I) trees can reach even 26 m in height and 30 cm in diameter. Yield increment at the age of 20 years: 10 m^3 ha^{-1} (Mūrnieks, 1963).

Birch and grey alder or above ground biomass increment lines are of the same shape; however, they are displaced in time. If several aphacelous trees are excluded, in the birch stand at the age of 15 years and in the grey alder stand at the age of 10 years the above ground biomass reaches 40 t ha^{-1}. For both species up to the age of 30-35 years, branches and foliage make up relatively small portion compared to all or above ground biomass. Only after this age, depending on the shape of the crown, differences appear in the total tree or above ground biomass.

The annual stem increment for both species is quite similar. In stands older than 10 years it is 4.5-7.6 t ha^{-1} a year. The biomass of branches is a bit smaller in grey alder stands due to faster natural pruning.

After the age of 10 years, annual biomass increment in birch stands is from 0.25 to 0.70 t ha^{-1} $year^{-1}$, but in grey alder stands - from 0.45 to 1.7 t ha^{-1} $year^{-1}$.

The highest differences are between the birch and grey alder stands, and annual foliage biomass. In stands of

both species up to the age of 10 years there is approximately an equal annual foliage biomass (2.4 - 2.5 t ha^{-1} year) produced. With increasing age the annual birch foliage biomass increases. In birch stands it may reach up to 3.38 t ha^{-1} per year and in grey alder stands – 2.98 t ha^{-1} per year. In investigations of the ecosystem of birch and grey alder stands they may be considered to be similar in biomass and wood annual increment (Utkins, Guļbe et al., 2005).

Grey alder biomass is dependent on wood density, but density – on wood moisture. Air-dry timber density (moisture 15%) is different among tree species. Alder wood belongs to a light wood group with a density of 0.40-0.50 g cm^{-3}. To this group also belong the aspen, pine, spruce, lime and willow wood. Stem wood density sometimes is higher in parts of the tree crown (Vaņins, 1950). Absolutely dry wood density for trees felled in April is not dependent on the height at which the stem sample is taken and it is 0.43 g cm^{-3}, which is in accordance with literature (Vaņins, 1950).

Grey alder wood according to its heating ability (megajoules from kg of weight – MJ kg^{-1}), in comparison with other Latvian tree species, is in the third place after Norway spruce and Scots pine wood. Wood of coniferous trees has resin, which contains high proportion of hydrogen, that's why the heating ability of coniferous trees is higher. Heating ability for pine is 20.59 MJ kg^{-1}, for spruce – 20.31 MJ kg^{-1}, for grey alder – 20.05 MJ kg^{-1}, for oak – 19.87 MJ kg^{-1}, and for birch – 19.64 MJ kg^{-1} (Dolacis et al., 1999).

The aim of the research:

- to determine newly felled and absolutely dry wood density;
- to measure relative moisture % for freshly cut wood;
- to determine proportion dry substance for newly felled grey alder;
- to work out formulae for calculation of dry grey alder biomass.

Materials and Methods

Material for the investigation was collected in 2005 in Zemgale.

For analysis of stem volume and biomass, 111 sample trees were cut in the stage when there was no foliage in April and October. At the same time, the stem and branch weight (kg) was measured in naturally dry conditions. The length of the sample trees was from 1.55 to 17.06 m and the 1.3 m height diameter - from 0.2 to 14.8 cm (Sarma, 1949).

At the 1.3 m height and the height of ¼, ½ and ¾ from the total length of the stem, samples (cross cut discs) were taken. From these samples (2 from each disc), the wood density in naturally fresh and dry wood was measured. Wood density was measured for 19 trees in April and for 15 trees in October.

Grey alder biomass depends on wood density, but the latter – on the wood moisture.

The wood moisture is the relation between ground wood and volume; its unity of measure is g cm^{-3} or kg m^{-3}.

The formula for the calculation of wood relative moisture W_0:

$$W_0 = \frac{G_1 - G}{G_1} * 100, \qquad (1)$$

where

G_1 - damp wood weight;

G – absolutely dry wood weight.

Statistical data analyses were made according to generally recognized methods of biometry (Liepa, 1974; Arhipova, 2003).

Results and Discussion

Naturally fresh grey alder wood density

The average density of naturally fresh grey alder wood was 0.76 g cm^{-3}, which was obtained from various samples at different heights (Table 1). Average wood density from tree to tree varied from 0.67 g cm^{-3} to 0.85 g cm^{-3}, the

Table 1

Naturally fresh grey alder wood density, g cm^{-3}

Stems	Locality of disc cut from butt end				Average
	1.3	1/4	1/2	3/4	
average	0.72	0.74	0.78	0.80	0.76
s*	0.050	0.052	0.062	0.061	0.047
s_x*	0.011	0.012	0.014	0.015	0.011
s,%*	6.9	7.0	7.9	7.7	6.2

s – standard deviation; s_x – standard error; s% - ratio of variation

Table 2

Absolutely dry grey alder wood density for samples taken in October

Stems	Locality of disc cut from butt end				Average
	1/4	1.3	1/2	3/4	
Average	0.47	0.46	0.46	0.47	0.46
s	0.02	0.02	0.02	0.03	0.02
s, %	5.3	4.7	5.0	5.9	4.5
s_x	0.007	0.006	0.006	0.007	0.005

ratio of variation - 6.2%. In individual naturally fresh stem, wood density gradually increased from the height of 1.3 m to the top of the tree. The wood density ratio varied little among trees of diverse heights - from 6.9% to 7.9%.

There are significant differences between naturally fresh wood densities at different tree heights, for $F_{fakt} = 9.02 > F_{0.05} = 2.60$.

The smallest significant difference for comparison of gradation classes was found $\gamma_{0.05} = 0.036$. Wood density differences were not significant between the samples taken from 1.3 m height and ¼ of stem height. At ½ and ¾ of stem height wood was significantly denser.

Between wood density at 1.3 m height and ½ and ½ of the stem height a rather high correlation was found, which was characterized by the ratio determination of the regression slope R^2=0.59-0.60. Causation of wood density for samples taken from 1.3 m and ¾ of stem height was much weaker (R^2=0.34). It can be concluded that naturally fresh wood density in the crown part of the tree is more variable.

Absolutely dry wood density

For sample trees, which was cut in April, absolutely dry wood density at the height of 1.3 m was 0.42 g cm^{-3}, at ¼ from the tree height - 0.41 g cm^{-3}, at ½ 0.43 g cm^{-3}, and at ¾ at the 0.45 g cm^{-3}, but absolutely dry grey alder wood density in all samples taken from April was 0.43 g cm^{-3}.

The average of absolutely dry grey alder wood essentially was not affected by the place from where in the tree sample was taken (0.43 g cm^{-3}). The density of the tree gradually increases from bottom to top, but the differences were not significant. It was proven by the results of dispersion analysis: $F = 2.36 < F_{0.05} = 2.60$, but naturally fresh wood density depends on moisture content, which varies from tree to tree.

In order to increase the sample size for absolutely dry wood density evaluation, on October 15 different sized grey alders were felled (Table 2).

There were no wood density differences depending on where the stem sample was taken for grey alders felled in October. The average wood density was 0.46 g cm^{-3}. The wood density differences at diverse heights of trees were negligible – less than 1%. The density of individual trees varied and was unimportant; the standard deviation for the analyzed trait did not exceed 0.02-0.03, ratio of variation - 5.9%. Density differences among trees also were small – 0.42 - 0.49 g cm^{-3}.

Proportion of dry matter in stems of grey alder and wood moisture

In April, the average value of the proportion of dry biomass in stem of grey alder was 0.45, which means that the weight of one cubic meter of absolutely dry grey alder was 450 kg (Table 3). At different heights of trees there was no significant difference, which is confirmed by the average value of trait.

Among different trees the proportion of absolutely dry biomass had small variation, the differences between trees

Table 3

Proportion of dry biomass in grey alder stems in April

Stems	Locality of disc cut from butt end				Average
	1/4	1.3	1/2	3/4	
Average	0.45	0.46	0.46	0.46	0.45
s	0.02	0.02	0.02	0.03	0.02
s, %	3.7	4.2	4.2	5.9	4.0
s_x	0.004	0.005	0.005	0.009	0.005

Table 4

Proportion of dry biomass in grey alder stems in October

Stems	Locality of disc cut from butt end				Average
	1/4	1.3	1/2	3/4	
Average	0.47	0.46	0.46	0.47	0.46
s	0.02	0.02	0.02	0.03	0.02
s, %	5.3	4.7	5.0	5.9	4.5
s_x	0.007	0.006	0.006	0.007	0.005

were not significant, because $F = 0.023 < F_{0.05} = 1.75$.

In October, the proportion of absolutely dry biomass in grey alder stems was 0.46 (Table 4), which was 1% more than in the spring, however, these relationships did not prove significant.

Differences among trees were negligible, which was indicated by the standard deviation for trait – 0.02. The low value for the ratio of variation (4.5%) confirmed this conclusion.

Absolutely dry grey alder biomass

For estimation of grey alder biomass, a total of 111 trees with 1.3 m tree height in diameter of 0.2 to 14.8 cm were felled. All samples were subdivided into 2 parts – trees with an average height diameter less than 3 cm and more than 3 cm. It was impossible to work out empirical formula for both groups together because of the bend of the curve.

The proportion of fresh branch mass in total tree biomass varied from 1.6 to 32.5%, depending on the development of the tree crown, the number of branches, and the light conditions.

From the data, empirical formula for calculation of grey alder biomass was derived. Best suited was the second layer parabola (Figure 1).

Absolutely dry grey alder biomass (Y) depending on its average height diameter (up to 3 cm) (X) can be calculated according to formula (2):

$$Y = 0.1437x^2 - 0.1218x + 0.0769. \quad (2)$$

The determination ratio of the formula (1) is $R^2 = 0.976$, which means that the tree diameter explains 97.6% of the total dispersion of biomass. The equation is valid for young trees that were growing in forest stands, not on edges of the forest or the ditches.

Newly felled (fresh) grey alder with average height diameter of 13 - 15 cm is close to or even exceeds 100 kg.

Absolutely dry grey alder biomass is best described in Figure 2.

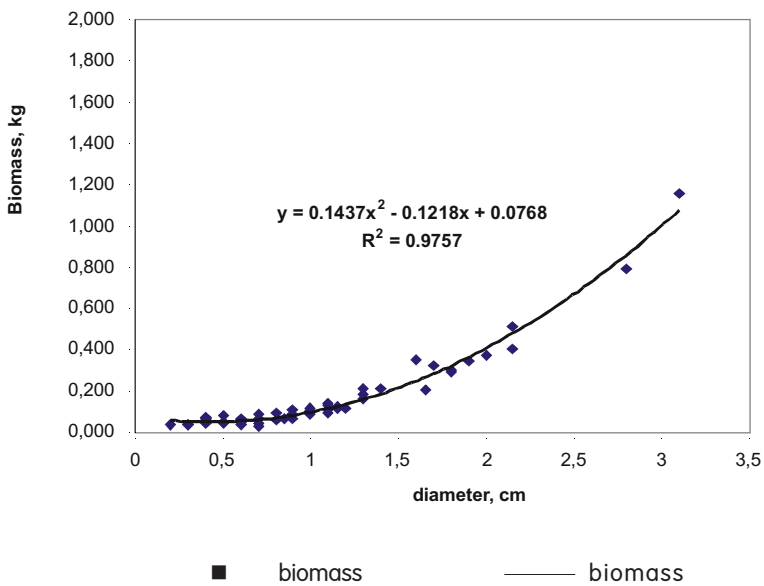

Figure 1. Absolutely dry grey alder biomass depending on its 1.3 m height (for trees up to 3 cm) diameter.

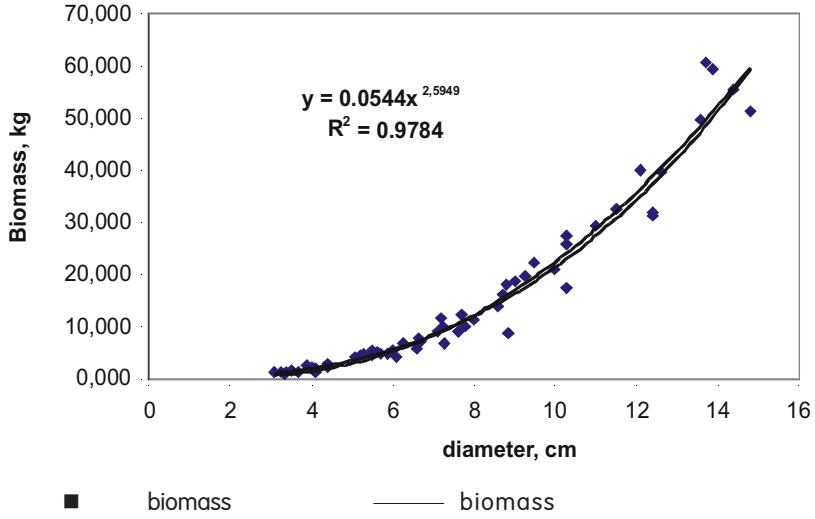

Figure 2. Absolutely dry grey alder biomass depending on its 1.3 m height (for tress over 3 cm) diameter.

Absolutely dry grey alder biomass (Y) depending on its average height diameter (for trees over 3 cm) (X) can be calculated according to formula (3):

$$Y = 0.0544x^{2.5949} \quad (3)$$

Conclusions

Newly felled (fresh) grey alder wood density in April was 0.76 ± 0.011 g cm^{-3}. Naturally fresh stem wood density in the tree crown was more variable. There were significant differences in wood density among samples taken from different heights of stem. From bottom to top of the tree, the wood density was gradually increasing, but difference end was not significant.

For trees felled in October, the average value of absolutely dry wood was 0.46 ± 0.005 g cm^{-3} which was 1% more than in the spring, but these relationships were not significant.

Relative moisture of the tree in April and October was almost equal – it differs only slightly more, than 1% but was insignificant. It is 54.7 ± 0.5 % in April and 53.5 ± 0.5 % in October.

Parabola (2) or the function of degree (3) can be used for the calculation of grey alder stem biomass depending on its stem diameter.

The cutting of grey alder after the vegetation period (the stage without foliage) ensures that organic matter stays in the forest, decays and releases nutrients necessary for growth of the next forest generation.

References

1. Arhipova I., Bāliņa S. (2003) Statistika ekonomikā (Statistic Ekonomics). Risinājumi ar SPSS un Mikrosoft Excel (Work with SPSS an Microsoft Excel). Datorzinību centrs, Rīga, 352 pp. (in Latvian).
2. Avotiņš A. (1962) Baltakšņu audzes, to izplatība un saimnieciskā nozīme (Grey Alder Stands, its Distribution and Economical Importance). Jaunākais Mežsaimniecībā, 3, pp. 30 – 46. (in Latvian).
3. Bušs K. (1981) Meža ekoloģija un tipoloģija (Forest Ecology and Typology). Zinātne, Rīga, pp. 29-30 (in Latvian).
4. Bušs M. (1996) Atvasāji un egļu mežs (Coppice and Norway Fire Forests). Sērijā Mežs – mans īpašums. Rīga, Lauku Avīze, pp. 5-25. (in Latvian).
5. Dolacis J., Hrols J. (2001) Par baltalkšņa un melnalkšņa koksnes fizikāli mehāniskajām īpašībām (About Mechanical Properties of Grey and black Alder Wood). II Pasaules latviešu zinātnieku kongress. Tēžu krājums, Rīga, LLU, 546 pp. (in Latvian).
6. Kundziņš A. (1937) Dažu faktoru ietekme uz baltalkšņa (Alnus incana Moench) veģetatīvo atjaunošanos (Influence of Some Factors). Rīga, MDI, 45 pp. (in Latvian).
7. Lange V., Mauriņš A., Zvirgzds A. (1978) Dendroloģija (Dendrology). Rīga, Zvaigzne, 304 pp. (in Latvian).
8. Liepa I. (1974) Biometrija (Biometry). Rīga, Zvaigzne, 335 pp. (in Latvian).
9. Mangalis I. (2004) Meža atjaunošana un ieaudzēšana (Forest Regeneration and of Forestation). Rīga, SIA "Et Cetera", 455 pp. (in Latvian).
10. Mūrnieks P. (1963) Baltalksnis (Grey alder. In Forestry Table). No: Sacenieks R., Matuzānis J. Mežsaimniecības tabulas. LVI, Rīga, pp. 112-113. (in Latvian).
11. Sarma P. (1949) Meža taksācija (Forest Inentory). Rīga, LVI, 485 pp. (in Latvian).
12. Vaņins S. (1950) Koksnes zinātne (Wood Science). Rīga, LVI, 464 pp. (in Latvian).
13. Valsts Meža dienests „Meža statistika 2005"(State Forest Service, 2005). CD:/lv/indexhtml (in Latvian).
14. Valsts Meža dienests „Meža statistika 2005"(Forest Statistic 2005).). CD:/lv/indexhtml (in Latvian).
15. Уткин А.И., Гульбе Я.И., Гульбе Т.А., Гульбе А.Я., Ермолова Л.С. (2005) Березняки и сероольшаники центра русской равнины - экотон между экосистемами хвойных пород и сельскохозяйственными угодьями (Birch and Grey Alder Forests in Ecotone between Coniferous Forest Ecosystems and Agricultural Lands in the Central Region of the Russian Plain). Лесоведение, № 4, с 49 - 66. (in Russian).

THE LICHENOINDICATIVE EVALUATION OF PINE NATURAL WOODLAND HABITATS

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Abstract

The main pine natural woodland habitats (woodland key habitats – WKH) and the importance of their management and monitoring have been described in this paper. The ecological importance of lichen epiphytes in forest ecosystem has been analysed. The lichenoflora and its percental cover features have been described. The exposition of lichen species depending on the cardinal points have been analysed. The paper presents the characteristics of ecological indicators of lichen in the landscape features. The lichenoindicative evaluation and comparison of pine WKH have been carried out.
Key words: lichens epiphytes, pine woodland key habitats, management of woodland habitats.

Introduction

As a result of the inventory of woodland key habitats (WKH) carried out in Latvia's state owned forests over the period of 1997-2002, 39,655 ha of WKH and 12,025 ha of potential woodland key habitats (PWKH) had been distinguished (Bērmanis, Ek, 2003). In order to preserve adequate conditions for special woodland habitat species, 6 % of WKH and 51% of PWKH require special management. In 2002, the joint–stock company 'Latvia's State Forests', State Forest Service and Östra Götland regional forest administration (Sweden) started the project 'Management of woodland key habitats in Latvia', whose main goals are to elaborate the most appropriate management types in WKH to preserve biological values and provide their effective protection in future. Simultaneously, monitoring has started in these areas, which reflects the condition of the environment concerning the living organisms there. The results of the monitoring make up a system of observation, control, analysis and forecasting, which gives information about the present environmental condition and possible changes in the future, as a result of the management (Donis et al., 2004; Bērmanis, 2006).

The pine WKH is a naturally regenerated stand, formed after storms and forest fires as well as a result of forest stand's gap disturbance processes. The most essential structure elements with a high potential of biological diversity in such forests are biologically old trees, decaying trees, naturally formed snags and also logs. The different ages, sizes, decomposition and degrees of moisture of the dead wood testify about the sustainability of the forest. It should be noted that the amount of biologically old trees and dead wood essentially depends on the previous management of the forest. In most cases the lack of dead wood in pine stands is attributed to the sanitary cuttings (Ek et al., 2002).

Because of natural peculiarities, a lot fewer WKH specialist and indicator species can be found in dry pine forests, compared to spruce forests. The main special woodland habitat species in pine ecosystems are insects (beetles) and those species which need light. On such occasions an important feature of pines is a rough, thick bark ('crocodile skin' bark) and thick branches, which are inhabited by rare and endangered beetle species (Johansson, 2005).

Nowadays in pine forests on dry soils and soils with a normal amount of moisture, a comparatively large number of spruces grow. Quite often the reason for that is the successful extinguishing of fire over a longer period of time. As a result of that, the spruces which are not so fire resistant, occupy more and more forest areas, where under natural conditions, pines would grow. Pines demand light and they are relatively fire resistant. In the forests, where most of biological diversity is connected with pine, and where the amount of the spread of spruce threatens the values of the biological diversity, the best management would be a partial cutting of spruce or imitation of a forest fire (prescribed fire). Only those spruces are to be preserved, which already sustain or will maintain certain biological values. The reduction of spruce admixture to the pine WKH is considered to be an experiment, the results of which will be possible to evaluate in a few years (Donis et al., 2004; Johansson, 2005).

Lichens are found in almost all terrestrial ecosystems, forming a significant biomas also in boreal coniferous forests. In forest ecosystems, lichen epiphyte communities have been studied comparatively little. These communities carry out nitrogen fixation and nutrient circulation functions (Pike, 1978; Will-Wolf et al., 2002). The lichen epiphytes make up microhabitats and nutrient basis for invertebrates. They also serve as nest building materials for birds and small animals (Will-Wolf et al., 2002). Lichen is a slow growing organism, having particular nutrition way and metabolism, which to a great extent depends on phytocenotic and ecological conditions in the stand (Somermaa, 1972). Lichens intercept and absorb precipitation

which contains different nutrients and pollution substances. Their development and growth depend on precipitation, air moisture, light, and potential evaporation (Will-Wolf et al., 2002). In the inventory of WKH, lichen is one of the groups of organisms, which is used to evaluate the biological diversity and forest continuity (Ek et al., 2002; Znotiņa, 2003). If over the last hundred year period mainly the correlation regularities of lichen and air pollution have been studied, then in the last decades considerable attention has been paid to the research of interdependence of lichen diversity and forest management (Nash et al., 1988). As a result of forest management, with the changes in the forest canopy, the changes take place also in the microclimate of the stand which has a direct influence on the lichen epiphyte communities and their development (McCune, 2000).

The aim of the research is to describe and evaluate the pine WKH from the lichoindicative point of view. In order to reach the goal, the following objectives have been set:

1) the epiphytic lichenflora and the analysis of its cover in percentage in pine WKH;

2) the description and analysis of dependence of lichen exposition on cardinal points;

3) the description of lichen ecological indicators.

Materials and Methods

In order to carry out the lichenoindicative analysis in pine stands, in 2005 four research sites were chosen with important proportion of spruce. One or two sample plot sections were made depending on the size or configuration of the sites, each section consisting of four 500 m^2 area circular sample plots. One sample plot section is envisaged for the woodland key habitat control part in the future, while the other is to be used for experimental or management part. Different management types are envisaged in the selected pine stands – the decrease of spruces and burning. Sample plots are arranged according to a definite scheme, which, if necessary, gives the opportunity to supplement the scheme up to 9 sample plots per section, which are located interdependently in a network of 30 m*30 m (Donis et al., 2004). The general description of the sites is shown in Table 1.

In all the sites the inventory of epiphytic lichens is made, using the line intercept method. In each sample plot, 3-4 pines and one spruce are selected randomly. In total, 76 pines and and 18 spruces have been measured. The lichen record for the selected trees has been done at two heights – 0.5 m and 1.5 m above the root collar. Both marks of height are fixed with screws on the northen side, which has been identified by a Suunto compass, in order to repeat the measurements at certain times and compare the changes. The trunks of the trees are girdled by bands on which all the lichen species, which touch the band and the distances in cm occupied by lichens, are marked. The precision is 0.1 cm in circumference. The record is made clockwise (N – E – S – W). In order to define more accurately the species of lichens, samples were collected to identify them under laboratory conditions. The conspectus of lichens in Latvia is used for the classification of lichen species (Piterāns, 2001). The bands with the field data information on lichen were measured and the data obtained were summarized in the tables. When summarizing the line occuppied by each lichen species in cm and dividing that by the perimeter of the trunk and then multiplying it by 100, the projective coverage of each species is obtained. After that, summarizing the data obtained on the sample trees, and dividing this figure by the number of studied trees, the average projective coverage for each lichen species in sample plot is obtained.

Table 1

The description of the research sites

Site code	State Head Forestry (SHF)	State Forestry (SF)	Compartment / subcompartment	Forest type	Stand composition	Average pine age in years	The number of measured trees (pine/ spruce)
13	Aizkraukle	Taurkalne	24./1.	Myrtillosa	7P2 E1B	162	12/4
16	Jēkabpils	Viesīte	360./ 2.,12.	Hylocomiosa	6P4E	156	16/8
17	Ventspils	Usma	58./ 27., 28.	Myrtillosa	8P2E	147	23/4
19	Jelgava	Garoza	40./ 6., 14.	Myrtillosa mel., Hylocomiosa	7P2E1B, 8P2E	143 163	25/2

In the preliminary processing of data, to determine the exposition of lichen species depending on the cardinal points and height, MS Excel 2003 program was used, calculating how many times in the course of 2 degrees (0 – 2; 2 – 4; etc.) the respective lichen species was found out in distribution by species (pine P, spruce E) and heights (0.5 and 1.5 m) in each site. If certain species in the classification group in total (site x tree species x measurement height) has been stated in more than 1000 stages, its number is reduced 2 or 3 times, choosing every second or third measurement from the range if number of observations exceeded 1000 and 2000 respectively. For further processing of the data, the circular data statistical analysis computer programme AXIS 1.1. (PISCES Conservation Ltd.) has been used. The mean direction has been calculated for each classification group and its 95% confidence interval, the mean resultant length and other statistical indicators (Fisher, 1993). The correspondence of the niche direction carried out by the species to the randomness has been verified, using The Rayleigh test for unspecified mean direction. The mutual comparison of objects has been done by means of GLM Univariate analysis (SPSS 12.01 GLM) method, using the total projective coverage and 'site *tree species* height' as classification group (Field, 2005). For the decrease of heterogenity of data variability, arcsin transformation has been used (Liepa, 1974; Krebs, 1999). The projective coverage of separate species is compared, using TWINSPAN and DECORANA analysis in computer programme CAP 3.1. (PISCES Conservation Ltd.) (Kent, Coker, 1999).

In all the research sites, using lichen species and their coverage in percentage on tree trunks in two heights, the ecological evaluation has been performed, using the following six indicators: light, temperature, continentality, moisture, reaction, and amount of nutrients (Wirth, 1992).

Results and Discussion

The analysis of epiphytic lichenflora and its percentile coverage in pine WKH.

A total of 13 lichen species, belonging to 12 genera were found in the research sites (Piterāns, 2001) (Table 2).

In all the sites the crustose lichen species *Lepraria incana* (L.) Ach. is present, constituting a significant proportion of coverage in percentage (Table 3).

Only on one tree and with small percentage of coverage proportion, there were found the lichen species *Parmeliopsis ambigua* (Wulfen) Nyl., *Pertusaria albescens* (Huds.) M.Choisy & Werner, *Ramalina farinacea* (L.) Ach. un *Scoliciosporum chlorococcum* (Grewe ex Stenh.) Vezda. Only in one site – 17 stand – there was found the WKH's indicator species *Lecanactis abietina* (Ach.) Körb. which can be found on spruces and which indicates high moisture content of the air and long-time continuity of the trees. Only in this site two other species are found on pines: *Cladonia squamosa* Hoffm. and *Hypocenomyce scalaris* (Ach.) M.Choisy.

The number of species on the trunk is shown in Table 4. The composition of lichens on the trunk is more homogenious than on the basis of the trunk: overall on the

Table 2

The lichen species found in pine woodland key habitats

No.	The lichen species	Morphological group	On pine	On spruce
1.	*Chaenotheca ferruginea* (Turner & Borrer) Mig.	K	*	*
2.	*Cladonia coniocraea* (Flörke) Spreng.	Kr	*	*
3.	*Cladonia squamosa* Hoffm.	Kr	*	–
4.	*Hypocenomyce scalaris* (Ach.) M.Choisy	K	*	–
5.	*Hypogymnia physodes* (L.) Nyl.	L	*	*
6.	*Lecanactis abietina* (Ach.) Körb.	K	–	*
7.	*Lepraria incana* (L.) Ach.	K	*	*
8.	*Micarea melaena* (Nyl.) Hedl.	K	*	*
9.	*Parmeliopsis ambigua* (Wulfen) Nyl.	L	*	–
10.	*Pertusaria albescens* (Huds.) M.Choisy & Werner	K	*	–
11.	*Platismatia glauca* (L.) W.L.Culb.&C.F.Culb.	L	*	*
12.	*Ramalina farinacea* (L.) Ach.	Kr	–	*
13.	*Scoliciosporum chlorococcum* (Grewe ex Stenh.) Vezda	K	*	–

Designations: K – crustose, L – foliose, Kr – fruticose lichens.

Table 3

The coverage of lichen species *Lepraria incana* (L.) Ach. in objects in percentage

Site code	State Head Forestry (SHF)	State Forestry (SF)	The coverage in percentage at the trunk height 0.5 m	The coverage in percentage at the trunk height 1.5 m
13	Aizkraukle	Taurkalne	42	25
16	Jēkabpils	Viesīte	49	35
17	Ventspils	Usma	31	22
19	Jelgava	Garoza	40	24
Average			40.5	26.5

pine and spruce trunks at the height of 0.5 cm, 13 lichen species have been found, but at the height of 1.5 m – 9 species.

There are controversial facts in literature about the connection between the lichen species and the tree species. Some authors consider that with the age the physical properties of the bark become more significant and similar (water absorbtion capacity and texture), while the specifics of the substratum correspond to certain ecological conditions (Somermaa, 1972; Uliczka et al., 1999; Lohmus, 2005). Thus, approximately in 60% of cases the lichen community is determined by the substratum factor and in 40% of cases by microclimate. Some authors have an opposite view – they hold that the lichen species and their amount are related to a definite species of trees. There are researches that indicate that lichen species are connected with definite forest growth types (Somermaa, 1972).

The mean numbers of lichen species by heights are the following: 6.75 species at 0.5 m and 4,5 species at 1.5 m height. The largest number of species on the trunk at the height of 0.5 m – 8 species – are found in site 16; whereas at the height of 1.5 m 7 species – are found in site 17. The fewest number of species on the trunk at the height of 0.5 m (5 species) and at the height of 1.5 m (3 species) are found in site 19, as well as at the height of 1.5 m – 3 species in site 13.

The coverage with lichen species on the trunk in percentage is shown in Table 4, too. Totally the lichens coverage in percentage is about twice higher at the spruce trunk height of 0.5 m and about three times higher at the spruce trunk height of 1.5 m than at the pine trunk. The average of the lichens coverage in percentage at the pine trunk height of 0.5 m is 44.3% but at the height of 1.5 m – lower – 24%; at the spruce trunk height of 0.5 m – 84.4%, but at the height of 1.5 m – slightly lower – 71.9%. The highest lichens coverage in percentage at the pine trunk height of 0.5 m is in site 16, on the spruce trunk – in site 19, but at the height 1.5 m respectively both on pine and on spruce trunk – in site 17. The lowest lichens coverage in percentage at the pine trunk height of 0.5 m is in site 19, at the spruce trunk height of 1.5 m – in site 16; at the height of 1.5 m respectively both on pine and on spruce trunk – in site 13.

Pine bark is flaky and peels off, therefore there are not much lichens on the upper part of the trunk (Znotiņa, 2003). On old pine trunks, lichen is usually found in the cracks between the flakes of the bark, which can be valued as

Table 4

The number of lichen species and coverage with lichens in percentage

Site code	The number of species at the trunk height 0.5 m	The number of species at the trunk height 1.5 m	The coverage in percentage at the pine trunk height 0.5 m	The coverage in percentage at the spruce trunk height 0.5 m	The coverage in percentage at the pine trunk height 1.5 m	The coverage in percentage at the spruce trunk height 1.5 m
13	7	3	44.8	89.5	21.9	65.7
16	8	5	46.1	74.6	24.2	72.6
17	7	7	45.1	83.2	27.7	76.3
19	5	3	41.2	90.2	22.2	72.9
Average	6.75	4.5	44.3	84.4	24.0	71.9

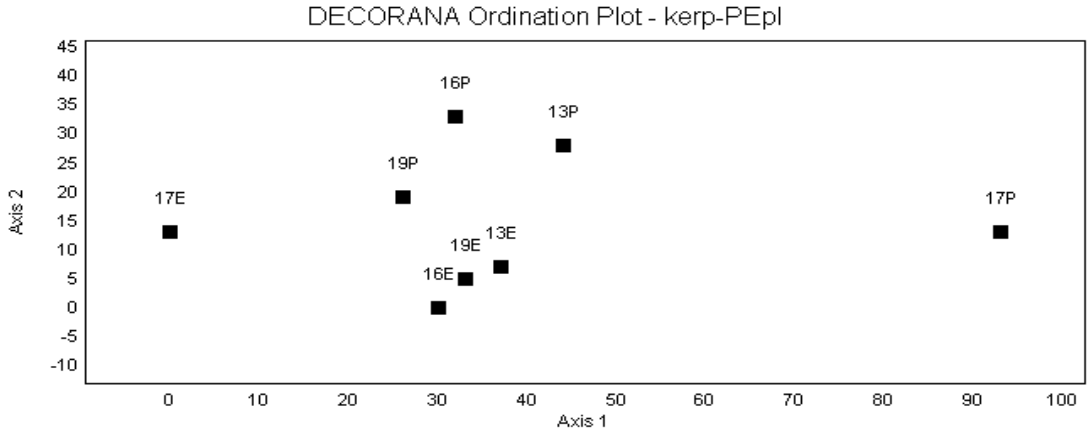

Figure. 1. The comparison of sites using DECORANA analysis.
Designations: 13, 16, 17, 19 – research site codes; P – pine, E – spruce.

important microbiotopes for their propogation and development processes (Hyvarinen et al., 1999). It explains the differences in lichen coverage in percentage of the basis of the trunk and on the trunk.

The species which are found on the basis of the trunk are found with a higher frequency and higher coverage in percentage. Thus, for example, *Cladonia coniocraea* (Flörke) Spreng. forms big groupings on the trunk in favourable conditions. At the same time, one can observe a strong competition between lichen and moss. The species *Lepraria incana* often is a parasite on it. On the trunk at the height of 1.5 m more often crustose lichens are found, less often foliose lichens and their coverage on the stem is lower in percentage. At the same time on the trunk the lichens composition is more homogeneous than on the base of the trunk (Somermaa, 1972). It is thought that wind also influences the lichen communities: on the one hand, the lichen which are in the cracks are protected against evaporation, but, on the other hand, under the influence of prevailing winds they get additional moisture. Higher moisture content determines higher location of epiphytes on the trunk (Znotiņa, 2003).

The sites are compared using TWINSPAN and DECORANA analysis (Fig. 1).

When comparing the sites by the species, the differences appear in site 17 (respectively 17E un 17P), besides, separately distinguished are both pines and spruces. Whereas the other sites are grouped according to tree species (respectively 19P, 16P, 13P and 16E, 19E, 13E). The amount of data is not sufficient for describing results because respectively 26.4% and 5.3% of data dispersion are explained by the axes 1 and 2.

TWINSPAN analysis shows a similar situation, where sites are grouped according to lichen species – *Cladonia coniocraea, Cladonia squamosa*, and *Lecanactis abietina*, from which the last two have been found only in site 17 on different tree species as a result of that they have been distinguished (17E and 17 P). Similar are also pines in site 13 and 16 (the group has been distinguished – according to the lichen species *Parmeliopsis ambigua* and spruces in site 13 and 16, as well as pines and spruces in site 19.

In order to compare the research sites according to the coverage of lichen species in percentage, a three factor analysis of variance has been used (site* tree species* height). The results prove that at the 95% confidence level limit there are significant differences between tree species – pine and spruce – and heights – $F_{0.05}=196.6 > F_{0.05} = 27.6$ respectively ($n_{total}=188$).

Description and analysis of the dependence of lichen exposition on the cardinal points.

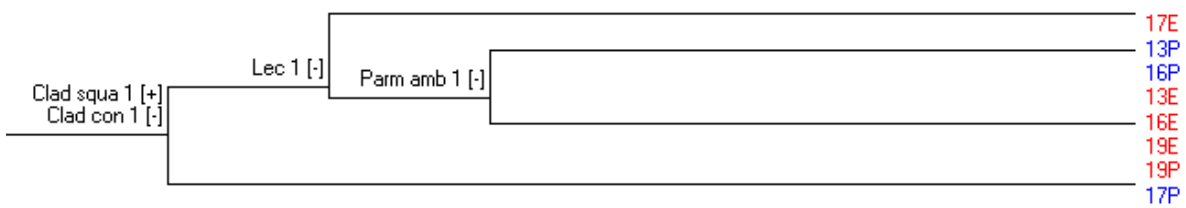

Figure. 2. The comparison of sites using TWINSPAN analysis.
Designations: Lichen species Clad squa – *Cladonia squamosa,* Clad con – *Cladonia coniocraea,* Lec – *Lecanactis abietina,* Parm amb – *Parmeliopsis ambigua;* 13P – site code and tree species; tree species P – pine, E – spruce.

The vertical exposition of lichen on cardinal points is determined by the ecological situation (light, moisture) and physical-chemical properties (the age of the tree, the texture of the bark surface and the presence of nutrients) (Znotiņa, 2003). The age of the substratum is an influencial factor, since within one group the trunks are similar with regard to the composition of lichen species and coverage. The research shows that on average the largest number of species is found in the northern side, but on average the largest coverage in percentage is found in the western side. There are lichen species which have been found in different expositions, but with greater potential coverage found in certain exposition (Somermaa, 1972). The mean values of expositions of lichen species depending on the cardinal points are shown in Fig. 3.

Only those 6 lichen species have been analysed which are found in several objects and on both coniferous species. The Figure 3 shows that the lichen species utilize different exposition niches not only depending on the geographical point, but also on the tree species. Most widely represented species found on trunks *Lepraria incana* found in smaller amount is only on the NE side, but the total mean value is directed to the west; with regard to tree species there are sharp differences in exposition: on pines it is found on NW, but on spruces on the S side. The total mean value of exposition of the species *Chaenotheca ferruginea* (Turner & Borrer) Mig. is directed toward the West. Also on pines it is found in the W, whereas on spruces – on the NW side. The total mean value of the species *Cladonia coniocraea* is directed eastward. The total mean value of both species *Hypogymnia physodes* (L.) Nyl. and *Platismatia glauca* (L.) W.L.Culb.&C.F.Culb. is found in the NE, on pines in NE and in E, but on spruces in the N and NE side respectively. Ecological indicators of both species are similar. The moisture index was considerably different, which is higher for the species *Platismatia glauca*. The mean value of the species *Micarea melaena* (Nyl.) Hedl. is directed toward SE, also on pines, but on spruces it is found on the southern side.

The description of lichen ecological indicators

The research sites have been ecologically evaluated according to the proportion of the coverage of the lichen species in percentage, using the values of ecological indicators (Wirth, 1992). In the objects mainly shade-tolerant and half shade lichen species are found (relative lighting 5–10%), only in site 17 also half-shaded lichen species are found. The lichen species found belong to W and E European species, which grow in temperate temperature conditions. Dry place lichen species prevail in sites. Site 17 is an exception, where the composition of the lichen species corresponds to the conditions, where the precipitation reaches 700–1000 mm. That is explained by the location of the plot – it is situated between lake Usma and the river Engure. The reaction of substratum-bark is rather acid in all the objects (pH 4.1–4.8) and there is a medium amount of minerals on the bark. The indicator of bark's pH varies with the height: at the base of the trunk it is less acidic due to the influence of soil particles and also in the direction towards the top of the tree the acidity decreases. The pH value of

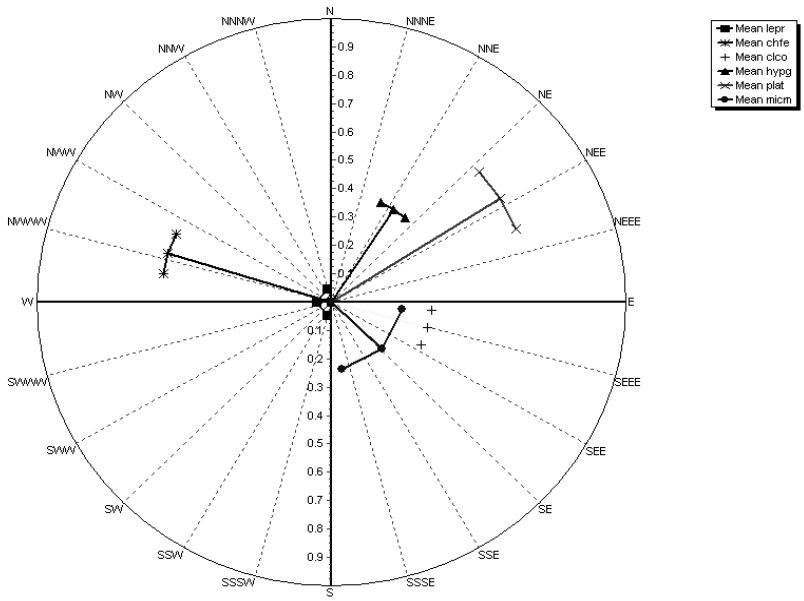

Figure. 3. The exposition of lichen species depending on the cardinal points.
Designations (abbreviations of lichen species): Lepr – *Lepraria incana*; Chfe – *Chaenotheca ferruginea*; Clco – *Cladonia coniocraea*; Hypg – *Hypogymnia physodes*; Plat – *Platismatia glauca*; Micm – *Micarea melaena*.

pine and spruce bark is lower than 4.0 (Kuusinen, 1996), and with the stand age increasing, it becomes more acidic (Hyvarinen et al., 1992). It is supposed that the value of the substratum-bark reaction is also influenced by the amount of minerals in that. When analysing the indicators of toxicotolerance it should be noted that they are different for different lichen species. These indicators reflect the sensitiveness of lichen species to air pollution. At the same time, in different ecological conditions one and the same species can develop different mechanisms of resistance, the relationships of which have not been studied much. When in a stressful situation, the indicators of toxicotolerance of the species decrease and they react to air pollution with higher sensitiveness (Wirth, 1992). For some species, like *Cladonia coniocraea, C.squamosa, Lecanactis abietina*, and *Micarea melaena* such indicators have not been measured. The highest indicators of toxicotolerance are typical of the following species: *Lepraria incana* (very high tolerance), as well as *Hypogymnia physodes, Hypocenomyce scalaris* and *Scoliciosporum chlorococcum* (high tolerance). The species with the lowest tolerance to pollution is *Chaenotheca ferruginea*. It is not found only in one research site – site 19, in other sites this species is recognized on the trunks of pines and spruces.

Conclusions

1. In research sites of pine woodland key habitats, 13 lichen species have been found: on pine trunks – 11, but on spruce trunks – 7 lichen species.

2. On the trunk the composition of lichens is more homogeneous than on the base of the trunk. The species, which are found on the base of the trunk, have a higher frequency and a higher coverage in percentage.

3. The difference in lichen coverage in percentage on the base of the trunk are explained by the characteristics of pine bark. Totally the lichens coverage in percentage is about twice higher at the spruce trunk height of 0.5 m and about three times higher at the spruce trunk height of 1.5 m than at the pine trunk.

4. The three factor analysis of variance (site*tree species*height) used for the comparison of the sites at the confidence level of 95% revealed that significant differences exist in coverage of lichen species in percentage between the tree species – pine and spruce and height of the trees.

5. Lichen species utilize different exposition niches not only depending on geographical points, but also on tree species.

6. Dry place, shade-tolerant and half-shade lichen species (relative lighting 5–10%) prevail in the objects. The species belong to W and E European species, which grow in temperate temperature conditions. The substratum- bark reaction in all the objects is rather acidic (pH 4.1–4.8), and on the bark there is a medium amount of minerals.

7. The highest indicators of toxicotolerance are typical of the following species: *Lepraria incana*, as well as *Hypogymnia physodes, Hypocenomyce scalaris*, and *Scoliciosporum chlorococcum*. The least resistance species to pollution is *Chaenotheca ferruginea.*

References

1. Bērmanis R. (2006) Dabisko meža biotopu apsaimniekošana Latvijā (The management of natural woodland habitats in Latvia). In: Baltijas Koks, 2 (70), pp. 46-48. (in Latvian).
2. Bērmanis R., Ek T. (2003) Inventory of Woodland Key habitats in Latvian State Forests. Final Report 1997 - 2002. Riga, 75 pp.
3. Donis J., Bambe B., Barševskis A., Meiere D., Pilāte D., Piterāns A., Straupe I. (2004) Dabisko meža biotopu monitoringa metodikas izstrāde un aprobācija (The elaboration and approbation of the methods of the monitoring of the natural woodland habitats). Salaspils, 70 pp. (in Latvian).
4. Ek T., Suško U., Auziņš R. (2002) Mežaudžu atslēgas biotopu inventarizācija (Inventory of Woodland Key habitats). Riga, 76 pp. (in Latvian).
5. Field A. (2005) Discovering Statistics using SPSS. Sage Publications, 799 pp.
6. Fisher N. I. (1993) Statistical Analysis of Circular Data. Cambridge University Press, 277 pp.
7. Hyvarinen M., Halonen P., Kauppi M. (1999) Habitat type and primary colonisation of annual shoots of conifer saplings by epiphytic lichens. Nordic J.Bot., 19, pp. 505-511.
8. Johansson T. (2005) Dabisko meža biotopu apsaimniekošanas vadlīnijas (The guidelines of the management of the natural woodland habitats). Riga, 36 pp. (in Latvian).
9. Kent M., Coker P. (1999) Vegetation description and analysis. A practical approach. John Wiley&Sons, 363 pp.
10. Krebs C.I.(1999) Ecological methodology. Benjamin/Cumming, 620 pp.
11. Kuusinen M. (1996) Epiphyte flora and diversity of basal trunks of six-growth forest species in southern and middle boreal Finland. Lichenologist , 28, pp. 443-463.
12. Liepa I. (1974) Biometrija (Biometry). Riga, Zvaigzne, 340 pp. (in Latvian).
13. Lohmus P. (2005) Forest lichens and their substrata in Estonia. Dissertationes Biologicae Universitatis Tartuensis, 107, 31 pp.
14. McCune B. (2000) Lichen communities as indicators of forest health. The Bryologist 103, pp. 353-356.
15. Nash T. H. III, Wirth V. (1988) Lichens, Bryophytes and Air Quality. Bibliotheca Lichenologica 30, J.Cramer in der Gebruder Borntraeger Verlagsbuchhandlung, Berlin-Stuttgart.
16. Pike L.H. (1978) The importance of epiphytic lichens in mineral cycling. The Bryologist 81, pp. 247-257.
17. Piterāns A. (2001) Latvijas ķērpju konspekts (The conspectus of lichens in Latvia). In: Latvijas veģetācija, 3. Riga, pp. 5–46. (in Latvian).

18. Somermaa A. (1972) Ecology of epiphytic lichens in main Estonian forest types. Tartu, 117 pp.
19. Uliczka H., Angelstam P. (1999) Occurence of epiphytic macrolichens in relation to tree species and age in managed boreal forest. Ecography 22: Copenhagen, pp. 396-405.
20. Will-Wolf S., Esseen P.-A., Neitlich P.(2002) Monitoring biodiversity and ecosystem function: forests. In: Nimis P.L., Scheidegger C., Wolseley P.A. (eds.) Monitoring with Lichens-Monitoring Lichens, pp. 203-222.
21. Wirth W. (1992) Zeigerwerte von Flecten. In: Ellenberg H. et al. Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobotanica 18. (2.Aufl.) Verlag Erch. Goetze, pp. 215-237.
22. Znotiņa V. (2003) Epiphytic bryophytes and lichens in boreal and northern temperate forests. In: Proceedings of Latvian Academy of Sciences, Vol.57, No.1/2 (624/625), pp. 1-10.

INITIAL RESEARCH OF STRENGTH OF THE WOODEN PALLETS

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Abstract

The manufacture and export of pallets is one of the largest sectors of the wood industry. For the manufacturing of pallets mainly softwood - spruce (*Picea abies* L. Karst.) and pine (*Pinus sylvestris* L.) wood - materials are used. The price of those materials is increasing. It could be better for the production of pallets if the manufacturers could use hardwood - alder (*Alnus incana* L. Moench) and aspen (*Populus tremula* L.) wood materials. The reasons for that could be that these materials are not so expensive and that softwood materials could be used more in the wood industry where it is more necessary. But at that point more information about the physical and mechanical properties of hardwood materials is needed. Basing on the previous research on quality and mechanical properties of softwood and hardwood and on the present research work the practical and theoretical values of deflection and strength of pallets have been assessed. The research enables us to optimize the preparation for pallet production.
The aim of the research is to find out the strength of the pallets without destroying.
Key words: pallet, deflection, strength.

Introduction

In Latvia, for manufacturing of pallet components there are currently used: the round assortment of softwood (the spruce and the pine) of a small diameter (10...16 cm) and the packaging logs from hardwood (the aspen and the alder) with diameter 10...40 cm, as well as the thin side boards 14...19 mm in thickness, supplied by sawmills.

In the process of maintaining the pallets, particularly important is their bending strength, as well as stability. These indices to a great extent depend on the bending strength of the components and indices of the modulus of elasticity. As the above indices of the wood for different species of trees are different (Уголев, 2001), then in the pallet constructions sizes of the cross-section of the used components depend not only on the heaviness and character of loading, but also on the strength and elasticity of the used wood.

Therefore, the issue of the strength and stiffness of the demanded pallets is topical. Sizes of the components are determined by the heaviness and character of the loading taking into account the bending strength and the modulus of elasticity of the used wood, as well as price of the wooden materials for the definite species.

Strength of the pallet depends on the variety of species of the wood. Properties of the wooden materials used for pallets during the operation change due to the duration of the load (permanent, continuous, average in size, short-term, instant) and humidity.

Calculating wooden constructions, the main task of which is to secure sufficient strength and stability in the loading of the appropriate length in the definite moisture conditions, value of the strength calculation of the applied material is used (Ozola, 2001).

The maintenance conditions for wooden constructions are divided into three classes:

1) Class 1 which is characterized by air temperature of 20 °C and the relative humidity of the air up to 65%, allowing the increase to be above 65% only a couple of weeks per year. The absolute humidity of the wood in such conditions does not exceed 12%;

2) Class 2 which is characterized by air temperature of 20 °C and the relative humidity of the air up to 85%, allowing the increase to be above 85% only a couple of weeks per year. The absolute humidity of the wood in such conditions does not exceed 20%;

3) Class 3 which is characterized by a higher humidity than for Class 1 and Class 2. Usually to Class 3 correspond

Table 1

Pallets footprints recognized by LVS ISO 6780

Size of the pallet, mm	Region of application
1,200x1,000	Europe, Asia
1,200x800	Europe
1,140x1,140	Australia
1,100x1,100	Asia
1,067x1,067	Northern America, Europe, Asia

constructions which are located outdoors. For covered constructions, conditions of Class 3 are applied only in circumstances when there is a source of humidity in the premise.

Pallets are characterized by several parameters, from which the most important are as follows: size of the pallet, mass, mechanical strength, stiffness, and price. The most essential index is price which is directly affected by the price of the raw materials components, blocks and connections - for the pallets. Pallets are carrying constructions and their mechanical properties depending on both quality of the pallet components and cross-section sizes of the components. For freight, in the world basically 6 standard sizes of pallets are used (see Table 1).

For description of sizes of the numerous pallets and the mechanical properties of the pallet cross-section sizes, the proposed solution is to determine the mechanical strength of the pallets using software.

The carried out research and the elaborated software allow obtaining deflections of pallets and strength to optimize the pallet components in a comparatively short time.

Materials and Methods

At the previous research preparation of the pallet components from softwood (spruce and pine) and hardwood (aspen and alder) of strength were carried out accordance with the standard LVS EN 408:2003 requirements. As a result of the research, the average values of the bending strength and the modulus of elasticity are obtained. By calculating the statistical indices, the normative (5% percentile) values of the bending strength and the modulus of elasticity are obtained, correlation of the bending strength and the modulus of elasticity are found.

By calculating strength of the pallet at a definite load, it is advisable that the actual strain does not exceed the threshold of 20...25 $N \cdot mm^{-2}$.

Such an increased strength is accepted taking into account the fact that in order to simplify the calculation, resistance of the bottom deck boards is not taken into account.

The load, which the pallet can hold in maximum, is determined taking into account values of the actual load and strain as well as the strain (5% percentile) value. The normative (5% percentile) value is determined experimentally.

At the same time the calculation program 'Pallet Testing' (PT) is created applying the programming language C# (C sharp) (Liberty, 2005). C# is a modern, object-centered programming language which provides the programmers to quickly form wide-scale applications for the new Microsoft®.NET platform. The platform is provided with tools and services and is used for computations and communication. C# is created by combining C++ and Microsoft Visual Basic® (MacDonald, 2005). By C# you can form wide-range components starting with a high level business and ending up with objects of the system level.

Simultaneously with the theoretical calculations of the pallet strength (Lavendelis et al., 1970), practical research was carried out for pallet loading by loading pallets and determining deformation (deflection) values. The obtained deformation (deflection) values are used for the theoretical calculations of the pallet strength.

In the tests, one type - the four way pallets are used, the dimensional sizes of which are as follows: width-1200 mm, length-800 mm (see Figure 1).

Sizes of the pallet boards:

Pallet No. 1

- sizes of the top deck boards: width - 75 mm, thickness - 18 mm, number - 5 pieces;
- sizes of top stringer boards: width - 100 mm, thickness - 23 mm, number - 3 pieces;
- sizes of the bottom deck boards: width - 75 mm, thickness - 18 mm, number - 3 pieces;
- height of the block - 75 mm.

Pallet No. 2

- sizes of the top deck boards: width - 75 mm, thickness - 18 mm, number - 7 pieces;
- sizes of top stringer boards: width - 160 mm, thickness - 18 mm, number - 3 pieces;
- sizes of the bottom deck boards: width - 75 mm, thickness - 18 mm, number - 3 pieces;
- height of the block- 75 mm.

Pallet No. 3

- sizes of the top deck boards: width - 75 mm, thickness - 18 mm, number - 7 pieces;
- sizes of top stringer boards: width - 120 mm, thickness - 15 mm, number - 3 pieces;
- sizes of the bottom deck boards: width - 75 mm, thickness - 16 mm, number - 3 pieces;
- height of the block - 75 mm.

Results and Discussion

Results of research of the theoretical pallet testing

The calculation program is created for its user to be easily understood and used. Currently, in the calculation method of the pallet strength, computations for two types of pallets are set: for the two way pallet and for the four way pallet (see Figure 1).

Pallets differ in their construction and type of lifting: the two way pallet is lifted only from the front, but the four way pallet can be lifted from the front and the side.

Supplements are easily attached because the program consists of attachable models, for instance, calculation for pallets of a different construction is developed and as a model it is added to the basic data of the program. It enables

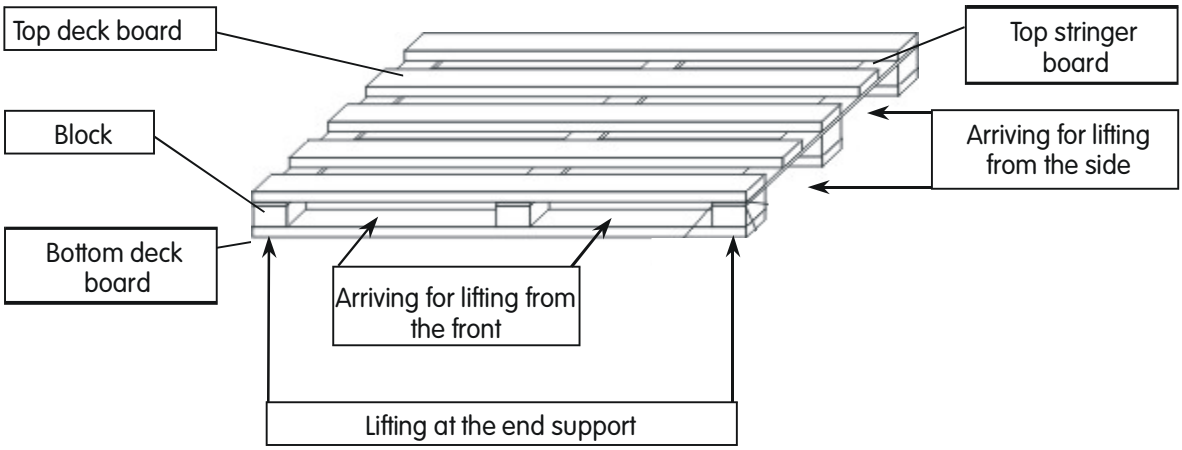

Figure 1. The four way pallet.

to easily improve and to perfect operation of the program without interrupting structure of the program.

The program consists of two parts:

1) the part of data input (see Figures 2, 3);

2) the part of calculation (see Figure 4).

In the part of data input, data, which are needed for calculations, are fed in. Due to logical considerations, sizes, which depend on the size of the part, are not required. In the input part of data, the pallet is visually reflected where the required data are specified in the input field (see Figure 3). This enables to decrease possibility of faulty data input and allows the user to easier orientate in the program and ensures a correct result of calculations. Moving along the input fields, the place in the pallet is visually reflected and sizes of the places, which are necessary to feed in, are specified. In the calculations of the pallets, a method is introduced that the width of the top deck board can differ.

For the calculations to be precise, a table is introduced in the program which feeds in sizes of all the top deck boards (only in the case when they differ). For every pallet only these input fields are activated which are needed for the calculations (see Figure 3).

After the input of data, the process of calculations follows, which is visually reflected in the calculation part (see Figure 4). Under the figures, data are specified according to their type of loading. Strength and deflection are specified in millimeters for every loading diagram and the maximum weight to be allowed is specified with which it is possible to load the pallet.

The obtained results of calculations can be displayed in the MS Word program. The display function is built into the calculation program. Using MS Word opportunities, it is possible to print out the form of the calculation results, to send it by E-mail or to save it.

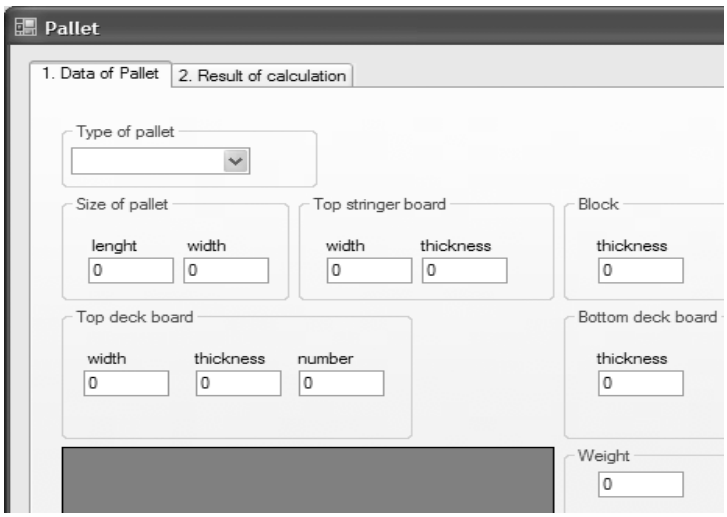

Figure 2. Part of data input.

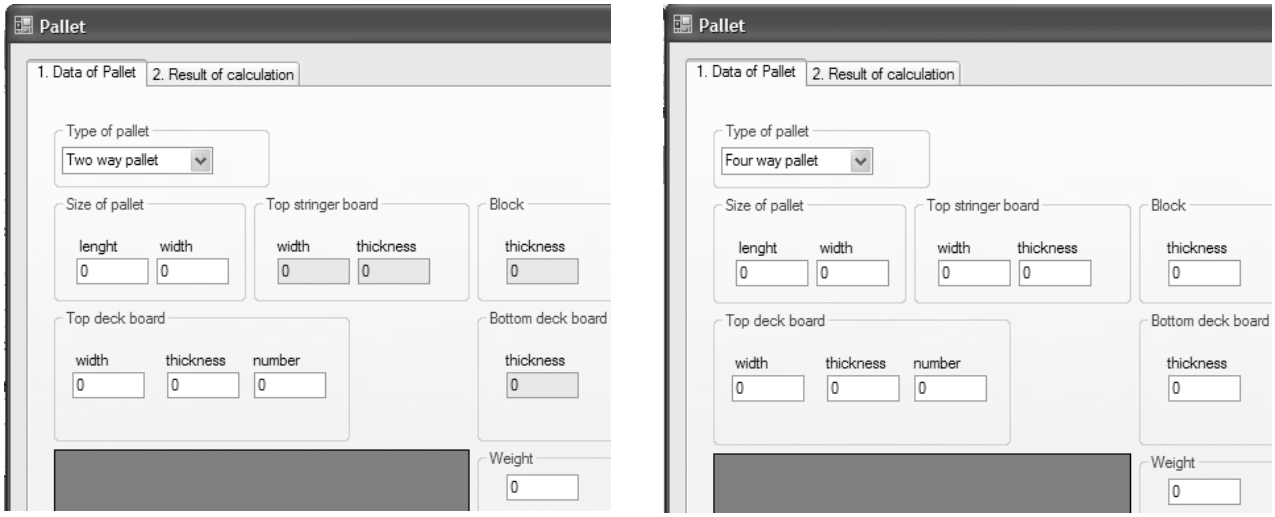

Figure 3. Activated fields for the input of data.

Using the program of calculations, you can easily operate with sizes of the materials and to determine for which loads this pallet is envisaged. It enables to save consumption of the materials as well as to construct a pallet with the required sizes of the cross-section for definite loads.

Results of research of the practical pallet testing

Determining the practical values of the deflection of the pallets was carried out in three ways by loading the pallets and lifting by the lorry loader, or placing at the end support (see Figure 1).

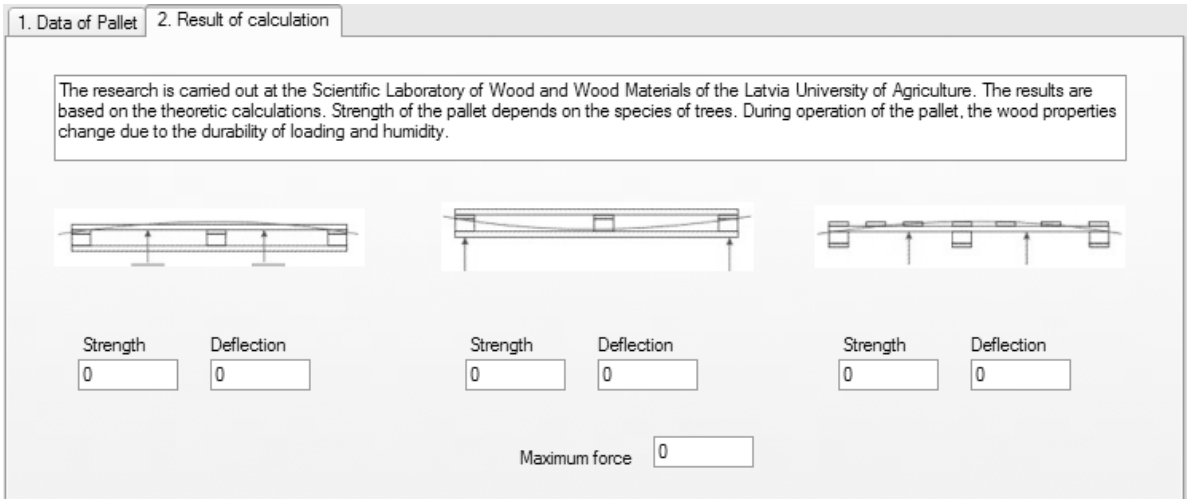

Figure 4. Part of calculation.

Table 2

Practical and theoretical deflection values of the pallets

	Pallet No. 1		Pallet No. 2		Pallet No. 3	
	Practical value, mm	Calculated value, mm	Practical value, mm	Calculated value, mm	Practical value, mm	Calculated value, mm
At the end support	11	9.8	5	9.5	8	11.1
Lifting from the front	3	3.5	2	3.4	2	4
Lifting from the side	1	1.6	1	2.1	1	4.9

Lifting by the lorry loader, the inter-axial distance of forks is as follows: arriving from the front - 650 mm, arriving from the side - 450 mm and loading force - 1.490 kg.

Analyzing the obtained values of deflection it is evident that the theoretically calculated values are averagely on 20...40% higher. It is explained by the fact that for the purpose of simplifying the calculation, resistance of the bottom deck boards and irregularity of the nail connections are not taken into account.

Conclusions

1. The software 'Pallet Testing' (PT) enables to determine the theoretical values of deflection and the maximum load using boards of a definite size.

2. Due to the regularity of the nail connections, which is practically difficult to forecast, the theoretical calculation is simplified by excluding resistance of the bottom deck boards and increasing the calculating resistance.

3. The allowed strain (the normative resistance) in the calculations is increased to 25 $N \cdot mm^{-2}$ due to neglecting calculation of resistance for the bottom deck boards.

4. The practical values of deflection for the pallets are averagely on 20...40% lower than the theoretically calculated ones and the started research is to be continued in order to improve the software.

References

1. ISO 6780 (2003) Flat pallets for intercontinental materials handling - Principal dimensions and tolerances, 2, ISO standards, 13 pp.
2. Lavendelis E., Valdmanis A. (1970) Materiālu pretestība. Mācību līdzeklis (Strength of materials. Study aid). Zvaigzne, Rīga, 456 pp. (in Latvian).
3. Liberty J. (2005) Programming C#, 4th Edition, O'Reily, UK, 666 pp.
4. LVS EN 408 (2003) Timber structures - Structural timber and glued laminated timber - Determination of some physical and mechanical properties, Latvijas valsts standarts, Rīga, 31 pp.
5. MacDonald M. (2005) Visual Basic 2005: A Developer's Notebook, O'Reily, UK, 262 pp.
6. Ozola L. (2001) Koka konstrukciju projektēšana. Slodzes, materiāli, elementu aprēķini, EUROCODE 1, EUROCODE 5 (Design of wooden constructions. Part I. Loads, materials, calculations of elements (EUROCODE 1, EUROCODE 5). I daļa, LLU, Jelgava, 68 pp. (in Latvian).
7. Уголев Б.Н. (2001) Древесиноведение с основами лесного тавроведения (Wood sciences with basic of the forest marketing). 3-е изд, МГУЛ, Москва, 340 с. (in Russian).

VARIABILITY AND GENETIC DETERMINATION OF SCOTS PINE QUANTITATIVE TRAITS AT THE AGE OF 32 YEARS

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Abstract

Survival, growth (height, diameter at breast height, stem volume, yield) and quality (thickest branch up to 2 meters of tree height, branchiness, and stem straightness in grades) of phenotypically selected Scots pine plus-tree progenies from different regions in Latvia at the age of 32 years have been analyzed. The material was planted in 4 tests in different forest types (*Cladinoso-callunosa*, *Vacciniosa*, *Hylocomyosa,* and *Oxalidosa*) in Kalsnava, eastern part of Latvia.

Average number of trees per family varied from 11 to 21 (survival 18-35%). Mean height for Scots pine at the age of 32 years was 14.2-16.3 m, coefficient of variation – 10-17%, diameter at breast height – 13.1-17.7 cm, 24-32%, stem volume 0.1-0.2 m^3, 49-64%, diameter of thickest branch at up to 2 meters of tree height – 1.3-1.7 cm, 23%.

To secure ability for detection of significant (α=0.05) family differences, average number of trees per family at evaluation age should be at least 24. Narrow sense individual tree heritability (h^2) was 0.11 for stem volume, 0.09 for diameter at breast height, and 0.07-0.11 for diameter of thickest branch up to two meters of tree height.

Best families and individuals were selected for further breeding process. Among-family selection resulted in breeding difference of 37% (80 m^3) in yield and 18% in stem volume without causing changes in quality properties. Combined among-family and within-family selection resulted in double increase of stem volume, improvement of stem straightness of 7-11%, but the selection caused also considerable increase of branchiness (11-42%). Additional testing for material is suggested before using it in further breeding process.

Key words: heritability, survival, growth, quality, improvement.

Introduction

Forest tree breeding in Latvia is being carried out for almost 50 years. During this process phenotypically superior trees (so called plus-trees) have been selected in forests and grafted in seed orchards. To reveal true performance of plus-trees and select best of them for further improvement of economically important traits, progeny tests have been established. According to previous evaluations of some of plus-trees, superior clones have been selected and grafted in second-stage seed orchards to produce seed with higher genetic value.

To continue Scots pine breeding process and increase important traits, it is essential to carry out controlled crossings and increase proportion of favorable alleles for particular trait in genotypes of next generation seed orchard clones. Besides, to secure seed supply and not decrease genetic diversity, it is important to select new sets of clones for second-stage seed orchards for the western part of Latvia. To support both mentioned actions with appropriate material, progeny trials must be evaluated.

There are more than 80 ha of trials established between year 1970 and 1980. They have now reached a suitable stage for evaluation and reliable conclusions can be obtained. Besides, natural differentiation, that reduces number of trees per family, takes place in those experiments. If they are not evaluated soon, there is a high risk that the amount of trees left will not be sufficient for detection of genetic differences and ranking of families. That would cause a necessity to look for new plus-trees in forests and considerably delay establishment of third stage seed orchards with ability to produce seeds with superior genetic value.

There is not only practical, but also scientific (theoretical) interest of evaluation of genetic determination and variability of traits at the age of more than 30 years, since few reports are published about it. Besides, no information about such results from open-pollinated progeny trials of Scots pine has been gained and analyzed in Latvia so far.

The aim of the study is to estimate the level of variability and genetic determination of Scots pine quantitative traits, its genetic determination and effect from within-family and among-family selection (breeding difference); to produce practical recommendations for establishment of new trials, if their final evaluation is planned at the age of 32 years; to select families most suitable for future breeding process.

Materials and Methods

The material consists of 4 tests of open-pollinated progenies of Scots pine phenotypically selected plus-trees from different regions of Latvia, established in years 1973 and 1974 in Kalsnava, eastern part of Latvia. The families (open-pollinated progenies of one mother-tree) are planted in block-plots containing 15 trees (5 trees in 3 rows) in 4 replications. The initial spacing is 2x1 m. No thinning was performed in the experiment. Some of the families are not in all replications, so the total number of families is 56 in Test 1, 50 in Test 2, 49 in Test 3, and 51 in Test 4.

The soil type differs among tests and, according to classification of Latvian forest types based on dominant ground vegetation, is *Cladinoso-callunosa* in Test 1,

Vacciniosa in Test 2, *Hylocomyosa* in Test 3, and *Oxalidosa* in Test 4. All tests are performed on dry mineral soils with gradually increasing fertility from *Cladinoso-callunosa* to *Oxalidosa* (Bušs, 1976).

The trees were measured in 2005, when they had reached age of 32 years. Height, breast height (1.3 m) diameter, and diameter of thickest branch up to two meters of tree height were measured for every tree. Stem straightness and branchiness were evaluated in grades, where 1 – thin branches, straight stem, and 3 – thick branches and stem with 2 or more bends. The evaluation was made relative to trees in the same test. Occurrence of root-rot was reported.

Analysis of variance was performed on each variable measured. The effect of blocks and families was considered as random and calculated with SAS proc glm. The model used in analysis was following:

$$Y_{ijk} = \mu+F_i+B_j+FB_{ij}+e_{ijk}, \quad (1)$$

where

Y_{ijk} – phenotypic observation (height, breast height di ameter or branch diameter) of the individual tree from the i-*th* family in j-*th* replication;

μ – the general mean;

F_i – the effect of the i-*th* family;

B_j – the effect of the j-*th* replication;

FB_{ij} – the interaction effect between the i-*th* family and j-*th* replication;

e_{ijk} – the residual effect of the individual tree from the i-*th* family in j-*th* replication.

The assumptions used in the analysis were that the random effects F_i, B_j, FB_{ij}, e_{ijk} are normally distributed with means zero and variances σ^2_f, σ^2_b, σ^2_{fb}, and σ^2_e, respectively.

Variance components were estimated using the restricted maximum likelihood (REML) method (as default in SAS proc mixed). In this method, variance components are estimated by maximizing a marginal (or restricted) likelihood function, that is, a likelihood function obtained after the model has been transformed to eliminate the fixed effects. This method produces unambiguous estimates of variance components from unbalanced data.

Calculations of genetic components were based in theoretical principles described by Falconer (1981).

Additive genetic variance (Va) was obtained as follows:

$$Va = 4^* \sigma^2_f , \quad (2)$$

where

σ^2_f – family variance.

Phenotypic variance (Vp) was calculated as the sum of variance components:

$$Vp = \sigma^2_f+\sigma^2_{fb}+\sigma^2_e , \quad (3)$$

where

σ^2_b – block variance;

σ^2_{fb} – family-block interaction variance;

σ^2_e – residual variance.

Narrow-sense heritability (h^2) based on additive genetic effect was obtained as:

$$h^2 = Va^*Vp^{-1} \quad (4)$$

Results and Discussion

A good survival of planted material is essential for successful development of the stand. It indicates that the material planted is appropriate (adapted) for particular conditions (Eriksson, 1998). Significant survival differences have been reported among distant Scots pine provenances (geographical transfer) (Shutyaev et al., 2000) as well as among populations and families (Ruotsalainen et al., 1998). The trend is to increase initial spacing (planting less and less trees) in order to reduce costs. The recommendations started from 7000 trees ha^{-1} in year 1971 (Bušs, 1971), and ended up with 3000 trees ha^{-1} currently. For the formation of a forest stand, that means increasing importance of survival of each planted tree. That's why this characteristics needs to be considered first in tree breeding process too.

The average number of trees per family in Test 1 is 21 (survival 35%), in Test 2 – 16 (27%), in Test 3 and Test 4 – 11 (18%). Distribution of families according to their survival is shown in Figure 1.

Jansons (2005) for the same design trial for Scots pine at the age of 32 years in forest type with rich soil (*Hylocomiosa*) reported survival from 5 to 29 trees and in forest type with poor soil (*Cladinoso-Callunosa*) – from 11 to 41 trees. That is in a good agreement with this study.

With the age and increase of dimensions, competition among trees also is increasing, which is the cause of differentiation and natural mortality. To evaluate survival of families at the age of 32 years, it should be considered that in this age the optimal density for Scots pine is approximately 1000 trees ha^{-1}. That means – 14 trees per family in particular tests. To ensure that, the number is increased roughly by 10% – up to 16 trees per family. In Test 1, survival of 16 or more trees per family is shown for 27 families (80% of all analyzed), in Test 2 – for 27 (57%), in Test 3 – for 10 (22%), and in Test 4 – for 7 families (15%). Among these families, the best one according to volume and quality can be chosen for future breeding process and also grafting in second-stage seed orchards.

The stand productivity (yield) depends not only on survival, but also on the speed of growth (productivity). As productivity measures, height, diameter and stem volume have been chosen. The potential to improve growth is related to variation of the mentioned traits (indicated by coefficient of variation) and genetic determination of this variation (indicated by heritability).

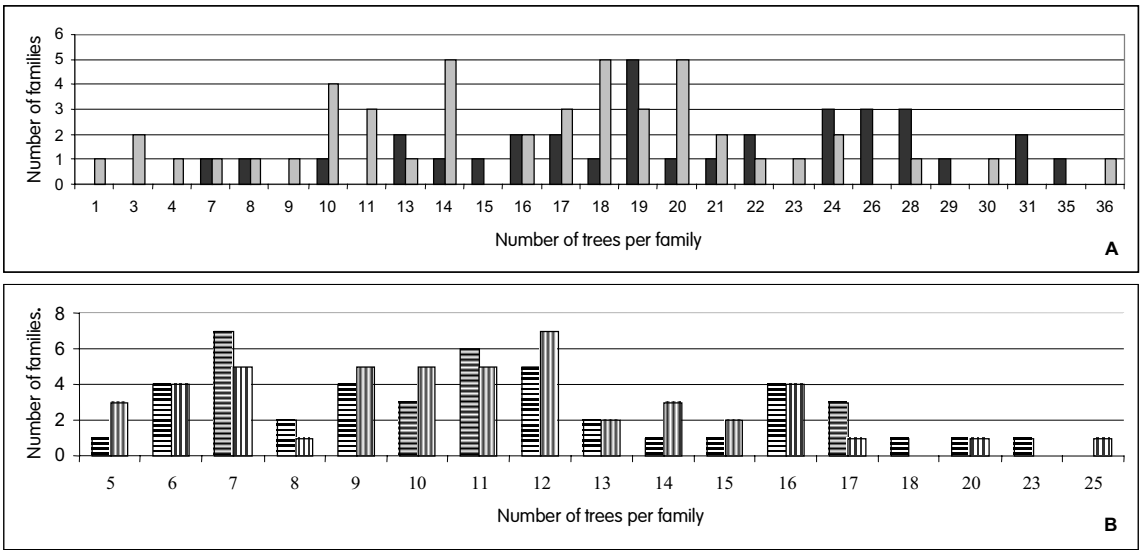

Figure 1. Survival (number of trees per family) of Scots pine at the age of 32 years
A – Test 1 (black columns) and Test 2 (gray columns), B – Test 3 (horizontally dashed columns) and Test 4 (vertically dashed columns).

Variation of traits in all 4 tests is summarized in Table 1, which demonstrates that the variation of diameter is roughly double than of the height, and for stem volume – roughly double that of the diameter.

There is also increasing variation with increasing number of trees observed (in tests with higher survival). Test site with poorer soil (test 1) demonstrated the highest number of trees, lowest mean values and highest coefficients of variation for dimensions of live trees. Poorer conditions lead to a delayed competition factor and consequently lower mortality at the same age. It is in accordance with previous findings in Scots pine experiments in Latvia (Jansons, 2005).

Results demonstrated large variation of productivity traits, which means that selection among individuals to improve mean performance is possible. Not all improvement made by selection can be transferred to next generation. Prerequisite of successful breeding work is heritability of traits – estimation of genetically determined part of total variation. In this case, narrow sense heritability (based only on additive genetic effect) is used, since creation of next generation in industrial scale will take place in open-pollinated seed orchards. With this method only additive genetic effects can be utilized in improvement of genetic properties of seedlings (and future stands).

At first, significance of effects (family, replication, family-replication interaction) in total variance needs to be considered. If family effect is not significant, there is no use from further calculations and among-family selection.

In all 4 tests, to all 3 traits (tree height, diameter at breast height, and stem volume) replication effect had a significant influence. Family-replication interaction had a significant influence in most of the cases (except for stem volume and tree height in test 1 and tree height and breast height diameter in test 3), but family effect was significant only in 3 cases (for tree height in test 4, and breast height diameter and stem volume in test 1). All significances tested were in level α=0.05. It is clear that there is an environmental gradient within test sites that influences the average performance and also interacts with families (and is a

Table 1

Variation of quantitative traits for Scots pine at age 32 years

Experiment	Height, m		Diameter at breast height, cm		Stem volume, m^3	
	Mean	CV	Mean	CV	Mean	CV
Test 1	14.2	17	13.1	32	0.1	64
Test 2	15.2	15	15.0	31	0.2	62
Test 3	15.9	12	16.9	26	0.2	52
Test 4	16.3	10	17.7	24	0.2	49

CV – coefficient of variation, %

Table 2

Evidence of block effect - average performance of trees in different replications

Replication	Test 1				Test 2			
	N	H	DBH	VOL	N	H	DBH	VOL
1	124	15.2	15.1	0.15	122	16.6	16.5	0.11
2	164	15.0	14.0	0.12	135	15.8	15.7	0.15
3	179	13.8	12.3	0.10	135	15.3	15.0	0.17
4	180	13.0	11.5	0.08	167	13.9	12.8	0.19

N – *total number of trees;*
H – *average height, m;*
DBH – *average breast height diameter, cm;*
VOL – *average stem volume, m³*

cause of changes of family ranking). The absence of significant family effect could be explained by low survival and consequently insufficient number of observations per family to detect this effect. To test this assumption, all families with survival lower than 16 trees were excluded and new analysis was performed. The analyzed sample from Test 1 contains 27 families and average number of trees per family – 23, for Test 2 – 27 families and 21 tree, Test 3 – 10 families and 18 trees, and Test 4 – 7 families and 18 trees. Analysis is justified also by a previous statement that all families with survival lower than 16 trees will be excluded from future selection due to poor adaptation in particular conditions.

When working with the reduced samples, the coefficient of variation for all analyzed traits has not been changed by more than 2% (except stem volume in Tests 3 and 4, where it was increased by 4%). Mean values of height and volume remained unchanged (except in Test 4 for height – increased by 0.2 m). Breast height diameter increased by 0.4 cm in Test 3 and by 0.7 cm in Test 4. In Test 1, significant family effect was detected to diameter at breast height and tree volume (α=0.05). Replication effect remained significant. In Test 2, replication effect is significant and family effect isn't significant for all traits analyzed. That indicates inaccuracy in selection of area for experiment – there are differences in soil that influence growth of trees. Average performance of trees in different replications in Tests 1 and 2 are presented in Table 2. If only family as a factor was evaluated within each replication in Test 2, its effect appeared to be significant (α=0.05) to all traits in 2 replications.

In Tests 3 and 4, neither family nor block effect was significant. Only significance remains for family-block interaction. It indicates that datasets with particular properties (open pollinated families with survival of only 11 trees per family) are not suitable for detection of among-family differences.

Kowalczyk (2005) for evaluation of genetic effect of Scots pine used trials, where average number of trees in family varied from 68 to 180 at the age of 19-21 years.

For characterization of genetics influence on Scots pine productivity, stem volume and breast height diameter (significant family effect) were chosen. For those traits, narrow sense individual tree heritability (h^2) was 0.11 and 0.09 respectively. The results were lower than those obtained by Costa e Silva et al. (2000) in 15-18-year-old progeny tests of Norway spruce. There h^2 ranged between 0.09 and 0.27 for diameter. Our findings are not in agreement also with the data presented by Hannrup et al. (1998) for Scots pine at the age of 33 years. In this experiment, h^2 for breast height diameter was 0.27, and h^2 for height – 0.32. It can be partly explained by comparably low competition factor among trees – they exposed slower growth (average height of only 10.8 m and diameter at breast height – 10.5 cm) and 1 systematic thinning was done. It can be concluded that for analysis of genetic properties, larger number of trees per family is needed and it can be obtained either by measurements in early age (when crown closure is already formed, but before competition causes mortality) (Svensson et al., 1999) or by planting more trees per family initially.

From Tests 3 and 4, where no significant family differences can be detected due to low survival, individual trees according to their superior performance can be chosen for further testing. Since they are progenies from already selected plus-trees, the probability to find superior productivity is high. Besides, if additional material for breeding population is needed, it is easier to work with those trees than to carry out new plus-tree selection. Since replication effect influenced growth significantly, the best 10 trees according to stem volume were chosen in each replication. That forms a group of 40 trees. To avoid relatedness in future breeding process, only one tree from each family was left. The number of individuals was further reduced to 20. In both steps, trees with lowest volume and, if that's equal, quality were excluded at first. The result of selection is summarized in Table 3.

Among-family selection intensity of 40% (20 from 49) in combination with within-family selection intensity of 10%

(1 from 11) resulted in more than double increase of average stem volume. That indicates large potential of productivity increase by use of chosen trees.

For Tests 1 and 2, where it was possible to detect significant family differences, average results for families were calculated and ranking was made according to stem volume. Families with insufficient survival (less than 16 trees) and planted in less than 3 (for Test 1) or 4 (for Test 2) replications were excluded from top rank. Also if one of stem straightness or branchiness measures were more than 10% below average of the experiment, these families were excluded. Families with highest survival usually tend to have lower stem volume due to increasing competition among trees. To compensate that, the fifth family in ranking according to average stem volume was replaced with the best family in area-based productivity (yield). Among-family selection with intensity of 15% resulted in breeding difference for yield of 37 % (approximately 80 m^3*ha^{-1}) and average stem volume of 18 % in both tests (Table 3). Differences in average height and diameter are in good agreement with the results of the experiment, where average samples from first-stage seed orchards (containing only phenotypically selected clones) and stands were compared (Baumanis et al., 2002). It indicates that the next step of tree breeding (selection of the best plus-trees in orchards according to performance of their progenies) could bring the same high results of the growth improvement of progenies as the first step (selection of plus-trees). In summary, the breeding differences in height growth compared to stands could be as high as 15% (7% in first stage plus 8% in second stage). When using progeny tested clones of Scots pine compared to stand material, a bit more than double increase in genetic gain in height growth has also been found in Finland (Velling et al., 2002). Figures in absolute values (1.6% to 4.2% in Finland compare to 7% and 15% in Latvia) are different, since in Finland only genetic gain (pure

Table 3

Breeding difference among selected and un-selected material of Scots pine at the age of 32 years

Experiment	Selected group and breeding difference	Trait						
		H	DBH	BD	BG	SG	VOL	Y
Test 1	average selected	15.0	14.2	1.3	1.3	1.1	0.13	301
	average all	14.1	13.0	1.3	1.4	1.1	0.11	219
	breeding difference	0.9	1.2	0.0	0.0	0.0	0.02	81
	breeding difference, %	6	9	2	-2	2	18	37
Test 2	average selected	16.2	16.2	1.5	1.5	1.2	0.18	316
	average all	15.3	15.1	1.4	1.4	1.2	0.16	229
	breeding difference	0.9	1.1	0.0	0.1	0.0	0.03	88
	breeding difference, %	6	8	3	5	0	18	38
Test 3	average selected	18.0	25.3	2.1	2.1	1.2	0.42	N
	average all	16.0	16.9	1.6	1.4	1.3	0.20	N
	breeding difference	1.9	8.4	0.4	0.6	-0.1	0.22	N
	breeding difference, %	12	49	27	42	-7	114	N
Test 4	average selected	18.9	26.2	2.0	1.7	1.1	0.47	N
	average all	16.3	17.7	1.7	1.5	1.3	0.21	N
	breeding difference	2.6	8.5	0.3	0.2	-0.2	0.3	N
	breeding difference, %	16	48	18	11	-16	120	N

average selected – average value of particular trait for selected group;
average all - average value of particular trait in all experiment;
breeding diference = average selected - average all;
breeding difference, % = (breeding diference average all^{-1})*100%;*
H – *height, m;*
DBH – *diameter at breast height, cm;*
BD – *diameter of thickest branch up to 2 meters height, cm;*
BG – *branchiness in grades, 1-thinn, 3 – thick branches;*
SG – *stem straightness in grades, 1-streight, 3- double bended;*
VOL – *stem volume, m^3;*
Y – *yield, m^3*ha^{-1};*
N – *yield in Test 3 and 4 can not be calculated, since individual tree selections have been made*

genetic effect) was calculated, but in our case it was the breeding difference.

Latvian pine is well known for its high quality – both straight stems and thin branches. It has been proven also in provenance trials, planting it together with pines from Poland and Germany (Jansons and Baumanis, 2005). That's why the main aim of tree breeding is to increase survival and growth without causing significant decrease in quality for improved material of Scots pine.

For significance tests, diameter of the thickest branch up to 2 meters of tree height (further denoted as branch diameter) was used as indicator, since it was the only quality variable measured (not estimated in grades) and had continuous distribution. In the first analysis of original dataset, a significant block and block-family interaction effect (α=0.05) to branch diameter was found, but no family effect was found. Mean branch diameter in Test 1 was 1.3 cm, in Test 2 – 1.4 cm, in Test 3 – 1.6 cm, and in Test 4 – 1.7 cm, coefficient of variation in all cases – 23%. The exclusion of families with survival below 16 trees did not change the situation with significance of different factors. Mean branch diameter decreased in Test 4 (to 1.6 cm) and coefficient of variation in Tests 1 and 4 also decreased (to 22 and 20% respectively). When only family factor influence was estimated in Tests 1 and 2, it was significant (α=0.05) in most of the cases (except replication 1 in Test 1 and replications 1 and 4 in Test 2). Narrow sense heritability (h^2) of branch diameter in Test 1 was 0.07 and in Test 2 – 0.11. That indicates rather high potential of selection for quality. Danusevičius (2000) reported heritability of only 0.03 at the age of 12 years and 0.11 at the age of 17 years.

Resulting changes in quality properties after selection of the set of the best families and individuals are summarized in Table 3. Among-family selection (tests 1 and 2) has negligible (5% and less) influence on branch diameter, branchiness in grades and on stem straightness in grades. Combined among-family and within-family selection (tests 3 and 4) resulted in rather high increase in branch thickness and branchiness (11-42%), but led to improvement of average stem straightness (-7 – -16%). When trees were selected, stem straightness was considered more important than branch properties. The soil in Tests 3 and 4 is too rich to recommend for pine growth (forest type *Oxalidosa* is most appropriate for growth of spruce – Bušs, 1976). Together with low survival causes it increases the branchiness of pine. In comprehensive study of branch properties of Scots pine in Southern and Central Finland, Mäkinen (1999a, b) revealed that the branch growth is prolonged by rapid radial growth of stem. This consequently leads to delayed death of branches – they become thicker and natural pruning is slower. Also wider spacing (e.g. caused by high mortality – as in this case) delayed the reduction in branch growth and increased branch longevity.

That causes difficulties in correct evaluation of branch properties. However, more attention should be paid to branchy trees in future testing and they can not directly be used for propagation in seed orchards.

Conclusions

1. Mean height for Scots pine at the age of 32 years is 14.2-16.3 m, coefficient of variation – 10-17%, diameter at breast height – 13.1-17.7 cm, 24-32%, stem volume – 0.1-0.2 m^3, 49-64%, and diameter of thickest branch up to 2 meters of tree height – 1.3-1.7cm, 23%. It indicates a potential of improvement of mentioned traits along the tree breeding.

2. If average number of trees reaches 24, significant family differences can be detected. This number and average survival must be considered, when the planting of new trial blocks is planned.

3. Narrow sense individual tree heritability (h^2) is 0.11 for stem volume, 0.09 – for diameter at breast height, and 0.07-0.11 for diameter of thickest branch up to two meters of tree height.

4. Best families and individuals have been selected for further breeding process. Among-family selection resulted in breeding difference of 37% (80 m^3) in yield and of 18% in stem volume without causing any changes in quality properties. Combined among-family and within-family selection resulted in double increase in stem volume, improvement in stem straightness – 7-11%, but caused considerable increase in branchiness (11-42%). Therefore additional testing for the material is suggested before using it in further breeding or seed orchard establishment.

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References

1. Baumanis I., Gailis A., Liepiņš K. (2002) Priežu sēklu plantāciju pēcnācēju novērtējums (Evaluation of progeny of Scots pine seed orchards). Mežzinātne, 45, pp. 46-59. (in Latvian).
2. Bušs K. (1976) Latvijas PSR meža tipoloijas pamati (Basics of Latvian SSR forest typology). LRZTIPI, Riga, 24 pp. (in Latvian).
3. Bušs M. (1971) Kultūru biezums (Spacing of forest tree plantations). In: Bušs M., Mangalis, I. (eds) Meža kultūras (Forest tree plantations). Zvaigzne, Rīga, pp. 294–300. (in Latvian).
4. Costa e Silva J., Borralho N.M.G., Wellendorf H. (2000) Genetic Parameter Estimates for Diameter Growth, Pilodyn Penetration and Spiral Grain in Picea abies (L.) Karst. Silvae Genetica, 49 (1), pp. 29-36.

5. Denusevičius, J. (2000) Pušies selekcija: Monografija (Breeding of Pines: Monograph), Lietuvas Miškų Institutas, Kaunas, 351 pp. (in Lithuanian).
6. Eriksson G. (1998) Evolutionary forces influencing variation among populations of Pinus sylvestris. Silva Fennica, 32 (2), pp. 173-184.
7. Falconer D.S. (1981) Introduction to Quantitative Genetics, Second edition, Longman, London, UK, 340 pp.
8. Hannrup B., Wilhelmsson L., Danell Ö. (1998) Time Trends for Genetic Parameters of Wood Density and Growth Traits in Pinus sylvestris L. Silvae Genetica, 47 (4), pp. 214-219.
9. Jansons Ā. (2005) Distinguish Between the Effect of the Seed Material and Forest Type on Scots Pine Stand Productivity. In: Gaile Z., Špoģis K., Ciproviča I., Valters J., Alsins J., Bernhards A. (eds), Research for Rural Development 2005. 11 International Scientific Conference. LLU, Jelgava, pp. 227-233.
10. Jansons Ā., Baumanis I. (2005) Growth Dynamics of Scots Pine Geographical Provenances in Latvia. Baltic Forestry, 11 (2), pp. 29-37.
11. Kowalczyk J. (2005) Comparison of phenotypic and genetic selections in Scots pine (Pinus sylvestris L.) single tree plot half-sib progeny tests. Dendrobiology, 53, pp. 45-56.
12. Mäkinen H. (1999a) Growth, suppression, death, and self-pruning of branches of Scots pine in southern and central Finland I. Canadian Journal of Forest Research, 29 (5), pp. 585-594.
13. Mäkinen H. (1999b) Growth, suppression, death, and self-pruning of branches of Scots pine in southern and central Finland II. Canadian Journal of Forest Research, 29 (8), pp. 1216-1224.
14. Ruotsalainen S., Lindgren D. (1998) Predicting Genetic Gain of Backward and Forward Selection in Forest Tree Breeding. Silvae Genetica, 47 (1), pp. 42-50.
15. Shutyaev A.M., Giertych M. (2000) Genetic Subdivision of the Range of Scots Pine (Pinus sylvestris L.) Based on Transcontinental Provenance Experiment. Silvae Genetica, 49 (3), pp. 137-151.
16. Svensson J.C., McKeand S.E., Allen H.L., Campbell R.G. (1999) Genetic Variation in Height and Volume of Loblolly Pine Open-Pollinated Families During Canopy Closure. Silvae Genetica, 48 (3-4), pp. 204-208.
17. Velling P., Haapanen M., Napola M.-L., Ruotsalainen S., Venäläinen M., Viherä-Aarno A. (2002) The impact of genetically improved reproductive material on forest regeneration. Metla Project 3235. Available at: www.metla.fi/hanke/3235/index-en.htm, 01.03.2006.

EDUCATIONAL SCIENCES

TE POSSIBILITIES OF UPBRINGING STUDENTS' PATRIOTIC ATTITUDES DURING THE ACQUISITION OF THE COURSE OF STUDIES 'RURAL TOURISM'

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Abstract

After Latvia has joined the EU, all the positive social and economic changes make us to believe that students' personalities will be developed in the same positive way. Of course it should be admitted that any changes in young personalities can be strongly affected by the university study course, its aims and content. Joining the EU allowed many Latvian students to use the possibility of studying and working abroad, and many of them are already using this chance not even thinking about the future of their native region. The majority of LUA students come from province as do many more from other higher schools but they differ from the previous generations with their more dynamical and free vision and more constructive actions. At the same time the idea of students' responsibility and upbringing their sense of affiliation to their native regions becomes more relevant.

We investigated students' awareness of responsibility and civil maturity. The attention was paid to the development of students' patriotic attitudes during the acquisition of the course of studies at the institution of higher education. It is very important how a student's matured personality was developed. Love to the motherland was emphasized in Latvian pedagogy in pre-war years, but in our higher schools the idea of patriotic upbringing still remains at the very low level or sometimes does not even exist. The main objective for the higher schools management is initiating this process overwhelming student's drift away from their native district. The innovating rural tourism course for higher schools can be regarded as one of the possible instruments of patriotic upbringing.

Key words: study course, patriotism, civic maturity.

Introduction

Modern situation in Latvia should be regarded as controversial it seems that young people love their motherland, but still they leave the country in search of better education and higher income. The youth migration problem is not only pure economic, it has its educational and upbringing roots. The economic conditions play the major part exactly and the lack of motivation to return to their native region and work for its prosperity after courses in high school. That is why the development of students' patriotic attitudes and civil maturity during the acquisition of the course of studies at the institution of higher education was investigated. The question was whether learning at the institution of higher education hastened the development of patriotism and students' attitude to a student's native country. Our aim is to promote the development of a student's patriotic attitude. The content of the course of studies 'Rural Tourism' was investigated at the institutions of higher education in the regions of Latvia, the Baltic and the Northern Sea in previous years, the goals and directions were determined, the volume of the courses of studies were compared (Dunska,2005). The attention in this work was paid to students' patriotic upbringing at institutions of higher education. The Latvian educators J.Students, A.Kronvalds, P.Dāle, J.Greste and others paid attention to the questions of personal development and upbringing young generations. The Latvian educators and philosophers J.Osis, J.Kriškāns, K.Cīrulis, J.Asars, V.Dermanis investigated the questions of an individual development and upbringing In 1930s, Latvia faced the similar problem of young people leaving villages for big cities and there was a concern that it was all due to the lack of culture institutions in province. Also there was a concern that it could have been solved by establishing the national university (Students, 1931). Today the problem still exists but it seems that the scale has grown up. Regions are still miles away from the developed parts of our country despite the fact that there are many possibilities of taking part in different projects that will allow investing a great amount of EU money in the development of native districts. The tendency that is noticeable among Latvians who immigrated to other countries to prepare their children or grandchildren for returning back to Latvia faces the fact that our own young generation wants to leave the country and never come back. Latvian districts consist of everlasting cultural, natural and historical values, which should be preserved not only for Latvians but for the whole humanity. Here lies a great part for the Latvian youth which can appear to be civic matured and conscious. During the research the hypothesis was worked out, that it can be more successful if a rural tourism course includes all the patriotic potential parts civic conscience can be successfully unravelled if students have the possibility during the course to explore their native region's natural, cultural and historical objects and to take part in further explorations. In this way all the possible reasons to affect a student's attitude toward his own native district will be initiated. While the person

takes part in different social processes the civic maturity is transformed into the sense of high responsibility for one's country and people. The sense of affiliation unravels in different situations when students feel their unity with their native region, when the 'us' word appears (Hessens, 1929). And this is why it is extremely important to develop the native region identification to discuss every possibility of students doing something for their native land, to create region's development projects, and to propose decisions for relevant problems. Young man can even become an altruist towards its native land if the sense of affiliation appears. Students who associate themselves with their native region's problems and interests should be regarded as patriots. Unfortunately, nowadays more and more young people lose not only their identity but also their nature comprehension. But any activity which can be accompanied by the comprehension that this is our common home and that one's investment in it is a common care gives a good sense of affiliation. Taking care of one's native district is the affiliation certificate. During the course it is quite important for any young student to have a chance of taking part in the district social organization, problem analyzing and solution finding process, as well as taking responsibility for making decisions.

The majority of students, in fact, are well-educated and open-minded for activities the problem lies within their motivation of taking part in any social activity in their native region or in solving any relevant problems. Education should consist of essential elements that would give them the sense of affiliation with their native area and the sense of responsibility for it. The membership of Latvia in the EU has given our students the right to be European citizens, which also signifies unravelling new aspects of consciousness. Students become aware of the so-called European dimension, they receive new knowledge through new languages, social and other sciences. They have to understand Latvian cultural distinctive features within the multicultural European community. Young people from Europe were brought up as new European citizens despite the fact that they all understand and admit their national identification. From September 2006, the basic course 'The Local and Global Citizenship' will become an obligatory course in Northern Ireland (Northern Ireland schools, 2006). Respect to nature, culture, history and other national profusions will still remain among the important features in any education program. Several targets can be possessed: one of them should be the attitude and comprehension development, which will allow young people to identify themselves as citizens of the EU and their own country and to take part in the social life of their native region. This target as well as others can be integrated into the course of rural tourism in such a way that students of Latvian high schools could develop their civic maturity.

The aim of the work is to determine the content of students' civil maturity, to observe if the course of studies 'Rural Tourism' can be used as the teaching aid in students' upbringing. The task is to investigate the possibilities of the course of studies for upbringing, if it promotes the development of students' patriotic attitudes during the acquisition of the course. The development of the role of feeling of belonging in students' patriotic attitudes was promoted.

Materials and Methods

During the research 53 LUA students, who had chosen the rural tourism course were asked several questions. Thirteen indicators were used in order to comprehend students' attitude towards their native region's culture, nature and historical values. These themes are usually included in the content of the course of studies 'Rural Tourism'. The course of studies 'Ethnic Tourism' is offered for students of LLU. The Latvian rural tourism

is offered here as the potential of Latvian culture, history and nature (Pogulis, 2003). The course of studies

'Nature Study' was developed in this research and was studied in secondary schools where the foundations of the nature study research were studied. The students of LLU were chosen for this research, because they were offered the most voluminous course of studies 'Rural Tourism' – 10 credit points. We used empirical methods in this work – loading data in the database, written questionnaires because these methods give the largest volume of data and results during the pedagogical experiment. We worked out students' questionnaire with 13 questions, methods of mathematical statistics: descriptive statistics method and estimation of sample parameters. We have worked out the questionnaire which aim is to reflect students' attitude to their native land values. We have included questions about native land researchers, culture and historical objects in the native area, attitude to polluted environment, local lore, native area attraction as tourism object and knowledge of native land language peculiarities. The students' poll was conducted during the students' acquisition of the course of study 'Rural Tourism'. We used the Narrative Interviews – negotiations, when students expressed their thoughts, opinions about the study process and the content of the course of studies. The questions included into the questionnaire were connected with the Latvian man, environment, culture, history and natural resources.

The students' attitude to their own natural resources were found out.

Students evaluated their native environment during the time of research, small rural districts from the view of tourism attraction. Students' attitudes to the environment were found out and their opinions about the importance of these attitudes in an individual's life were determined. Students have to discover if they know about the protection of

historical monuments in their native land and about the research connected with the native land nowadays. Students' attitudes about life and work after finishing the institution of higher education on their native land were found out in the research.

The essence of student's educational progress is the embodiment of their conscious choice with the comprehension of one's duties comes a mature attitude towards oneself, others and the country, a student's self-realization spreads on the one's attitude towards Latvian nature, activity and culture. Obligations turn into the tasks, which can be successfully completed meanwhile perfecting one's sense of responsibility. Maturity should be regarded as the state of mind and body when they reach maximum of their capabilities. Students reach the so-called early maturity level (Tunne, 1997) when one of the important things becomes the kind of self-approval. Success in that sphere can be reached by creating an adequate system including moral values, behaving and action. During this period it is very important to support young people in completing their tasks and assignments which can help them to feel their actual possibilities and their maturity so that they could successfully and effectively work further.

Citizen's maturity is a kind of a student's personal attitude, which is accompanied with great amount of responsibility this determines student's conscious obligations in taking part in district's social happenings and in its constructive development as well as a student's probing and comprehension of processes among people and among people and the nature. It should be noticed that the psychological closeness and the sense of belonging to the native region, as well as the confidence in one's native country could not be underestimated. Citizen's maturity affects student's behaviour creating a basic for a conscientious, proper attitude full of respect towards one's native region and it has the following indications:

- the sense of responsibility for one's native region;
- the necessity of taking care of any environmental cultural or historical object;
- the necessity of taking an active part in district's social life;
- the aptitude for self-realization, the will of working for the good of one's native district.

Citizen's maturity and patriotism are very close concepts patriotism is related with the sense of belonging to one's native region or village, one's confidence in Motherland. The readiness to work selfless for one's Motherland defines patriotism itself. Selflessness helps to overwhelm any possible obstacles creating an emotional towards native region environment. Patriotism is a student's aptitude of refusing something for oneself and doing something for the nation and country. It is an internal conscious process which can be analyzed basically by observing one's behaviour. Patriotism is associated with deep and strong moral feelings which connect youth with its nation and Motherland, with national material and cultural values, with its language and the historical past. Students must comprehend the necessity of careful and preserved attitude towards the nature and cultural and historic profusions (Zelmenis, 1991). Patriotism can be examined with observations of any kind of one's social activity, one's educational aspirations and so on. The important role is played by a student's family where he receives the basics of such notions as love towards one's Motherland, region and patriotism.

The development of a student's personality comes in the self-relevant way in the process of effective and productive working. To remain independent and have the ability of independent judgment students must be able to create the distance between the society and themselves, to create an independent point of view from outside. Every student must be able on the one hand to create this distance inside and on the other hand to remain one's identification with one's nation outside this will give him the possibility to stay independent and continue one's growth. The development in the self-relevant way forces a person to create tasks and evaluate one's abilities, while the process continues until the possible maximum is reached during the process a student will face hard tasks and will have to use intense actions. If student's personality becomes integrated we should tell that the same thing must have happened with his environment, and if he feels good then he perceives the environment positively enough (Karpova, 1998). Young people often are curious and try to understand themselves and the environment they live in, they try to find their place in life and to strengthen their identification. The sufficient part of a student's nature is the will to find a fulfilled sense of life he is living in 'endless movement' and he is very open-minded, that of course helps to direct the process of unravelling the citizen's maturity. Education and self-education play the important role in the formation of responsibilities while education describes the process of student's personality formation, self-education comes from the inner process and has no visible limits (Hegel, 2000).

Students have to comprehend themselves in 'true' vision they have to learn how to learn and interpret the truth. And, basically, the interpretation is a more complicated process with its dialogs with nature and has more value than the knowledge itself. Students must evaluate their own conditions as the most important existential problem. Also during the educational process students collect the necessary comprehension experience. Kant, the widely known philosopher, assesses how far our faculties move us in answer to the questions: 'What can I know?' 'What ought I do?'

'What may I hope?' Kant analyses the capacities and limits of human mental powers, the theoretical or scientific understanding (Kant, 2002). These questions are still up-to-date in our modern society and especially in the environment of young and open-minded students. It is significant to indicate a finality or purpose, because people can be at the same time objects under the laws of the nature and free subjects of the moral law. We can rely on Kant's moral philosophy in this research: 'The human being can only become human through education'. Meanwhile, a student can derive important conclusions by just abstracting from certain situations or examples. The ability to abstract from something must be evaluated much higher than the ability to concentrate on a certain object it proves the independence of a student's mind, his ability to think widely and to manage his own notions and ideas. Kant notices the importance of student's beliefs first, person feels oneself, and only then he thinks (Louden, 2005). If a student does not check egoistically his own ideas and conclusions then he lefts himself without a chance of proving them to be wrong or right. And if he does not compare his conclusions with others then he cannot check whether they are right or wrong.

Consciousness allows expanding the comprehension from the actual existence to the universal concept. While it is working on creating something, it is creating oneself (Hegel, 2000). The idea of labour should be found among the process of creation, not the usability of the result. While working for the good of their native region students are transforming their own consciousness. The labour educates youth. It highlights the expansion from private interests to common the idea of working for the common good. While a student voluntary limits his own will and needs to work for the common good, somehow this common good transforms into personal good. A student must learn to find something personal that attracts him in that what is foreign and has nothing to do with him then the spirit of a person will be advanced in the development so that the personality could return to oneself from non-existence. A student controls the situation, knows the essence comprehends the situation, interprets it and uses his knowledge this is the way of spiritually developed personality. Comprehension of the truth is not only the method, but it is also a condition for further complex processes (Gadamer, 1999). It is impossible to work effectively without comprehending the truth.

A mature personality differs from an immature one qualitatively. Mature personality allows to work for the change of everyday happenings. If the upbringing task is to force students to change their attitude towards their own native regions then the concept will be to create a new motivation system instead of the old one. Changing the basics will allow to transform attention from peripheral motivation to basic motivation which will mobilize their creative abilities meanwhile directing them to the opposite direction from the idea of moving to a big city. The result of education will be a complete liberation form infantile motivation and students will begin their activities as matured personalities (Karpova, 1998). Mature personality will be able to work not only for oneself but for the common good of all society as long as maturity will signify the elimination of egocentrism.

Maturity also means that a person is capable of right comprehension and estimation, as well as to have an ability of a full load work in order to reach the target or to complete a project – a person can be oriented to the basic problem (the task is to create the result not to use the result). Maturity allows to know oneself, to estimate one's capabilities and limitations. Mature person tries to identify oneself in the society, meanwhile trying to preserve autonomy, he is ready to face problems that he will not be able to solve, he has the sense of direction from the very beginning and he is trying to construct his own life according to the models of self-esteem and self-realization concepts (Karpova, 1998).

This work consists of several educational methodological principles: corresponding to the nature, corresponding to culture and the regional research. During the educational process it is very important how a student as a part of a common biological system is affected by the laws of the nature. In higher school students are prepared for a nature-friendly professional activity. The nature can give answers for many questions, related with the personality's harmonious development. The nature keeps every young person full of spiritual and physical power allowing everyone to use it as a spring of positive emotions (Students, 1931). The nature up-brings the youth being full of attractive emotional and aesthetic diversity. In 1930s, Latvian students were advised to be good and honest, open-minded in private and social life, strong and with a bright vision. All this was proposed by the nature and possibilities of having a trip across Latvian regions and then abroad. It is necessary to travel and observe your own country it is the only way to become a patriot. If you know your country well enough, then you will have something in your heart that will support your spirit and raise your love to Motherland (Kronvalds,1987).Young people are often ask for independence just for their spiritual freedom. They search answers abroad a long way from home and their native region. The principle to be corresponding to the nature is one of the methodological instruments for youth educational purposes. By realizing this principle we can achieve a reinforcement of spiritual connection with a native region or village. The principle to be corresponding to culture connects educational process with social and spiritual life and

its derivative products. Humanity has created culture and still it is creating every personality. The principle of regional research should be regarded as a main factor in the pedagogical maturity development of citizens. It is regarded as an educational and upbringing unit. The regional research cannot be considered only among historical researches it should consist of nature, culture and economical objects in the certain region.

It is impossible to love or like something that you have never heard or seen before. It is necessary to have a picture in your mind before it, it is essential to up-bring during the educational processes a new generation of patriotic youth with its respect and comprehension of historical and contemporary happenings, with its acceptance of traditions and respect towards Latvia and their native regions. This principle connects the knowledge and processes related to it with physical vicinity researches, which also direct self-educational processes. In Latvia, in 1920-30s, this method was realized by Arnold Shtokmanis. He stated that it is insufficient to use only cultural and historical facts during the educational process the additional element was the ability to find similarities and to state the role of students' native regions in the common process of cultural and historical development. The accents were made on native regional cultural and historical research and data collecting which should have been used further as a base for future education. Shtokmanis encouraged students to collect all the data about their region from all existed primary sources students should have collected and analyzed all the information so that they could have restored the connection between them and their native region, its social and cultural life. He also recommended getting to know the history of the region, as well as their ancestors' lives and their vivid witnesses. He proposed students to study their native regional history and culture more intensively. Students who study the course of rural tourism today should execute several research projects based on the idea of popularization, conscious utilization and preservation of regional historical, cultural and spiritual profusion. They can collect all the data needed to develop a route map for rural tourism with all the information on the most important natural, cultural and historical objects. It should reflect all possible national and native originality and characteristics, demonstrating its particularity in ethnos connections and cultural cooperation and interaction. During the course students should get to know the basics of regional architectural particularities. The course should contain the information about the regional nature, cultural events, and description of the traditional way of living and historical course of events. Developing this course it is advisable to use the methodology of collecting the necessary information developed by Shtokmanis (Millers, 2003).

Results and Discussion

The students' attitude to the culturally-historical wealth of the native land was found out during the time of the research. This research is connected with those students who have chosen the course of studies 'Rural Tourism'. During the interviews it was found out if the student had the feeling of belonging to their native land, small rural districts. About 95 % of the students claimed that it was very important to them. It was questioned what influenced on the development of the sense of belonging. Cultural events, the assistance and taking care about their own land, meetings with popular people of their land were the most often things mentioned.

Latvian pedagogy in 1920-30s accentuated the effort on the 'love to Motherland' theme the upbringing was based on collecting previous generation's knowledge and work. Apart the work the main course consisted of ethics and national patriotic upbringing. During week-ends there were specially organized collective trips across Latvia. Young people got to know about their father's land, its history, writers and other famous people, who retained their national identification. The essence of the existed patriotic upbringing was emotionally approved notion and comprehension of Motherland. It consisted of the nature, native habits and knowledge of one's native district. Young people were taught how to live in the Latvian way but much more was done to stop the flow of people from villages and regions to big cities or even abroad. From the very beginning, Latvian children were up-brought as scouts – the typical representatives of rural youth. The content of scouts' classes was – the practical trend of the agricultural areas, craft, housekeeping. Upbringing on the base of civil patriotism and similar world outlooks are the common features of scouts. These organizations provided children with much needed information about their native regions peculiarities and the way they could help to preserve their village or region from disappearance in the future. During the Soviet period it was quite a rare situation when the feeling of national identification could have been created. In 1930s, collective rural education was widely spread across the country, while in the USA it was quite a popular organization since 1900. The American government supported these kinds of organizations saying that it is extremely important for a young man to grow up in accordance with the nature. Work is a task and an instrument at the same time to up-bring students, developing their possibilities and peculiarities. Young people are regarded to be from 14 till 25 years old with the period of the late youth starting from 15-18 years old. Youth is a period of searching the sense of life and common existence. It is regarded that during this age they should be taught to evaluate their own decisions and actions. They even should be pointed at consequences of their decisions

and shown or proposed to start a discussion on what could have happened if they had have made other decision. The discussion about what can happen to their native region, district or village if they don't care about it should be wide open.

In order to initiate citizens' maturity development the didactic model of the course of rural tourism has been presented which will be the educational and the upbringing unity. During the period of the course the basic part of the above mentioned didactic model will consist of:

- self-upbringing (will be included into the program of rural tourism course) – the EU citizens' obligation and responsibility for one's native region preservation, protection, development and progress. Real upbringing is a self-upbringing (Students, 1998);
- self-education (student's education process in tourism) the plunge into the culture in order to inherit the mental experience and to educate the society (Bakhtin, 1994). Students always have an option to use the experience and knowledge they gained during the educational process in higher school or to be directed by one's active initiative. Students must not be satisfied with the knowledge level they gained from others.

The model was created and then updated basing on information from different pedagogical observations and experiments in the higher school, and on Latvian and non-Latvian didactical and methodical material based on the latest gained experience. Its development is based on several principles: corresponding to the nature, corresponding to culture and regional research. Of course, there is the possibility of the appearance of already foreseen problems: the content of the course must be sorted in some kind of way in order to attract students and raise their level of respect towards their own native regions, its natural, cultural and historical profusions. There should be always a place for the philosophical approach – a student's essence must be explored and examined in order to create a complete course which will meet their needs. In 1920 - 30s, Latvian education included a special course called "Environment Science" where students were able to connect cultural, natural and historical elements. As an additional task we can regard the possibility of unravelling within the students' consciousness not only a certain positive attitude towards nature, but also the same positive attitude towards the native region. By using the available cultural and historical heritage including folklore, writers' and musicians' works it is possible to create the needed attitude towards their native region, to create a comprehension of that everyone is a part of a grand total and to raise a necessary level of citizen's maturity.

Our country has many attractive places, historical monuments and ethnographic peculiarities – all these things should be regarded as the necessary matters in or-

Table 1

Students' attitude towards their native region's culture, nature and historical values

Indicators to comprehend students `attitude to the native land, culture and historical wellness	Positive	Percents
Can specify native land discoverers and cultural workers	29	54 %
Know interesting places of nature, cultural and historical objects	52	98%
Are worried that many places in Latvia have unspruced environment	51	96%
Studied subject 'Nature' in secondary school (optional course)	10	19%
Positively value the attractiveness of their land from tourism point of view	46	87%
Are sure that spruced landscape has great influence on human life	50	94%
Interested about tourism object protection	38	72%
Know own native language's peculiarities	33	62%
Can specify authors or prose work where their native land is depicted	28	53%
Think that nature objects are protected in their native land	36	68%
Know that people in their native land make discovery work	27	51%
Are sure that there are many reasons why students should stay in their country and not leave abroad	40	76%
Take active part in cultural life of the native land	46	87%

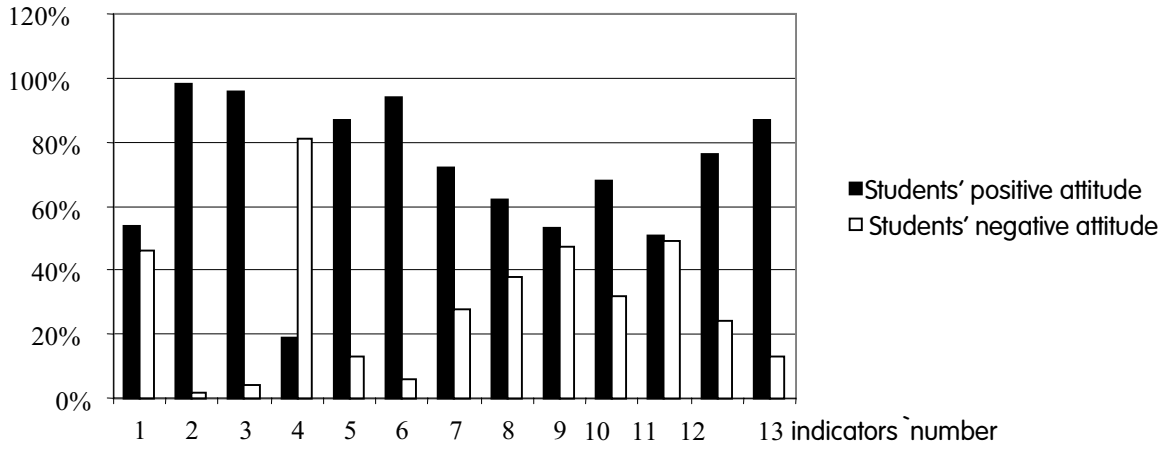

Figure 1. Attitude to the native land, culture and historical wellness in percent.

der to know the educational contents for the successful development of the course of rural tourism. Latvian students despite their interest towards the Latvian history and culture consider patriotism and education to be internal family processes – and all the information they get there is regarded as sufficient. It is very important what exactly students feel towards their native region. Generally, students concentrate on their families and education, leaving out their Motherland and native regions – this is not the far-sighted tactics. The well-based civic maturity cannot be developed without national holidays and daily life traditions. It means that a student represents one's region not only mutually but also by doing something (Vēbers, 1998). Youth is the main force that decides the destiny of regions and the country. The educator Anna Zeidare investigates the situation when Latvian young people easily leave the native country for another one bringing with them their own culture which they have accepted (Zeidare, 2004). She admits that the attempt to stop this tendency by creating a wealthy society is a very big mission of the whole country. The period of a student's life is full of creative processes that can be used for the good of a student. Higher schools should be at the first place among many educational establishments where a student can obtain the comprehension of the civic maturity, its benefits, and in such a way creating the whole social group whose main goal will be the economical and cultural growth of the native land.

Conclusions

The author of the research concludes - the students who have chosen the course of studies 'Rural Tourism' are worried about the future of their native land. They take part in different cultural events on their native land, they are proud of the cultural and historical monuments on their land. The sense of belonging to their native land is important to them. Discussions with students prove that the course of studies 'Rural Tourism' is interesting to them, many of students believe that the obtained knowledge will be useful for them in their future life.

One on the base of the obtained results can conclude that the content of the course of studies 'Rural Tourism' can widen the students' knowledge about the cultural values of their land, the importance of historical objects on their native land in their life. Discussions with students prove that many students have changed their attitude to the old castles, parks on their native land. They recognize them not only as the significant culturally-historical objects but also as the perspective objects for rural tourism. Many students have written course works and projects devoted to significant historically-cultural objects of their native land. Students worked out new tours and have presented them. It is indisputable that during one term it is difficult to change a student's attitude to the native land but the results show that positive changes occur. Students' patriotic upbringing will be much more successful if the patriotic potential is included into the course of studies 'Rural Tourism'. It is important to conduct the cooperation with the leadership of the institutions of higher education and maybe at the higher level. Necessary support is needed also from the government side, because pedagogy influences also politics and culture. Pedagogy depends on many factors, because politics and government dictate the policy of education. Higher school practice is mainly focused on intellectual activities, sometimes this process has the narrow direction, leaving mass culture science and will for education, the expression of the emotional sphere. Education lifts the student's culture; it also ensures only tools for culture, nature perception. During the time of study in higher school students can be brought up to change their attitude to the native region, and this can result that people stay in their lands

and do not leave abroad, because there is a critical situation in Latvia. Native land gives many goodies, brings to the cultural life, the closest link with the Mother land is in language, history. Students should respect these values and love them. The patriotism should be developed greatly, the patriotism of the native land, respect of traditions and historical values. This will lead to the sense of responsibility for native land and develops citizens' maturity. Discovery of the native land, learning history is students' patriotic tool. This is long-term knowledge, ethical values, this also develops a sense of respect to the heredity of previous generations and motivates citizens' maturity.

References

1. Bakhtin M. (1994) The Bakhtin reader: selected writings of Bakhtin, Medvedev and Voloshinov. Arnold, New York, 262 pp.
2. Dunska I. (2005) Study course 'Rural tourism' in higher educational establishments. Jelgava. 250-255 pp.
3. Dunska I., Luse N. (2006) Rural Tourism as Study Subject at Universities. Jelgava. (nodots publicēšanai), 15 pp.
4. Gadamer H.G. (1999) Truth and Method. London, Continuum. 366 pp.
5. Hegel G.W. (2000) Vorlesungen ueber die Philosophie der Geschichte. Nauka, S-Peterburg, 477 pp.
6. Hessens S. (1929) Paidagoģikas pamati. Zinātniskās izglītības teorija (Basics of pedagogics. Educational theory of science) Rīga. O.Berga izdevniecība. 253 pp.
7. Kant I. (2002) From Kant to Levi-Strauss. The Background to Contemporary Critical Theory, Edinburg Un-ty Press, Edinburg, 256 pp.
8. Karpova Ā. (1998) Personība. Teorija un to rādītāji (Personality. Theory and Indices). Zvaigzne ABC, Rīga, 223 pp. (in Latvian).
9. Kronvalds A. (1987) Tagadnei (For the Present Purposes). Liesma, Rīga, 300 pp. (in Latvian).
10. Louden R.B. (2005) The second Part of Morals: Kant's Moral Anthropology and its Relationship to his Metaphysics of Morals. Un-ty of South-Maine. Available at: www.cle.unicamp.br/kant-e-prints/ articles.htm, 20.02.2006.
11. Millers T., Cimermanis S. (2003) Skolotājs un novadpētnieks Arnolds Štokmanis (Teacher and Local Lore Investigator Arnold Shtokmanis). LZA vēstis. Volume 58, N3-4, pp. 58-66. (in Latvian).
12. Northern Ireland schools. (2006) Available at: http/www.bbc.co.uk/northernireland/schools/
13. Pogulis A., Lūse N. (2003) Lauku tūrisms (Rural tourism). Jelgava. 12 pp. (in Latvian).
14. Students J. (1931) Jaunatnes psiholoģija (Youth Psychology). Mazpulks, 2, pp.1-2. (in Latvian).
15. Students J. (1931) Ko vēlamies no mūsu lauku jaunatnes? (What do we wish from your rural youth?). Mazpulks, 1, pp.3-4. (in Latvian).
16. Tunne I. (1997) Studējošas jaunatnes vērtību orientācija Latvijā (Values Orientation of the Latvian Youth). RaKa, Rīga, 143 pp. (in Latvian).
17. Vēbers E. (1998) Pilsoniskā apziņa (Civil Consciousness). IU Mācību apgāds, Rīga, 320 pp. (in Latvian).
18. Zeidare A. (2004) Rietumu trimdas latviešu pedagoģiskā doma (Latvian Pedagogical Thought Development in Western Exile). RaKa. 332 pp. (in Latvian).
19. Zelmenis V. (1991) Īss pedagoģijas kurss (Brief Course of Pedagogics). Zvaigzne, Rīga, 213 pp. (in Latvian).

INDICATIONS OF PUPILS' COMPETITIVENESS

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Abstract

The ongoing globalisation and integration processes increasingly influencing the different social processes, including the situation in labour market, have raised up the topicality of the necessity in education to develop competitiveness of the society in general as well as of every individual. Several documents of international and national importance provide evidence for such an assumption. Education is to become the precondition, process, result, and tool for the development of competitiveness of an individual. This promotional process should be based on scientific research as well as become a part of the duties of every educator. Therefore it is important to scientifically substantiate the conceptual notion 'competitiveness', differentiating between its structure, components, and features. The authors of the present paper have found the theoretical background: 1) theoretical substantiation of the concept of competitiveness in the researches by scientists from Western countries and Russia; 2) appropriate definitions of the concept 'competence' for research of pupils' competitiveness.

Key words: pupils' competitiveness, competences.

Introduction

The processes of globalisation and integration have a direct impact on today's development of education, and they also determine the aims of today's education to a great extent. The education system in Latvia is also currently going through a transition period, therefore it is of great significance to give real input to arrive at the best possible solutions in the future education environment and system. An attempt to determine the factors that form the environment in which a regular schoolchild has the most opportunities for personal growth, developing their competencies and recognising their flair for particular things has been made.

In the Lisbon strategy (Lisbon strategy, 2000) there has been emphasised the idea of education to be regarded as one of the main assets leading to progress. Education becomes the main precondition to make European Union (EU) 'the most competitive and dynamic knowledge based economy in the world, which is capable of independent economic growth, more and better workplaces, and closer social cooperation'.

Therefore 'knowledge society' or 'society that learns' is one of the basic aims of education of Latvia – an EU memberstate. Education is not only process and result, it is also an important tool to ensure the society's sustainable development and increase the level of welfare in today's changing environments. Education is characteristic feature/quality/indicator of a society that learns as well as of every its individual as a personality.

In the 'Education development conception for the years 2006–2010' issued by the Ministry of Education and Science of the Republic of Latvia (Pamatnostādnes..., 2006) there is defined the aim of the contemporary education in Latvia: it is to 'model a balanced education system that the lifelong development of a society that is knowledge based, democratic and socially integrated, contributes to the raise of competitiveness of the inhabitants and economy of Latvia, aligning with the European education area, and at the same time maintaining and developing the cultural values characteristic of Latvia'.

The authors think that competitiveness of all society can be achieved only by developing and improving competitiveness of every its individual.

The development and improvement of competitiveness of today's younger generation can be provided only in a competitive educational environment, which is possible only by ensuring a balanced development and quality of educational environment both in cities and rural areas of Latvia, not regardless of Latvia's – EU memberstate's –educational environment. The researches of Katane (2005; 2006) have shown that nowadays due to the processes of globalisation as well as of localisation the educational environment of Latvia develops unequally and is of heterogeneous character. Special attention should be paid to the development of the educational environment of rural areas, including rural schools. Nowadays the topicality is still on competitiveness development problems of the new generation in rural areas. These problems are closely connected with the provision of sustainability and quality of educational environment of rural schools. Solving of both of these problems may contribute to integration of rural school pupils in the educational environment of city higher educational establishments, not excepting the educational environment of the Latvia University of Agriculture.

The authors of the present paper have launched a new research on the development of the competitiveness of high school pupils in the rural school educational environment. The aim of the research described in the present paper is to develop a theoretical background of the category 'competitiveness', as well as diagnostics of the

connection between development of pupils' competencies and promoting of the development of their competitiveness. The authors offer an insight: in the theoretical background of the terms 'competitiveness' and 'competence', in the results of researches on the development and assessment of the competences of rural school pupils as indicators of their competitiveness, which were carried out in Latvia.

Materials and Methods

Methods of the research include studies of scientific literature and reflection of personal pedagogic experience. The authors have a great deal of substantial experience in working with pupils as well as experience in managing a project for Secondary and high school children.

The Scientific Substantiation of Competitiveness in Education

The formation and development of the labour market in today's society postulates high requirements in the field of education for the new generation. Nowadays the diploma of acquired comprehensive secondary education with high marks does not guarantee the further education of the young person in higher educational establishments. Similarly the graduates of professional higher educational establishments not always are capable of securing themselves with a workplace according to their profession and compete in the labour market. Nowadays the labour market evolves salutatory, and its development is not of systematic character. And such conditions have an impact on the supply of education, including the sustainability and programme diversity of schools and higher educational establishments.

Nowadays particular attention in school education should be paid to motivation of pupils for further education, and choice of education programmes and higher educational establishment environments that would meet their interests and needs. As it was pointed out by the Russian scientist E.Ionina (Ионина, 2003), competitiveness of the young should be examined in two aspects:

1) the acquired professional competencies, and value and competitiveness in the educational and/or professional activities and

2) personal qualities that witness of readiness for life, self-development, and self-actualisation in the conditions of changing social environment.

In the education process it is quite possible to promote the development of pupils' competitiveness only if the many-angular conceptual notion of the term 'competitiveness' is deciphered and scientifically substantiated.

The defining of the conceptual notion of the term 'competitiveness', its structure and characteristics in the field of education is one of the top research topics in many countries, including Russia (Борисова, 1996; Гарафутдинова, 1998; Митина, 2002; Широбоков, 2000; Фатхутдинов, 2000). 'Competitiveness of personality' and 'the development of a competitive personality' is also studied by scientists in Western countries, including representatives of the discipline of comparative education (Cook et al. 2004; Epstein et al., 2005; Keith Olson, 2006; Mestenhauser et al., 2005).

Our theoretical research shows that in the field of education there is no single and universally agreed definition of competitiveness. Each author defines and explains competitiveness from their point of view, regarding their professional operation, field and/or context of the conducted research.

Nevertheless in the field of education it is possible to differentiate between two tendencies of defining the competitiveness of an individual.

1. Specialists and scientists in the field of economics as well as in other fields of research have been trying to transfer the defined concept of 'competitiveness' from other fields to the field of education adjusting and adapting it to the humanitarian character of the science of pedagogy. There are several examples to be mentioned.

The two scientists - N.Garafutdinova (Гарафутдинова, 1998) and J.Tarakanova (Тараканова, 2004) - working independently from each other in their publications have substantiated the parameters of a competitiveness of an individual. Both authors write that the definition of the competitiveness of a product should be used in defining the competitiveness of an individual. They hold a view that competitiveness of a product is determined by the total of the qualities the product possesses, and that allows to distinguish between the qualities of a particular product in comparison with other products or goods. The total of the product qualities consists of three groups of elements: technical, economical, and socially organisational indicators. Following groups of parameters are obtained when applying these groups of parameters to the characteristics of the competitiveness of the next professional. Technical – profession and specialisation. The amount of the mastered programmes measured in hours. Compliance with the national standard. The area and limits of utilisation of the acquired profession, the diversity of the environment of the professional operation of a specialist, as well as the acquired diploma. Economical – the resources that have been invested in the preparation of a specialist, including the resources for job search and mobility increase of the labour force. Socially organisational – record keeping of social structure of the consumers, as well as register of the national and religious peculiarities of organisations. N.Garafutdinova (1998) and J.Tarakanova (2004) emphasises that the record of these elements will enable the

increase of competitiveness of the graduates of schools or higher educational establishments in the education and labour market.

N.Garafutdinova (Гарафутдинова, 1998) differentiates between following features in the pattern of the competitiveness of an individual:

1) the importance of aims and personal values;
2) attitude towards work;
3) creative approach to work;
4) ability to take reasonable risks;
5) independent decision making skills;
6) ability to be a leader;
7) capability of unremitting self-development;
8) willingness to improve professional skills;
9) willingness to achieve high results due to one's operation;
10) stress resistance.

S.Shirobokov (Широбоков, 2000), comparing the preparation quality of professionals in Russia and in the USA, in his article defines competitiveness as reliance on one's own abilities and initiative, enabling the individual to overcome the psychological barrier, depression and pessimism; competitiveness is what gives one the opportunity to find ways of tackling problems.

2. The representatives of the education science are beginning to elaborate on the theoretical background of human competitiveness, trying to find grounds in the contemporary conceptions and theories of the education science as well as in definitions of competitiveness formulated by scientists in other fields of science (utilisation of transfers).

Being aware of the results of theoretical research, the authors think that the scientists of pedagogy that are examining the processes of contemporary education system are trying to define the term 'competitiveness', not focussing only on egocentric way of thinking and acting in the social environment, but more using the ecologic and humanistic approach. The definitions of the second approach show attempts to complementary unite the ego- and eco- approaches in the human thinking and acting, as well as to respect the interdisciplinary approach in research. Some of the definitions of competitiveness are given in the next paragraphs.

B.Parigin, a representative of social psychology (Практикум по социально-психологическому тренингу, 1994) writes that competitiveness is a body employing its own resources – psycho-physical health, age, appearance, abilities, flair, level of intellect and energy reserves, and the aspects of morality – the hierarchy of values, the system of beliefs, prohibitions and personal restrictions. B.Parigin differentiates between following elements in the structure of competitiveness:

1) the psycho-physical element;
2) the element of values, beliefs, inner/outer prohibitions and restrictions;
3) the element of one's professionalism;
4) the element of psychological readiness to participate in competition.

Whereas V.Andreev (Андреев, 1998) points out on 10 elements in the structure of competitiveness of an individual: the element of needs and motivation; the element of business/constructive activity; the element of self-organising; intellect; will; the element of culture; ethics and morals; self-esteem; the element of one's psychological structure; the element of communication.

The authors of the present paper, backing their ideas with theoretical research, offer their definition of 'competitiveness': competitiveness is the integrative totality of the inner resources of a personality that determines their ability in the environment in today's changing society to elaborate on a precise self-development programme, and preparedness to purposefully implement this programme at a short notice developing, realising and actualising of one's self; (regarding the humanistic and ecological way of thinking and action that is determined by system of values and personal characteristics that has arisen as the result from the upbringing and moral development, and enables individual's choice of action and/or cooperation and co-working in tackling problems); the indicators and the resource of competitiveness are the acquired competencies and their exploitation in the activities carried out by the individual, as well as responsibility in front of one's self and others for the made decisions and purposeful implementation of those decisions.

Competencies as the indicator of the development of pupils' competitiveness

After having carried out the theoretical research, the authors can say that in studying, evaluating and promoting the development of pupils' competitiveness pedagogues must not disregard the notion of pupils' competencies. We think that competencies are an important precondition, indicator, and result of the development of competitiveness.

The European education information network EURYDICE, with Latvia also participating in it, has launched three publications: 'Key Data on Education in Europe, 2002', 'Key Competencies: a recent term in the comprehensive obligatory education, 2002', and 'European Glossary on Education: The Administrative, Monitoring and Support Personnel, 2002'. These publications indicate that many European countries face the new term in the field of school education key competencies. In the publications mentioned above the notional meaning of the term has been substantiated as well as the topicality and importance of compe-

tencies in the development of competitiveness of the different societies, including the new generation of the EU.

A.Eickhorst (Eickhorst, 1998) supports the category of competencies, emphasising that a competency is a manifest of substantiated proficiency, responsibility for action, and the ability to make independent decisions. 'Humans are inclined to competency, but achieve it only through learning.' Hence the scientist emphasises that competency is the level of quality of the subject activities, associating it with proficiency, independence, and responsibility.

The professor of the Latvia University of Agriculture, Dr. paed. B.Briede (Briede, 2003; 2004a; 2004b) indicates that according to her findings competency is a very complicated concept: one word often combines two polar evaluations – competent or incompetent. The scientist emphasises that in order to characterise competencies elements as 'knowledge', 'experience', 'skills', and 'reflection' are often mentioned. It is typical of 'competency being determined by the way knowledge and skills are manifested in real action. Competence is associated with fulfilling of certain duties, the person is held responsible for – hence they must possess sufficient knowledge and skills'. B.Briede (Briede, 2004a) defines competency as 'the total of knowledge, skills, and the ability of reflection that are supported with a document and can be verified, and appear through certain activities performed by an individual according to agreement to do so with initiative and sense of responsibility'. It is very important to master skills of adapting one's self in the changing environment. As the result of the theoretical research on competencies, the scientist distinguishes several aspects of the study of 'competency' that mutually overlap:

1) there is a complex connection between knowledge, skills, reflection, and creativity;

2) in order to prove one's competency willpower and responsible activity is of importance;

3) competency can be proved documentary and/or through action.

The European Council has defined five main competencies the new generation should acquire while learning at school (Briede 2003; Hutmacher, 1997):

1) political and social, e.g. to bear responsibility, participate in the decision-making within a group;

2) solve conflicts in a non-violent way;

3) preparedness for life in a multicultural society, e.g. accept customs, languages, and religions of different nations;

4) oral and written communication, e.g. having a good command of more than one language;

5) ability to live in the information society, e.g. to be able to use information technologies for acquisition of information;

6) critical evaluation of information, especially in the mass media;

7) preparedness for lifelong learning.

In the context of evaluating and promoting the development of pupils' competitiveness there is one more definition to mention. Competency as preparedness for life has been studied and supported by J.Stabins (Stabiņš 1998) in his promotional work, saying that competency is 'the total of personal skills and attitudes, that manifest in achieving the goals of life and satisfying of one's needs'. The author does not emphasise the role of knowledge in achieving these goals, but stresses the essential personal characteristic features that indicate on readiness for certain action in one's life, and that is developed through a pedagogic process: '(..) personal independence (constructive and creative choice of life values), responsibility, self-actualisation, that seeks for productive communication'. The scientist actually expresses the idea of different levels of quality of actions of an individual (the level of independence and responsibility), and also he emphasises the importance of communication and cooperation in developing competencies.

Conclusions

- One of the topicalities in the contemporary educational environment is to create the scientific substantiation of the category 'competitiveness' in the context of society of individuals, personalities. Such substantiation is important in the research and evaluation of the ongoing processes in the education systems.
- There is no single and universally agreed definition of the category of competitiveness. In developing the theoretical background of the category there are two main trends being followed: 1) deriving new definitions, concepts, and theories from the already existing ones in the field of economics; 2) developing the theories of competitiveness basing on the concepts, theories and ideas of the authors of evolutionary, social, and human psychology and pedagogy.
- Within the field of education the term 'competitiveness' is closely connected with the term 'competency'. The elements and characteristics of the competitiveness are highly correspondent with the elements and characteristics of competencies. Both competitiveness and competency is the total of characteristic features presented by a person that can be evaluated during their operation in the social environment.
- In the development of the pupils' competitiveness much of the emphasis is to be put on the development of the key competencies, including also the development of learning and social competencies in order to prepare the next generation for living, integration, and self-realisation in the democratic

society, where the skills of cooperation and co-working are essential.

- Competitiveness has many different characteristics including knowledge and learning skills. The pupils' study results (including the level of study progress) can also be seen as one of the characteristic features of competitiveness, and serve as an indicator when evaluating the development of the competitiveness of an individual.

References

1. Briede B. (2003) Kompetences iegūšana augstskolā Mūžizglītības memoranda kontekstā. (Acquisition of Competence in a Higher Educational Establishment in the Context of the Memorandum on Lifelong Learning) Starptautiskās zinātniskās konferences rakstu krājumā „Lauku vide. Izglītība. Personība". Jelgava: LLU IMI, pp. 223-227. (in Latvian).
2. Briede B. (2004a) Education for Getting Competence from Constructivists Perspective in the Context of Environment". Research for Rural Development 2004. Latvia, Jelgava: LLU, pp. 215-221.
3. Briede, B. (2004b) Problems of Reaching Competence During Studies at a Higher School. Journal of Science Education. Vol.5 No.1., pp. 8-12.
4. Cook B.J., Hite S.J., Epstein E.H. (2004) Discerning Trends, Contours, and Boundaries in Comparative Education: A Survey of Comparativists and Their Literature. Comparative Education Review. Available at: http://www.questia.com, 13.12.2005.
5. Eickhorst A. (1998) Selbststtatigkeit im Unterricht. (Self-education) Munchen, 216 pp. (in Germany).
6. Epstein E.H, Carroll K.T. (2005) Abusing Ancestors: Historical Functionalism and the Postmodern Deciation in Comparative Education. Comparative Education Review. Available at: http://www.questia.com, 02.12.2005.
7. European Glossary on Education. Management, monitoring and support staff. Volume 4. (2002). Eurydice: The Information Network in Europe, Brussels, Belgium. Available at: http://www.eurydice.org/Documents/Glo4/en/FrameSet.htm, 15.04.2006.
8. Hutmacher W. (1997). Key Competencies in Europe. European Journal of Education, Vol. 32, No.1, pp. 45-58.
9. Katane I. (2005). Lauku skolas kā izglītības vides izvērtēšanas modelis. (Evaluation Model of a Rural School as Educational Environment) Promocijas darbs pedagoģijas zinātnes skolas pedagoģijas apakšnozarē. Daugavpils: Daugavpils Universitāte. Available at: http://www3.acadlib.lv/greydoc/Katanes_disertacija/Katane_lat.doc, 26.03.2006. (in Latvian).
10. Katane I. (2006) The Impact of Globalisation on Sustainability of Rural Schools in Latvia. The International Conference „Education Policy Transformations: Migration, Borrowings, Glocalisation". Vilnius: Vilnius University, Lithuania. Available at: http://www.svietimas.lt/konferencijos/, 07.03.2006.
11. Stabiņš J. (1998) Audzēkņu gatavības veidošanas dzīvesdarbībai komercskolas pedagoģiskajā procesā. (The Development of Preparedness for Life through the Pedagogic Process of Riga School of Commerce) Promocijas darbs. Rīga, LU PPI, 179 pp. 29.-30 (in Latvian).
12. Keith Olson G. (2004) Youth Personality Typs. Available at: http://www.vanishingcookies.com/kensapp/youthministry/ym_youth_personality_types.html, 05.10.2006.
13. Key Competencies: A developing concept in general compulsory education. (2002). European Comission: Directorate-General for Education and Culture. Eurydice: The Information Network in Europe, Brussels, Belgium. Available at: http://www.eurydice.org/Documents/survey5/en/FrameSet.htm, 15.04.2006.
14. Key Data on Education in Europe. (2002) European Comission: Directorate-General for Education and Culture. Eurydice: The Information Network in Europe, Brussels, Belgium. Available at: http://www.eurydice.org/Documents/cc/2002/en/CC2002_EN_home_page.pdf, 15.04.2006.
15. The Lisbon strategy: a more competitive Europe, with more and better jobs. (2004) European Parliament. Available at: http://www.elections2004.eu.int/highlights/en/1001.html, 09.01.2006.
16. Mestenhauser, J.A, Ellingboe B.J. (2005) Leadership Konowledge and International Education. International Educator. Available at: http://www.questia.com 07.03.2006.
17. Pamatnostādnes „Izglītības attīstības koncepcija 2006.-2010.gadam". (Education Development Concept Paper 2006-2010) (2006) LR IZM. Available at: http://www.unesco.lv/custom/izgl_attistibas_koncepcija.pps., 26.01.2006. (in Latvian).
18. Андреев В.И. (1998) Педагогика творческого саморазвития: Инновационный курс. Книга 2. (Pedagogy of creative self-development. Innovative course. Volume 2.) Казань: КГУ. 318 с. (in Russian).
19. Борисова Н.В. (1996) Конкурентоспособность будущего специалиста как показатель качества и гуманистической направленности вузовской подготовки. (Competitiveness as an Indicator of Quality and the Specialisation of Humanities in the Higer Educational Preparation of the Future Professional) Набережные Челны. Available at: http://bspu.secna.ru/Journal/pedagog/pedagog_6/a12.html, 12.03.2006 (in Russian).
20. Ионина Е.С. (2003) Формирование конкурентноспособной личности в современных условиях. (Formation of a Competitive Personality in the Environment of Contemporary Society) Available at: http://college.biysk.secna.ru/konf2003/ionbarn.htm, 20.03.2006. (in Russian).
21. Гарафутдинова Н.Я. (1998) Конкурентоспособность будущего специалиста высшей квалификации как показатель качества его подготовки. (Competitiveness as an Indicator of Preparedness of the Would-be Professional with the Higher Education) Вестник Омского университета, (1), 76-78 с. (in Russian).

22. Митина Л.М. (2002) Психология развития конкурентоспособной личности. (Development Psychology of a Competitive Personality) Москва, Воронеж: МПСИ. 268 с. (in Russian).
23. Практикум по социально-психологическому тренингу (1994) (Practice of Social-Psychology). Под ред. Б. Д. Парыгина. СПб: СКФ "Россия-Нева". 174 с. (in Russian).
24. Тараканова Е.В. (2004) Формирование конкурентоспособности специалиста на этапе профессиональной подготовки**.** (Development of Competitiveness – the Phase of Acquiring Professional Education) Available at: http://journal.seun.ru/J2004_1R/Socio/Tarak.doc, 10.03.2006. (in Russian).
25. Фатхутдинов Р.А. (2000) Конкурентоспособность: экономика, стратегия, управление. (Competitiveness: Economy, Strategy, Management) Москва: ИНФРА; Воронеж: НПО МОДЭК. 312 с. (in Russian).
26. Широбоков С. (2000) Оценка качества подготовки конкурентоспособного специалиста в России и Соединеннах Штатах Америки. (Evaluation of the Quality of Preparation of a Competitive Professional in Comparison in Russia and the United States of America) Материалы конференции "Гражданские свободы и образование на рубеже веков и континентов" Екатеринбург: Екатеринбургское отделение Ассоциации "Профессионалы за сотрудничество" и Уральский филиал Американского совета по международному образованию при финансовой поддержке Бюро по образовательным и культурным программам Госдепартамента США, Россия. Available at: http://www.prof.msu.ru/publ/conf/conf00.htm, 20.03.2006. (in Russian).

Table 1

The results of the evaluation of the development of the study competencies of rural school pupils (2000; 2004), (Nº 33)

Nr.	Indicators of evaluation of the features of competencies of rural school pupils	Coefficient of proportion of features, 2000	Coefficient of proportion of features, 2004	a. '–' differences b. '+' differences c. Ties	a. Sign test (Exact. Sig.) b. Wilcoxson's test (Asymp. Sig.) c. MacNemar's test (Asymp. Sig.)	Conclusions
1.	The educational environment of rural schools year on year provides opportunities for pupils' study progress in several different subjects.	p=0.48	p=0.70	a.1 b.8 c.24 N 33	a.p=0.039< α = 0.05 b.p=0.020< α = 0.05 c.p=0.039< α = 0.05	Remarkable disparity of the features among the selections of rural school pupils (2000;2004).
2.	Not only do rural school pupils gain good results in the daily study process, but also they participate in different educational activities organised by the regional institutions: Olympiads, competitions, exhibitions, tenders etc. in different subjects	p=0.91	p=0.97	a.0 b.2 c.31 N 33	a.p=0.500> α = 0.05 b.p=0.157> α = 0.05 c.p=0.500> α = 0.05	Moderate disparity of the features among the selections of rural school pupils (2000;2004).
3.	The environment of the rural schools allows accumulation of a positive cognitive experience, hence promoting the formation of adequate self-esteem in its pupils (reflection competency).	p=0.64	p=0.88	a.0 b.8 c.25 N 33	a.p=0.008< α = 0.05 b.p=0.005< α = 0.05 c.p=0.008< α = 0.05	Highly remarkable disparity of the features among the selections of rural school pupils (2000;2004).
4.	The environment of rural schools ensures the development the talented, according to their interests, needs, abilities, and possibilities promoting the growth of the level of their competencies.	p=0.48	p=0.82	a.2 b.13 c.18 N 33	a.p=0.007< α = 0.05 b.p=0.005< α = 0.05 c.p=0.007< α = 0.05	Highly remarkable disparity of the features among the selections of rural school pupils (2000;2004).

6.	Rural school pupils have skills of learning the within the alternative form of study organisation (through projects, cooperative studies, debates, seminars etc.), including the open air studies (on site case studies, study trips, plein airs etc.).	p=0.61	p=0.91	a.0 b.10 c.23 N 33	a.p=0.002< α = 0.05 b.p=0.002< α = 0.05 c.p=0.002< α = 0.05	Highly remarkable disparity of the features among the selections of rural school pupils (2000;2004).
7.	In a rural school every pupil has access to a computer hence ensuring the development of the basic skills (key competencies) of the usage of information and communication technologies (ICT).	p=0.21	p=0.82	a.1 b.21 c.11 N 33	a.p=0.000<α = 0.05 b.p=0.000< α = 0.05 c.p=0.000< α = 0.05	Outstanding disparity of the features among the selections of rural school pupils (2000;2004).
8.	In the pedagogical environment of rural schools the informal education is of importance, enabling the formation of study and social competencies.	p=0.88	p=0.91	a.3 b.4 c.26 N 33	a.p=1.000> α = 0.05 b.p=0.705> α = 0.05 c.p=1.000> α = 0.05	High compatibility of the features among the selections of rural school pupils (2000;2004).

ENVIRONMENT OF RURAL SCHOOL AS PROMOTER OF PUPILS'NEEDS FOR FURTHER EDUCATION

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Abstract

The school's education surrounding is the places where social experience and children's learning opinion are gathered develop the system of attitudes. It values actualizes education's needs and develop the motivation of self-realization and develop the motives to continue the education. It is important to develop the skills to make a prognosis, to plan and to Project the future. The aim motivation must be the real key in this process. The education of career is the school especially the main thing for rural schools that provide the long-term development during the crisis of demography and competition. The authors offer:

1) the typical needs of pupils for education in the surrounding of education, which is based on ecological approach in education and stresses the link between the surrounding and man in the holistic way,

2) the analysis of done investigations and evaluation in the part of discussions analysing the approach of career's education problems in the rural school, giving the references to other authors' views and investigations.

Key words: pupils' educational needs; career education; rural elementary school.

Introduction

Society, which learns, proposal of lifelong learning and guarantee that is near your place of residence is one of global aims of nowadays (Baltā grāmata, 1998), (Delors et al., 2001). The Ministry of Education has worked out 'The conception of the education's development' (Pamatnostādnes, 2006). There defined that aim of education is – to form balanced educational system and it is based on knowledge, society is democratic and socially integrated of lifelong and it promotes inhabitants of Latvia, increases national economy, it takes part in space of Europe, but at the same time to preserve and develop the characteristic values of culture.

The main priority is education of youth. It is systematic and scientifically based pedagogic interaction. The preferable result is to overtake even education is a value for youth, the process of self-development and result, which helps to find a right place in the society, it influences the responsibility, promotes the possibilities of self-realization and the goals. It is of great importance – the environment where pupils store knowledge and social experience form systems of attitudes and values. Rural schools should be the environment of education where the main stress is on educational needs and for young generation, they are motivated to continue the education, choose the profession and form the career.

The aim of the research is theoretical substantiation for experimental investigations are processing now. The authors of the present paper have launched a new research on the approach of career's education in the rural school.

Materials and Methods

Methods of the research include studies of scientific literature and reflection of personal pedagogic experience. The authors have a great deal of substantial experience in working with pupils in Primary and High school.

The actualization of pupils educational needs with interaction of school's environment, the theoretical motivation of investigations

The pupil's personality develops with interaction of culture, towns, schools pedagogic environment. We consider that upbringing and teaching are the forms of interaction between personality and school's environment.

The most important for development of personality and self-realization is interaction with social environment.

The most important for development of personality and self -realization is interaction with social environment. V.Zelmenis (Zelmenis, 2000) points that Social environment is not only passive object of observation and imitation. It moves forward concrete demands for young generation and tries to realize them. Taking into account the social environment and the character at school pupil's formation of personality happens with interaction of pedagogical environment, which based on systematic, successive, scientific basis and purposefulness.

According to Piazhe G. (Piažē, 2002) thoughts – a young man develops his inner structures with interaction of conditions of environment. Child develops himself, but he does not do it very free and independently, but he adapts to environment.

The development of man is with interaction of surrounding environment. There are three ways of interaction between human and environment (Bronfenbrenner, 1996; Briede et al., 1998; Katane, 2005a):

1) man is in environment and if the environment does not change, he is under influence of it,

2)man effects on environment and causes the changes, but man does not change obviously,

3)the interaction causes double-sided.

The third form of interaction is the most important.

We have to actualize pupil's cognition and needs of self-realization and then they are motivated to continue the education. It is important that rural school's educational environment should change according to pupils, teachers and interests and needs of society, certain priorities of development. A. Maslow – scientist from USA (Maslow, 1954) valued conclusion in one's own theory of motivation and met motivation that personality needs realization of man depends highly from environment. Conditions of environment either promote self-actualisation of man or forbid any of realisation possibilities of concrete needs. According to A. Maslow self-actualization is use of talent, abilities and opportunities. The man has to as it what he could be, the man to realize abilities and opportunities and has to fulfil one's own mission. A. Maslow (Maslow, 1968) describes eight ways what does individual can use for self-actualization (8 types of behaviour) which conduct to self-actualization:

1) experience (absolute, lively, selfless with a perfect concentration and reception in for myself of all happening);

2) understanding of life like that process and then self actualization is mean to fulfil every choice for improving;

3) to start one's own intentions realization, not only pets it and brings it inside, make skills for learning and studying to coordinate one's own activity with one's own inner character;

4) honesty and responsibility for one's own actions;

5) the first steps help to develop ability fulfilling 'the best choice of life';

6) regular process of developing one's own potencies;

7) tops of experiences, the highest emotional instants to perform what is passing and can serve outset borderline for new searching;

8) discovery of one's own 'protection' and overcome it.

The education is intellectual need, concrete action in which the result is expressed in a kind of intellectual values is defined of nowadays in 'The conception of education in Latvia' (Latvijas izglītības koncepcija, 1997). The education must help to develop and improve attitude of man for intellectual values. Process of education is effective if the pupil becomes inner free, can take in order one's own thoughts, has formed one's own world outlook, can improve one's own orientation of values. C.Rogers–scientist from USA (Rogers,1967) pointed the thought, that prerequisites for favourable emotional psychological environment pupils are centred in pedagogical process, double sided trusting in pedagogical interaction (teacher's and pupil's), respect, understanding and sensitivity. C. Rogers also has stressed that the emotional experience, teacher's supporting and favourable attitudes to pupils, encourage, feelings of security and believe of one's own are great importance for pupils. Just considering these precondition can insure:

1) necessary school environment for child development,

2) interaction of individual "openness" to dialogue,

3) making of learning motivation and adequate self-evaluation.

A long time before Latvian classic of pedagogy E. Peterson (Peterson, 1931) pointed thought that every who is aware of well-educated, understands and suspects that he is valued as a man and he has the one's own place in the events of history and connection of social life and transcendent.

To continue describing educated man, author stresses a man's inner displays can describe with an effort making of one's own individual merciless self-criticism and incessant struggle that reach one's own ideal 'me'. The school must provide for pedagogical support environment which is so necessary for pupils what would arouse pupils to search for further education and planning one's own future, promote pupil's adequate self-estimated formation process where pupils can feel the need for positive other estimation and understanding.

To search for one's own 'me' pupils have necessary maximal used utmost effort all skills, abilities and possibilities. The pupils have to come to understand what is he and what is the desire to become.

In National Curriculum (Valsts pamatizglītības standarts, 1998) is pointed that school teaching environment must enable pupils have sensation and believe that they can do much; favourable and optimistic environment in the lessons which create safety and protection sense, give possibilities for everyone without worry to try, to make mistakes, to learn from mistakes. They are very important precondition for successfully learning, pupils' attitudes and value system for their development. It is very important to make favourable psychological emotional environment.

At the beginning of the 20th century (in the 20th-30th years) many very famous Latvian pedagogy and psychology, for example, L.Ausejs, A.Dauge, P.Dāle, E.Peterson, M.Liepina, V.Seile, J.A.Students, O.Svence etc. integrated psychology conclusions to pedagogy, stressed emotional psychology climate sense in the school pedagogical process (Anspaks, 2003). For example, E.Peterson (Petersons, 1931) in his book Universal didactic stressed thought that good results in pedagogy reached to provide for favourable psychological conditions, recognition abilities of pupils. More safety means for discovery in school are stimulation of pupils' intellect and amateur activity how support child believes to oneself strengths. It can catch up with love and respect like as identity, to respect his needs. E.Peterson pointed child's intellectual and emotional development compact obligation and indivisibility. That conclusion is

found also in nowadays Latvians' scientists D.Liegeniece (Liegeniece, 1999), A. Spona (Spona, 2001), I.Zogla (Zogla, 2001) works. Positive experience meaning pupil's interaction with environment also is stressed L.Vigodsky (Вигодский, 2000). To learn on conclusions of scientists , we can say that child's experience which springs up in pedagogical process , is one of the famous indicators what give proof of pupil's and school's environment character of interaction, it influence on development of identity. But S.Rubinshtein stressed (Рубинштейн, 2004) that joy and satisfaction of success usually increase energy for further activities, but cares, embitterment, fears reduce people's capacity for work. It can influence not only mental but also physical health. Latvian scientist D.Ilishko (Ilishko, 1999) regards that nowadays class environment must be atmosphere where do not pressure, stress and it has sufficiency different kind of information. Class environment must give creative necessary information and possibilities to get more information, it means, must create the necessary preconditions for developing pupils' interests.

Supporting, positive pedagogical psychological environment and think over, purposeful pedagogical action and co-operation can arouse for pupils education needs. It can influence the pupil's learning motivation and further forming attitudes and values system.

It is of great importance to choosen career for rural youth cooperation among the school, family and potential other school in future. The next importance is to give possibilities for pupils it plays different social roles in different sectors of environment what enrich one's experience of life. In the development, process of everyone is very important to provide for all structure of life environment (cooperation between institutions of education) ordering common goals in education work and further development. The scientific motivation for this conclusion we can find in the ecology conception of man's development (Bronfenbrenner, 1996). In that way the rural school planning and carry out the career, education must take function of coordinator to all level cooperation to divide sphere of competences actions and responsibilities about gain results. We consider that the career education must take of great importance place in this pedagogical interaction and joint action and cooperation process.

Scientist O. Baitinger (Байтингер, 1999) points, that youth waiting events in future catch variously. Getting education, choosing suitable profession and fears to lost one's in daily routines - become of their actual points. Our observation witnesses of rural school leavers are not always are sure about right and conformity one's chosen future profession. However, all of them know or they continue and where continue studies. Then pedagogy from rural school have very wide action's field for career education. The needs realize career education in rural school environment can motivate to lean also on K. Levin (Левин, 2001) dynamic and conception of topology psychology where scientist calls the needs of environment stimulation and actualization about queasiness needs.

Results and Discussion

Nowadays planning of career education becomes more and more necessary how pupils know their parents. There are two conceptions: professional orientation and career education. The professional orientation is a kind of service, which provides different age of people with necessary information and support. The professional orientation helps people to choose the way of education or kind of employment. It moves and supports everyone to accept the effective plan to one's employment not only in education field but also in training for a new profession. It gives possibility people to understand and develop one's interests and abilities to find out one's recess in work market and develop one's skills for career planning. But the word 'career' we think about all plan of actions which moves and motivates a man to profit by the experience of social, professional skills through all life long. Career education advance and research are already necessary in the family, which can continue in different level educational institutions. The career education must be purposeful planning and its content must integrate in elementary school conformity.

Nowadays the school is institute that organizes powerful enterprises, supports planning and developing pupil's career identity renders professional assistance to families and in result of cooperation moves forward pupil to working life.

D. Pratt (Prets, 2000) in his work "Curriculum planning "notes that work-winners depend from schools because these determine how clever employees come in their enterprise. It has made works on (Crain, 1984) asking 11283 personals and has made out that to take on to engage schools' leavers, they value higher in their reliability (94%), attitudes to work (84%), ability for working in the team (74%), ability for quick learning (57%) and reading skills (57%). Therefore, teachers must give possibility for pupils' self-development, understanding one's, estimate one's cooperation possibilities and knowledge, acquainted with different possibilities for making a career, understand changing in educate and state development. The teacher's task is to develop interests about career and giving professional advice for chosen career, which answer to bring up his goals. The authors pedagogical experience witness that rural school pupils have necessary pedagogical support for further way of education because they have not:

1) goals motivation of further education,

2)have not necessary information and knowledge

about further education environment and possibilities that it offers. Therefore we consider that rural school must work out conformable models of career education what provide for many and different complex kinds of enterprises which give them necessary support in pupil's identity development of career. There would be show of great importance for different individual and institutes' groups' cooperation. Pupils must give possibility to introduce with all enterprises planning that can give them necessary support in individual career developing. These total enterprises could be integrate in the process of elementary school which encourage pupils for planning, projecting and forecasting one's future, one's professional action as such one of the way of personality self- realization.

Teachers consider their duty from personal experience:

1) help pupils to develop basic skills which necessary for pupils further educational environment planning and forming,

2) investigate pupils' interests and needs,

3) estimate learning achievement,

4) teach pupils use obtaining knowledge in new quality and new situation,

5) form supportive environment for pupils self- evaluation,

6) investigate pupils further education possibilities, offering of different kind of institutes and curriculum and give this information for pupils and parents,

Provide with cooperation and joint action for pupils and their families (parents, grandparents brothers, sisters) in the process of career realization.

Rural elementary school's educational environment groups of individuals' competences and functions in the career education

Pupil, family, subject teachers and form masters are involved in the career education. Each group has concrete duties in the development of the career. The authors worked out the model (see Figure 1) and point those pupil masters' social skills, follow his teaching achievements, store the

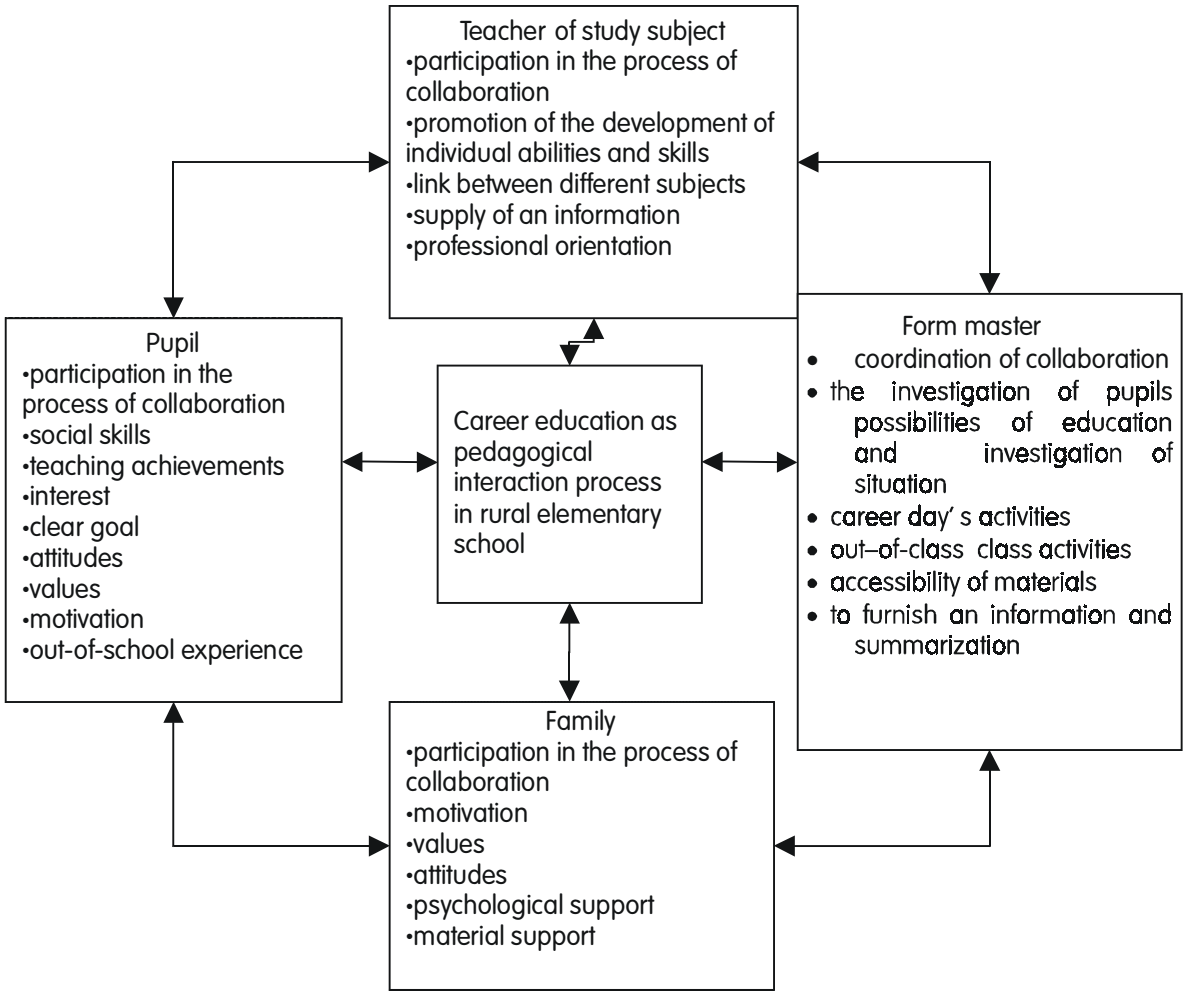

Figure 1. The authors made a diagram 'The subject groups' competences and functions on career education in rural elementary schools'.

knowledge and use them in new situation; he is motivated to reach the goal. Pupil has clear goals and stable system of values. Teacher of subject forms collaboration with pupil, develops his talents, gives the necessary information and supports a pupil in the career's education. Form master collaborates with pupil, parents and subject teachers, organizes the investigation of pupil and his abilities, involves him in out-of-school activities, stimulates pupils to search and summarize the information of career's education, and motivates pupils to reach the goals. Family supports the choice, shares the experience with pupils, offers material support, forms the system of values, stimulates pupils for promotion of competence, and is partner of collaboration. Taking into account the authors own pedagogical experience it is possible to stress the main steps of career education:

1) preparation – should be clean the goals, should choose those subjects which are necessary for the profession,

2) recognition – to do self-evaluation, to think about the choice and experience to take part in different pursuits which are connected with interests and of the development of abilities for chosen career, to store the necessary professional knowledge to stimulate for qualitative activity,

3) investigation – the collection of materials and information for the chosen profession using IT, libraries, acquaintance with the experience of professions representative, his positive and negative emotions,

4) settlement – according for the priorities to study the methods of acceptance the decision, collaboration with professional – advice giver,

5) summarization – looking back will give possibility to estimate of the done things and make the necessary corrections according to the goals and it will motivate the pupil to act – pupil ask questions for himself and gives the answers and he is sure of decision' s effectiveness,

6) planning – are clear goals in career education, plan is necessary and step by step pupil plans his activities to reach the goals, planning foresees resources, possibilities to overcome obstacles, and correction to accept a decision,

7) active action – the fulfilment of plan leads to the end, the storing of new information and processing is still going on, pupil realizes the goals, is opened to collaborate, he uses theoretical knowledge practically, he is motivated to reach the goal.

The author Katane I. (Katane, 2005b) worked out the investigation from 2000-2005, offers evaluation system for expertise of rural schools' educational environment. The investigation includes indications for evaluating of rural schools' functions on career education. Thirty-three rural elementary schools took part in this investigation from all four regions of Latvia. The structural, functional and evolutionary aspects were the basic means of investigation. The results of this research testify that the career education is a priority for many schools. It helps for the pupil's development and to motivate them to continue the education offer the graduation the elementary school. It is a guarantee for successful realization of pupils' educational needs in future.

Conclusions

The importance of education is a matter of current interest along with the processes of integration and globalization. Education considered as long-term society and guarantee of prosperity and an effective promoting mean to develop every individual. Man develops in the interaction with surrounding environment, which has a great importance of educations environment and it is as stimulator for personality of educational needs, the provider for necessary circumstances and a qualitative education.

Today many rural schools consider that the career education is not only development of pupil's personality but it is the mean of clearness of learning and also the long-term guarantee and the main way of development in the processes of competition and crisis of demography.

Investigations testify – in order to plan and realize career education each school has to work out its own model of educational needs according to an environment, pupils, teachers and all society where are certain responsibilities and spheres of competences, which are based on collaboration and joint action. Investigations testify that the realization of career education in rural schools promotes several factors of pedagogical culture – different traditions, varied collaboration with school leavers, parents and other schools as the real educational establishments of pupils.

There are qualitative and quantitative changes in the rural elementary schools in the sphere of career's education during the last years.

References

1. Anspaks J. (2003) Pedagoģijas idejas Latvijā (Ideas of Pedagogy in Latvia) Rīga: RaKa, 476 pp. (in Latvian).
2. Baltā grāmata (1998) Mācīšana un Mācīšanās – ceļš uz izglītotu sabiedrību (Learning and teaching – a way to educated society). Sagatavojusi Eiropas Komisija. Apgāds Lielvārds, 64 pp.(in Latvian).
3. Briede B., Pēks L. (1998) Pedagoģiskā vide (Environment of Pedagogy). Zinātniskās konferences materiāli: Mājturības pedagoģiskās aktualitātes. Raksti. Jelgava, LLU, pp. 87–92 (in Latvian).
4. Bronfenbrenner U. (1996) The Ecology of Human Development. Experiments by Nature and Design. Cambridge, MA: Harvard University Press, 330 pp.

5. Crain R.L. (1984) The quality of American high school graduates: What personnel officers say and do about it. Baltimore, MD: Center for the Social Organization of Schools, Johns Hopkins University. Available at: www.questia.com, 28.12.2005.
6. Delors Ž. u.c. (2001) Mācīšanās ir zelts (Learning is treasure). Ziņojums, ko Starptautiskā Komisija par izglītību divdesmit pirmajā gadsimtā sniegusi UNESCO. Rīga: UNESCO, LNK, 255 pp. (in Latvian).
7. Iliško Dz. (1999) Efektīva mācību vide (The effective learning environment). Skolotājs, 5(17), 1999, pp. 65-67 (in Latvian).
8. Katane I. (2005a) The Evaluation Model of the Rural School as Educational Environment. Summary of Doctoral Dissertation in Pedagogy Science. Sub-sector: School Pedagogy. Daugavpils: University of Daugavpils, Latvia, pp. 37-73.
9. Katane I. (2005b) Lauku skolas kā izglītības vides izvērtēšanas modelis (The Evaluation Model of the Rural School as Educational Environment). Promocijas darbs pedagoģijā. Daugavpils: Daugavpils University, Latvia, 195 pp. (in Latvian).
10. Latvijas izaugsmes modelis: Cilvēks pirmajā vietā (Model of the growth of Latvia: The man as the first). (2006) Projects. LR IZM. (in Latvian). Available at: http://www.litta.lv/documents/DG_ES_Fondi/lv%20att%20konc%20v% 205.0.doc, 02.01.2006.
11. Latvijas izglītības koncepcija (The conception of education in Latvia). (1997) Rīga: IZM, 32 pp. (in Latvian).
12. Lieģeniece (1999) Kopveseluma pieeja bērnu audzināšanā (The Commonwell approach to upbringing of children). Rīga: RaKA, 251 pp. (in Latvian).
13. Maslow A.H. (1954) Motivation and Personality. New York: Harper, 411 pp.
14. Maslow A.H. (1968) Toward a Psychology of Being. 2ed ed. Priceton M.Y.: D.Van Nostrand, pp. 2-84.
15. Memorandum on Lifelong Learning. (2000) Commission Staff Working Paper. Brussels, 30.10.2000. SEC (2000) 1832
16. Pamatnostādnes (Ground rules) Izglītības attīstības koncepcija 2006.-2010.gadam. (2006) LR IZM. Available at: http://www.unesco.lv/custom/izgl_attistibas_koncepcija.pps 28.01.2006 (in Latvian).
17. Pētersons E. (1931) Vispārīgā didaktika (Common didactics). Rīga: A.Gulbja izdevniecība, 130 pp. (in Latvian).
18. Piažē Ž. (2002) Bērna intelektuālā attīstība (Intellectual advance of children) Sorosa Fonds – Latvija. Rīga: Pētergailis, 319 pp.(in Latvian).
19. Prets D. (2000) Izglītības programmu pilnveide. Pedagoga rokasgrāmata. Rīga: Zvaigzne ABC, 383 pp. (in Latvian).
20. Rogers C.R. (1979) Freedom to Learn. Merill Publishing, pp. 4-53.
21. Rogers C.R. (1967) The Interpersonal Relationship in the facilitation of learning. Humanizing Education: The person in the Process. Washington, D.C.: Association for Supervision and Curriculum Development, pp. 1-17.
22. Špona A. (2001) Audzināšanas teorija un prakse. Rīga: RAKA, 162 pp. (in Latvian).
23. Valsts pamatizglītības standarts (National Curricullum). (1998) Rīga: IZM, 32 pp. (in Latvian).
24. Zelmenis V.(2000) Pedagoģijas pamati. Rīga: RaKa, 291 pp. (in Latvian).
25. Žogla I. (2001) Didaktikas teorētiskie pamati. Rīga: RaKa, 275 pp. (in Latvian).
26. Байтингер О. (1999) Переживание будущего как проблемы в ранней юности. В кн.: Наш проблемный подросток. Под ред. Л.А.Регуш. Санкт-Петербург: Союз, 42-49 с. (in Russian).
27. Выготский Л.С. (2000) Психология. Серия: Мир психологии. Москва: ЭКСМО-Пресс, 1008 с. (in Russian).
28. Левин К. (2001) Динамическая психология. Избранные труды. Москва: Смысл, 572 с. (in Russian).
29. Рубиншейн С.Л. (2004) Основы общей психологии. Из серии: Мастера психологии. СПб: Питер, 713 с. (in Russian).

TRAINING ACADEMIC WRITING IN UNIVERSITY STUDENTS

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Abstract

Training academic writing is proposed as a topical subject within the Teachers' Education study programme on graduate level at Latvia University of Agriculture. In order to promote the development of students personality self-actualization, we are called for introducing new digital technology as teaching-learning method contributing to opening up opportunities in training academic writing at University. How can we use the digital environment for developing formal academic writing technique in our students? The main argument is that digital environment is a key factor for changes in the teaching-learning process and organization of Teachers' Education study programme curricula as the traditional academic print world is changed. Students involved in the Teachers' Education study programme at University are using the Web conducting their learning process. Academic writing as a part of learning process at University is based on cognition and activity. We propose to define the training of students' academic writing at University as a learning process transforming the student's knowledge in unity of two positions: curricular academic writing and informal academic writing. We propose three criteria towards the students' academic writing as heuristics, self-dependence and collaboration. How can we help our students to promote academic writing by using the digital environment? How can we help them differentiate between the appropriate and inappropriate use of information found on the Web and understand what plagiarism is and how it is to be avoided?
Key words: digital environment, academic writing, plagiarism.

Introduction

At the beginning of the XXI century as the paradigm of Education is changing, the opinion about what makes a professionally competent and socially valuable teacher also changes. Academic writing training is proposed as a topical subject within the Teachers' Education study programme on graduate level at Latvia University of Agriculture. Teachers' Education is orientated to education of a well-balanced human personality, and a research in pedagogy field in order of widening understanding of pupils' behaviour is a special event and requires a spectrum of skills that are needed for success in academic writing technique.

Technological change is a troubling matter for much of higher Education. It is common now that the proposition of the digital environment is profoundly reshaping social relations and its impact on Education, and especially Teachers' Education, will be substantial. The main argument is that digital environment is a key factor for changes in the teaching-learning process and organization of Teachers' Education as the traditional academic print world is changed.

Our theoretical approach is that training academic writing is grounded on the basis of methodology principles of cognitive and activity theory. Central to a cognitive approach are the human mental abilities. H. Gardner argues that a mind consists of a number of fairly specific and fairly independent computational mechanics (Gardner, 1983). As the individual receives information the mind consisting of cognitive structures is enable to process the information into knowledge. Meanwhile academic writing as learning is a training of cognitive abilities accomplished by the student's work on academic writing technique, understanding and mental information processing from the Web.

According to activity theory, the individual's actions in the physical world both in social and practical situations are forming the basis of knowledge. A.N. Leontev argues that human activity is directed at an object in the external world (Leontev, 1978), but L.S. Vygotsky reflects that the individual uses the world as an instrument for his/her object-orientated actions (Vygotsky, 1978).

The acquisition of high order in academic writing is one of the traditional goals of Teacher's Education. University graduates will live and work in a world increasingly rich and diverse in information. We have a duty to suggest our students how to negotiate and evaluate the information in a manner that helps us realize our educational goals. Academic writing in Teachers' Education study programme at University is measured by its outcome. Research papers, reports, abstracts, presentations, conference publications, seminars, reviewing are involving students in the world of academic writing from the day they enter the study programme.

The problem in the real pedagogical process at University is that our students' academic writing technique could be progressed more effectively by regular using the digital environment for academic educational purposes. The aim of this paper is to discuss theoretically some distinct kinds of training students' academic writing by exploring the potential of the digital environment from pedagogical perspective.

Materials and Methods

The digital era, as the XXI century seems to be, is creating a range of new opportunities for education. The concept of digital environment describes the virtual space of the individual's relation to the information. In the

pedagogical area there are such two dominant advantages for using the digital environment as:

1) independence of time;

2) individuality (Koper, 2000).

Both these advantages are summed up in connection with training academic writing in University students in the frame of the digital environment. In the practising of academic writing at University, the use of digital environment in relation to pedagogical theories is reflected.

This paper tracks Teachers' Education study programme on graduate level at Latvia University of Agriculture covering the period from 2005 to 2006. The pedagogical research examined such two distinct conditions of students' academic writing as cognition and activity. The questionnaire was constructed in two parts. The first was about the students' academic writing as cognition and finding information on the Web. The second part of the questionnaire was about the students' academic writing as activity and thoughts about ethics and plagiarism. In the case study the author observed the graduate students during the lectures and preparing their reports.

Results and Discussion

The research is based on the data received from the analysis of the situation in the educational practice. During one academic year, 20 students of Teachers' Education study programme at Latvia University of Agriculture were asked to complete a questionnaire about training their academic writing. The results attributably to training academic writing at University confirmed large differences between assessments. Our students are educated in accession, identification and evaluation information by using the Web but they have very diverse thoughts about exploring the Web for developing their academic writing technique.

The results of the first part of the questionnaire about the training students' academic writing as cognition showed that 80% of respondents are satisfied with distinguished level of academic writing and 20% are not satisfied with it. All our students are using the Web encyclopaedias for learning purposes and doing their academic writing exercises-reports or course papers. Accomplishing this goal requires from students a high degree of writing technique.

Analysing the results of this investigation we can conclude that our students do not innately understand how academic texts are produced. It means that our students have diverse thoughts about exploring the Web for training their academic writing. They should develop such following components of academic writing as the technique of summarizing information found on the Web and critically evaluating information found on the Web. We can conclude that the Internet still continuous to be the dominant medium for their learning efforts and such three criteria for developing students' academic writing as heuristics, self-dependence and collaboration are acceptable.

The results of the second part of the questionnaire about the students' academic writing as activity and their thoughts about ethics and plagiarism showed that 65% of respondents are satisfied with their activity and ethics but 35% are not satisfied with it. Analysing the results of this investigation we can conclude that our students have not thought enough about illegal use of the intellectual property found on the Web and they must understand what plagiarism is and how to avoid it doing their academic learning activities.

Student plagiarism is undeniably a popular issue. The awareness of plagiarism stems from concern that plagiarism among students has flourished because of the readily accessible wealth of information available on the Web. The reliance on the Internet has promoted the unethical or illegal use of the intellectual and creative properties of others. Our objectives as lecturers include helping students differentiate between the appropriate and inappropriate use of information. Academic writing ethics include respect for other researchers and as the ethical principles are often stated, embrace the three main concerns 'beneficence, respect and justice´(Cohen, Manion, 1994). All Teacher's Education study programme students must maintain the highest standards of academic writing ethics, which includes correctly citing print or digital work as a source of information and full intellectual honesty in reporting on one's research work.

Education has a special responsibility to help clarify the choices and learning outcomes for this new digital era, and contemporary technological changes have enormous implications on it. Digital environment is both a product in itself and the key technology responsible for changing the human perception.

The form, content and methods of Education must evolve dynamically and in consonance with transformations for curricula innovation. While the benefits of the digital environment seem to be obvious, there are study subjects requiring a balance of teaching and learning for which it is a valid question whether academic writing can be developed by using the Web. Do Teachers' Education programme students at University need to have a clearer understanding of digital environment and how it relates to the society? Teachers' Education at University must become adept at both understanding the digital technology and using it in teaching-learning process. It means the ability to appreciate scientifically how digital technology operates and how to use it in educational practice.

According to activity theory, the relation between the individual and the world consists in interactions. Through the interactions the individual creates the world by creation of instruments, and knowledge as an instrument can also

be described as the media between the individual and the world. Fundamental to academic writing, supported by activity theory, is a problem of writing actions towards the digital environment - the same world of knowledge only virtual one.

In pedagogical theory (Bingham, 2005; Lindemann, 1995), the development of students' academic writing is described as an act of creation of new knowledge. D. Knowlton argues that academic writing is a learning process that helps to transform the individual and to master knowledge in an act of interpretation and invention (Knowlton, 2001). Analytically, we propose to define the training of students' academic writing at University as a learning process transforming the student's knowledge in unity of two positions based on cognition and activity:

1) curricular academic writing,

2) informal academic writing.

It is possible to conclude that informal academic writing is a personally important writing activity of the student that manifests itself in the free choice and grasping of the learning content and development of student's academic writing technique. It means conferencing activities, publications, presentation on the seminars and the talks.

On the ground of the two above-mentioned conditions as cognition and activity, we propose three criteria for proving theoretically the academic writing at University. These three criteria towards the student's curricular and informal academic writing as cognition and activity are:

1.criterion-heuristics,

2.criterion-self-dependence,

3.collaboration.

The general, universal pedagogical idea of writing to learn supports the use of digital environment for training students' academic writing at University. It means to enlarge the informal academic writing by selecting a series of pedagogical research journals from the Web for training students' summarizing technique (Ryan, 1994). Throughout the semester such forms of traditional summaries or liberal summaries could be used as paragraph approach, flow chart, PowerPoint slides, etc. The training of academic writing is simultaneously a developing of student's cognition and activity.

Another pedagogical condition is turning students into readers of their own writing. The practicing of the Web conferencing means a new sense of control within the academic learning process at University and involving our students for editing and reviewing practice by using the digital enviroment (Mendelson, Korin, 2001). Furthermore, the Web conferencing could improve our students' freedom of thinking and the pursuit of their own ideas by connecting conference content with study subject programme.

Conclusions

1. Training students' academic writing is based on cognition and activity as pedagogical conditions for improving the teaching-learning process at University.

2. Academic writing is transforming the students' knowledge by using digital environment in unity of two academic positions as curricular and informal academic writing.

References

1. Bingham Ch. (2005) The Hermeneutics of Educational Questioning. Educational philosophy and theory. Vol. 37, pp. 553-565.
2. Cohen L., Manion L. (1994) Research Methods in Education. London: Routledge, 414 pp.
3. Gardner H. (1983) Frames of Mind. London: Basic Books Inc. Publishers, 186 pp.
4. Knowlton D. (2001) Evaluating Students' Writing. New York: John Wiley, 87 pp.
5. Koper R. (2000) From change to renewal: Educational technology foundations of electronic environments. Available at: http://eml.ou.nl/introduction/articles.htm on, 29.03.2006.
6. Leontev A.N. (1978) Activity. Available at: http://www.marxists.org/archieve/leontev/works/1978/index.htm on, 29.03.2006.
7. Lindemann E. (1995) A rhetoric for writing teachers. 3rd edition. New York: University Press, 139 pp.
8. Mendelson H., Korin A. (2001) The Computer Industry. NY: Routledge, 394 pp.
9. Ryan M.L. (1994) Virtual Reality and Literary Theory: Postmodern Culture. Available at: http://muse.jhu.edu/journals/postmodernculture/V005/5.lryan.html on, 29.03.2006.
10. Vygotsky L.S. (1978) Mind in Society. New York: Harvard University Press, 241 pp.

ENVIRONMENTAL ASPECT OF DIALOGUE EDUCATIONAL METHOD IN LATVIA RURAL MUSIC SCHOOL

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Abstract

In XX century, educational dialogue is researched as educational and pedagogical method. Latvia rural music schools is good basis for scientific investigation. The aim of the research is to study situation of the educational dialogue in Latvia rural music schools and to analyse pedagogical aspects and authority, constructing progressive environment in understanding between individuals. A two thousand year's dialogue shows perspective way for best communication and cooperation. Dialogue idea in XX century philosophical and pedagogical theories is analysed in M. Buber, M.M. Bakhtin, P. Freire and N.C. Burbules works, and they have played an important role in the development of dialogue theory as a pedagogical problem. Dialogical interaction can provide to higher motivation of ensemble play lessons and to solve transportation and large way distance difficulties in Latvia rural areas.
Key words: dialogue educational method, environment, rural music school.

Introduction

In XX century, in education there is active interest in pedagogical and environmental role of the educational dialogue. Scientists are searching new ways to find educational methods, which do common school praxis more fruitful for education and lead people (teacher and students) toward better pedagogical and psychological understanding. The results of dialogue always change environmental situation. Instrumentplay has existence of conversation between artist and musical piece text or composer's idea, between artist and artist, or pupil and teacher. Finally, there is environment, where people are interested not only in their own views and ambitions, but they listen attentively in other person's mind, experience, thoughts, needs, etc., looking to the circumstances and situation around them. The aim of the research is to study situation of the educational dialogue in Latvia rural music schools and to analyse pedagogical aspects and authority, constructing progressive environment in understanding between individuals.

Materials and Methods

In 2005, in Tukums there was Music teacher Training courses, where piano play teachers participated from all four Latvian regions. Training courses was carried out at the Institute of Education and Home Economics. The content of Training courses includes some lessons and discussions about piano ensemble play practical problems: research of musical task difficulties understanding between teacher and pupil, organization of ensemble lessons, comparing teacher's experience about children's attitude to the piano ensemble play and class work etc. A questionnaire about some aspects of social communication and study problems was developed to get information for analyses and was given to 44 teachers who are practising at music schools in different rural regions of Latvia. The respondents were asked to fill in the questionnaire where they had to estimate the piano ensemble playing and choosed a programme for playing together.

The pupil can feel enormous emotional and musical support and enchanced music satisfaction if the teacher with her more mature musical skills plays together with him/her ensemble pieces. The teacher listens closely to the pupil, playing supportively and can then not only reflect but also initiate pupil's creativity, so that there is a dialogue of feeling in which both teacher and pupil are involved. Dialogue idea is an important research component in rural music education.

Dialogue has been a central concern of both Western philosofy and educational theory. J. Dewey (Dewey, 1916) reflects about the link between philosophy and education:

'At this point, the intimate connection between phylosophy and education appears. In fact, education offers a vantage point from which to penetrate to the human, as distinct from the technical, significance of philosophic discussions... Phylosophy may even be defined as the general theory of education... Education is the laboratory in which phylosophic distinctions become concrete and are tested.'

A two thousand year's dialogue shows perspective way for best communication and cooperation. Dialogue idea in XX century philosophical and pedagogical theories is analysed in M. Buber, P. Freire and N.C. Burbules works and has played an important role in the development of dialogue theory as a pedagogical problem. M. Buber investigates dialogue from religious and pedagogical viewpoint. He has written a book 'I and You' about dialogical relations between God and people, and has formulated dialogical attitude generally there are two laws:

1) Dialogical relation is characterized by animated attitude toward living centre;

2) Other sign of dialogical relation is in living, equal communication between individuals (Бубер, 1993).

Brazilian educator P. Freire has researched freedom aspects of dialogical idea:

'Dialogue is the sealing together of the teacher and students in the joint art of knowing and re-knowing the object of study… Instead of transferring the knowledge statically, as a fixed possession of the teacher's dialogue demands a dynamic approximation towards the object.' (Freire, 1999)

N. C. Burbules has looked to the dialogue as a source of knowledge and understanding, as a medium of interpersonal discourse, and as a pedagogic relation. N.C. Burbules observes: 'Dialogue is continuous with conversation generally…' (Burbules, 1993) In research 'Dialogue in education' he has written about critical and including types of dialogue (Burbules, 1993). Critical dialogue in most cases is used by ancient greeks it is a teleological dialogue all parties are researching a way toward the final purpose. The aim of including dialogue is in ethical critically revising the problem or relations to find new standpoints of understanding.

Results and Discussion

The experience of being rural is a positive force and value in the world. Rural Latvia has been and continues to be a vital part of the nation. As of 2005, rural Latvia comprised 4 regions, like the rest of the world, is steadily becoming more urban. Improvements in communication and transportation between urban and rural areas have reduced rural isolation and removed many of the cultural differences between the two areas. Television, phone service, and transportation systems have helped bring rural and urban dwellers much closer together in terms of culture, information, and lifestyles. No single definition exists to define rural Latvia music schools. American clasification of the areas has 3 categories:

- a central city of metropolitan area;
- metropolitan but not central city;
- nonmetropolitan (Guthrie, 2003).

Latvia is not so large and need not in such a classification, but all that is not metropolitan is often said to be rural. The categories of rural or small towns are often used to describe the rural segment of Latvian music schooling.

Cultural and pedagogical atmosphere in rural music schools is interesting basis for educational and social environment research.

In the rural areas environmental conditions for communication are more complicated:

1) problems linked with long distance from home and school- transport expenses;

2)time quantity, which must be spent on the way;

3)specific of ensemble play study, which includes many practising hours together.

Do the social and didactical aspects of dialogue in ensemble play help to overcome difficulties of these listed problems of complicated communication?

The results of questionnaire analysis(44 participants) show some aspects of social communication and study problems which exist in rural schools.To the question 'Do children like lessons of ensemble play?'

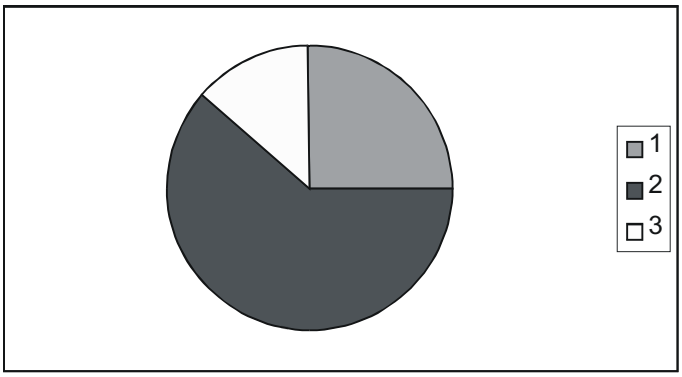
40 respondents gave an affirmative answer: in most cases children heartily play music together. Very important is the answer to the 3rd question- 'Do children practice, play together without teacher's assistance?' (Fig.1).

This answer shows that children in most cases have a will and purpose to play together. There are important

Table 1

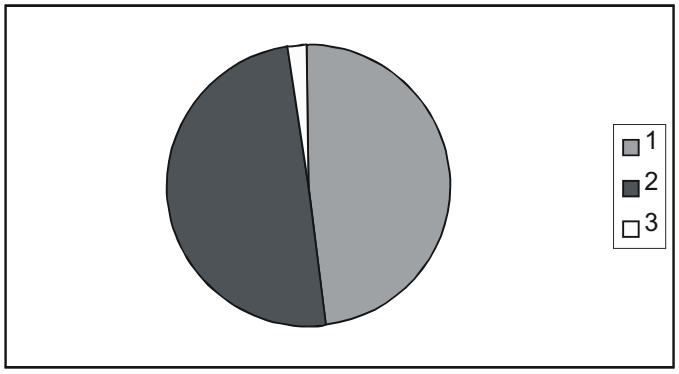
Basic differences between rural and urban areas adapted from Guthrie, 2003 and Nachtigal, 1982

Rural	Urban
Personal/tightly linked	Impersonal/loosely coupled
Generalists	Specialists
Homogeneous	Heterogeneous
Nonbureaucratic	Bureaucratic
Verbal communication	Written memos
Who said it	What is said
Time measured by seasons of year	Time measured by clock
Traditional values	Liberal values
Entrepeneur	Corporate labor force
Make do/ respond to environment	Rational planning to control environment
Self-sufficiency	Leave problem solving to eksperts
Poorer (in spendable incomes)	Richer (in spendable incomes)
Less formal education	More formal education
Smaller/less density	Larger/greater density



1- 25% of positive answers;
2- 61.36% of satisfactory answers;
3- 13.6% of negative ansvers.

Figure 1. Do children practice, play together without teacher's assistance.



1.- 47.7% of positive answers;
2.- 50% of satisfactory answers;
3.- 2.27% of negative answers .

Figure 2. Do children wish to listen carefully in other persons behaviour and musical perfomance.

thing-motivation for such a communication and study form.

Do children have a wish listen carefully in other persons behaviour and musical perfomance? There answer at most cases is positive, only small part answered negatively (Fig. 2).

Analysing the results of the investigation shows that majority of music teachers are interested to play together and improve dialogue skills.

Aspect of new understanding dialogical relation is seen in children's answers which verify motivation of wish to play together, to communicate.

The didactical aspects of dialogue in the music school are the concept of the musicians learning of the music and are realised in the pedagogical process of instrumental playing (Fig. 3).

Figure 3 shows the dialogical interaction between three sources: teacher, musical piece and pupil.

Dialogue in the form of question and answer can reflect feelings and ideas involved in musical piece. (Čerņavska, 2004)

Such dialogue as a music teaching and learning method has achieved the status of the most important form of organising studies in rural music schools.

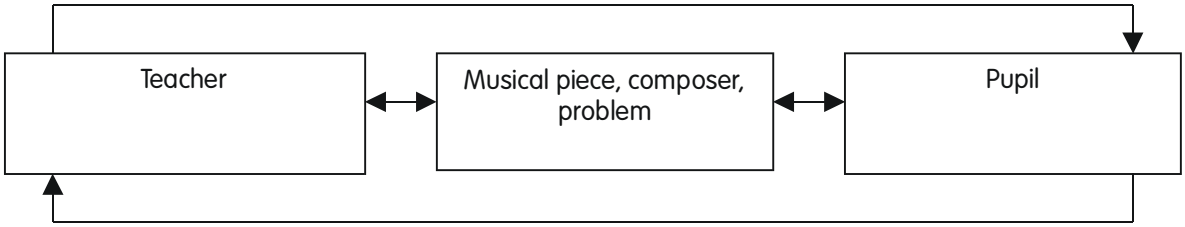


Figure 3. The dialogue as instrumental playing didactics (Lūse, 2003).

Conclusions

In the research the significance of the dialogue in music studies and social communication in rural music school was proven in such three didactical aspects:

1) the acceptance of the basic values of the dialogue idea, which lead to better communication;

2) the interaction of the dialogical approach;

3) Exchanges of mutual spiritual values in the teaching-learning process.

Finally, only dialogical interaction can provide to higher motivation of ensemble play lessons, to better communicating with other equals and these causes make possible to solve transportation and large way distance difficulties in Latvia rural areas.

References

1. Burbules N.C. (1993) Dialogue in teaching: theory and practice, Teachers College Press, NY-165 pp.
2. Čerņavska G. (2004) Dialoga izpausmes klavierspēles mācību procesā (The Expression of dialogue in the study process of Piano Playing) The International scientific conference Theory and Practice in Teacher Training II, Riga: Teacher Training and Educational Management Academy, pp. 167-171. (in Latvian.
3. Dewey J. (1916) Democracy and Education. New York: Macmillan, 211 pp.
4. Freire P. (1999) Pedagogy of freedom. London: Routledge, 127 pp.
5. Guthrie James W. (2003) Encyclopaedia of Education/second edition. Macmillan Reference USA, 2085 pp.
6. Lūse N. (2003) Latviešu pianisti pedagogi (Latvian pianist-pedagogues). Rīga: RaKa, 79 pp. (in Latvian).
7. Бубер М. (1993) Я и Ты. (I and You). М.: Высш. Шк., 175 с. (in Russian).