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RESEARCH FOR RURAL Development 2010

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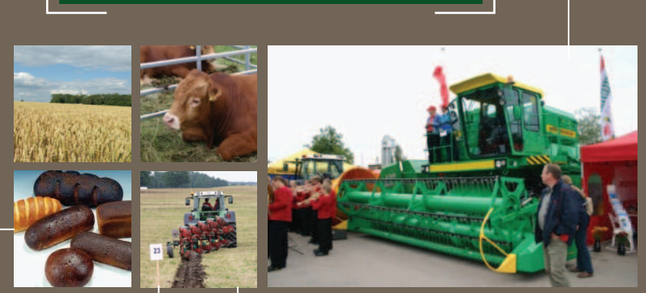

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EDITORIAL

With this issue of 2010, we bring 83 proceedings of the 108, which started life as presentations at the Annual 16th International Scientific Conference "Research for Rural Development 2010" held at the Latvia University of Agriculture, in Jelgava, on 19 to 21 May 2010.

In the retrospect of four months later, we can count the Conference as a great success. The theme – Research for Rural Development - attracted participation of 292 researchers with very different backgrounds. There were 11 presentations from Lithuania, 2 from Estonia, 1 from Romania and 107 from Latvia.

Four independent reviewers estimated each article.

The proceedings of the Annual 16th International Scientific Conference "Research for Rural Development 2010" 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, water management, landscape architecture, rural engineering, information and communication technologies.

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

CONTENTS

POSTPARTUM SERUM BIOCHEMICAL AND HAEMATOLOGICAL CHANGES IN COWS WITH AND WITHOUT RETAINED FETAL MEMBRANES

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Abstract. The aim of the study was to find out the differences of blood biochemical and morphological parameters in cows with and without retained fetal membranes. Sixty cows of different age of Latvian black-and-white breed from two Joint Stock Companies were used in the research that was divided into two groups: control group of 15 cows, and 45 cows with retained fetal membranes. Research was done from September 2007 to January 2009. In haematological parameters on the second day postpartum, control group cows had increased leukocyte count on the account of mature neutrophils, but in the group of cows with retained fetal membranes leukocytes were within the range of normal values. The difference of the above mentioned parameters between both of the groups was significant ($p<0.05$). At the same time, in cows of both investigated groups the number of band neutrophils was slightly increased ($p>0.05$). Haematological analyses showed leukocytes shift to the left and lymphopenia with a tendency to get normal within six weeks postpartum in both cow groups. On the third week postpartum, in cows with retained fetal membranes the band neutrophil count increased significantly ($p<0.05$) indicating that the inflammation process has flared up. Blood for biochemical examination was sampled from cows within 48 hours postpartum in order to evaluate the functional condition of liver in milking cows. A significantly higher ($p<0.05$) total and direct reacting bilirubin was observed in cows with retained fetal membranes, although it was within the range of normal values.
Key words: cows, retained fetal membranes, serum biochemistry, haematology.

Introduction

Fetal membranes in cows are considered to be retained if they have not been expelled during 8-12 hours postpartum.

Shortly before parturition and during the time of parturition the level of hormones in the organism changes, and changes are observed also in the haematological and biochemical picture of blood. Two weeks before calving, the leukocyte and neutrohpilic leukocyte count does not change, but during the parturition it increases and returns back to normal values in the postpartum period. The lymphocyte and eosinophilic leukocyte count, on the contrary, slightly decreases and remains increased in the postpartum period. The number of monocytes increases when the parturition begins and then decreases to normal values (Kornmastitsuk, 2002; Chassagne et al., 1998). During the first five days postpartum, neutrophilia, monocytosis and lymphopenia are observed in the blood cell count (Kornmastitsuk, 2002; Kimura et al., 2005; Meglia, 2004; Meyer and Harvey, 2004).

In cows with retained fetal membranes (RFM), on the second day postpartum, a decreased erythrocyte, all types of leukocyte and lymphocyte count is observed. Furthermore, shift to the left remains and band forms of neutrophils and metamyelocytes appear in the peripheral blood from the second to the fifth day postpartum that is a response to acute inflammation (Stockham and Scott, 2008; Schalm et al., 1975; Jain, 1986). An increase in the total number of monocytes in cows with RFM is observed all the postpartum period because the maturation process of neutrophilic leukocytes in the bone marrow is significantly inhibited and the percentage of segmented leukocyte count is low (Shalm et al., 1975; Jain, 1986).

K. Kimura et al. (2002) report that in cows with RFM activity of leukocytes is significantly low already before parturition, which remains 1–2 weeks postpartum. As to the biochemical parameters of blood, B. Kornmastitsuk (2002) describes that in cows before normal calving the level of calcium was a little lowered, but in the period of postpartum the level of calcium was decreased significantly. Calcium is a very significant mineral during the process of parturition and postpartum. If it is in insufficient amount in the body, the uterus atonia occurs and expulsion of fetal membranes is hindered. Concurrently, milk fever and ketosis may occur. Literature data show that in 75% of clinically healthy cows just after calving a stable hypocalcaemia occurs that is associated with lactation onset. Also, consumption of calcium from feed is decreased as well as the calcium level in serum lowers. The decreased calcium level plays an important role in retention of fetal membranes and further in the process of inflammation development (Smith, 1996; Liepa, 2000; Semacan and Sevinc, 2005). If there is a calcium deficiency in the body, very often a decrease of phosphorus level is also observed at the same time. Retention of fetal membranes and a downer cow syndrome are observed with a decreased phosphorus level in blood as well as problems with next conception might occur (Liepa, 2000; Antāne et al., 2000; A.I. Management Manual, 1996).

N. Farzaneh et al. in their studies of 2006 mention that in cows with retained fetal membranes 48 h after calving albumin decreases, whereas A. Semacan and M. Sevinc (2005) discover that in cows with RFM the mean serum levels of glucose, albumin, cholesterol, calcium and phosphorus are significantly lower than in cows of control group, but aspartate aminotransferase

(AST) is significantly higher than in cows of control group. These parameters may indicate a fatty liver.

Normally in cows at parturition the total protein amount, albumin/globulin ratio, and AST are slightly increased, but the cholesterol, calcium and phosphorus level is lowered, which later returns to normal values. **The aim of the research** was to find out the differences of blood biochemical and morphological parameters in cows with and without retained fetal membranes.

Materials and Methods

Sixty cows of different age of Latvian black-and-white breed from a Joint Stock Company "Agrofirma Tērvete" herd with 650 milking cows in Dobele region, and from "Daile Agro", Ltd., herd with 280 milking cows in Jelgava region were used in this research. Animal feed ratio is adequate to the standards of milking cows. On both farms the animal keeping, care and feeding are similar. In winter, on both farms animals are kept in the barn in tie-stalls and fed on corn, alfalfa, clover and grass crop silage, which is prepared in plastic rolls and mixed in the feed mixer before feeding and distributed by a feed mixer. Before silage feeding, concentrated mixed feed (barley+wheat) with microelements, rape seed oil-cake and salt is fed. The herd of "Agrofirma Tērvete" is also fed with beer distillery refuse together with the concentrated mixed feed. Several times a week, hay is fed on both farms. Molasses is poured on the silage and hay. In summertime, cows of both farms are grazing twenty-four hours, and at the time of milking they are fed with concentrated mixed feed with microelements, salt and rape seed oil-cakes. On the farm of "Agrofirma Tērvete", animals are fed with beer distillery refuse also in summertime. Reaserch was done from September 2007 to January 2009.

Cows were divided into two groups according to the third stage of parturition (expulsion of fetal membranes) process: control group cows, in which fetal membranes were expelled within 8 to 12 hours (n=15), and cows with RFM (n=45).

Blood samples for biochemical examinations were collected 48 hours postpartum, but samples for morphological examinations – 48 hours, 14, 22 and 28 days postpartum. Samples for biochemical examinations were collected in 7 ml sterile disposable vacuum test-tubes without anticoagulant from the tail vena, but for haematological examination, 3 ml sterile disposable vacuum test-tubes with 0.072 ml of K3E 7.5% anticoagulant were used to obtain a stabilized blood sample. To determine glutathione peroxidase, 7 ml sterile disposable vacuum test-tubes were used with heparin as an anticoagulant. Fresh blood samples were examined within six hours after sampling at the accredited laboratory 'Central Laboratory', Ltd., in compliance with the standard analyses requirements.

A comparative evaluation of blood biochemical and haematological parameters in cows with and without RFM was performed by using Microsoft Excel T-test: Paired Two Samples for means and calculation of arithmetic means were used. Differences were considered significant at $p<0.05$.

Results and Discussion

When analyzing haematological parameters in cows on the second day postpartum, it was obvious that in the control group cows the leukocyte count was increased, 13.94±1.59 (10^9 L^{-1}), on the account of mature neutrophils, but in the group of cows with RFM leukocytes were within the range of normal values - 9.09±0.76 (10^9 L^{-1}) (Table 1). The difference of the above mentioned parameters between both of the groups was significant ($p<0.05$). At the same time, in cows of both investigated groups the number of band neutrophils was slightly increased: 4.88%±0.81 in control group, and 6.25%±0.68 in cows with RFM, respectively. The differences were not significant ($p>0.05$). These results coincide with D. J. Meyer and J. W. Harvey's (2004), O. W. Schalm's et al. (1975), N. C. Jain's (1986), and S. L. Stockham and M. A. Scott's (2008) investigations where they have described an increase of leukocyte count with a shift to the left in cases of normal calving and a short time postpartum, and a decrease in the number of leukocyte count with a left shift in cows with RFM.

The mean lymphocyte count in the blood of cows of both groups of investigation was slightly below normal values: 31.56%±3.46 in control group cows, and 43.54%±1.0 in cows with RFM. The difference in this case was significant ($p<0.05$). W. J. Regan et al. (1998) reports that a decreased lymphocyte count is a typical occurrence postpartum and it can remain even for two months. Whereas several authors mention that a decreased lymphocyte count occurs in case of inflammation caused by an acute bacterial infection, acute viral infection or endotoxemia (Schalm et al., 1975; Jain, 1986; Stockham and Scott, 2008). On the second day postpartum, the number of monocytes slightly exceeded normal values, but the differences were not significant ($p>0.05$). Other researchers have reported that already during parturition the monocyte count increases but postpartum it returns to normal values unless inflammation develops (Kornmastitsuk, 2002; Kimura et al., 2005; Meglia, 2004; Meyer and Harvey, 2004; Schlam et al., 1975; Jain, 1986)

Table 1

Blood morphological parameters in cows with and without retained fetal membranes on the second day postpartum

Parameters	Cows without retained placenta	Cows with retained placenta	Standard[1]
White blood cells (10^9 L^{-1})	13.94 ± 1.59*	9.09 ± 0.76*	4 – 12
Erythrocytes (10^{12} L^{-1})	6.34 ± 0.18	6.55 ± 0.008	5 – 10
Hemoglobin (g dl^{-1})	10.86 ± 0.22	10.68 ± 0.13	8 – 15
PCV (%)	30.88 ± 0.57	30.83 ± 0.39	24 – 46
MCV (fl)	49.10 ± 1.05	47.08 ± 0.51	40 – 60
MCH (pg)	17.26 ± 0.36	16.49 ± 0.45	11 – 17
MCHC (g dl^{-1})	35.21 ± 0.35	34.73 ± 0.08	30 – 36
Platelets (10^9 L^{-1})	231.88 ± 19.37*	302.52 ± 3.61*	100 – 800
Band neutrophils (%)	4.88 ± 0.81	6.25 ± 0.68	0 – 2
Mature neutrophils (%)	51.56 ± 3.26*	39.31 ± 1.35*	15 – 45
Eosinophils (%)	1.75 ± 0.23	2.02 ± 0.45	2 – 20
Basophils (%)	1 ± 0	1 ± 0	0 – 2
Lymphocytes (%)	31.56 ± 3.46*	43.54 ± 1.0*	45 – 75
Monocytes (%)	10.0 ± 1.02	7.92 ± 0.77	2 – 7

[1] Adapted from M. C. Kahn and S. Line (2005).
* $p<0.05$

On the 14th day postpartum, in both investigated groups of cows leukocyte shift to the left remained, although the band neutrophil count, in comparison with the second day postpartum, was decreased (Table 2). Also the lymphocyte and monocyte count had stabilized in this period; it was most expressed in cows of control group. On the 22nd day postpartum, the band neutrophil count was increased in cows with RFM, but in cows of control group it continued slowly to decrease, and the difference of parameters between two groups was significant ($p<0.05$). Normally parturition causes stress in animals resulting in an increase of leukocyte count with a slight left shift (number of band neutrophils increases). Usually a shift to the left is associated with inflammation processes (Meyer and Harvey, 2004; Schalm et al., 1975; Jain, 1986). These obvious changes are observed from 12 to 24 hours postpartum that decrease within some days (Schalm et al., 1975; Jain, 1986). The lymphocyte count continued to stabilize although it was still below normal values (Table 3).

Table 2

Blood morphological parameters in cows with and without retained fetus membranes on the 14th day postpartum

Parameters	Cows without retained placenta	Cows with retained placenta	Standard[1]
White blood cells (10^9 L^{-1})	8.96 ± 0.68	7.87 ± 0.05	4 – 12
Erythrocytes (10^{12} L^{-1})	5.75 ± 0.17	6.09 ± 0.05	5 – 10
Hemoglobin (g dl^{-1})	9.73 ± 0.19	9.65 ± 0.12	8 – 15
PCV (%)	27.38 ± 0.78	27.79 ± 0.28	24 – 46
MCV (fl)	47.71 ± 1.95	45.79 ± 0.35	40 – 60
MCH (pg)	16.99 ± 0.32	16.05 ± 0.10	11 – 17
MCHC (g dl^{-1})	35.68 ± 0.46	35.04 ± 0.11	30 – 36
Platelets (10^9 L^{-1})	306.25 ±43.68	375.63 ± 35.21	100 – 800
Band neutrophils (%)	4.14 ± 1.02	4.84 ± 0.45	0 – 2
Mature neutrophils (%)	43.88 ± 3.10	42.37 ± 1.67	15 – 45
Eosinophils (%)	3.06 ± 0.65	1.73 ± 0.28	2 – 20
Basophils (%)	1 ± 0	1 ± 0	0 – 2
Lymphocytes (%)	38.25 ± 3.09	43.81 ± 1.91	45 – 75
Monocytes (%)	8.56 ± 1.12	6.93 ± 0.97	2 – 7

[1] Adapted from M. C. Kahn and S. Line (2005).
* $p<0.05$

Table 3

Blood morphological parameters in cows with and without retained fetal membranes on the 22nd day postpartum

Parameters	Cows without retained placenta	Cows with retained placenta	Standard[1]
White blood cells (10^9 L^{-1})	10.40 ± 0.51	10.13 ± 0.59	4 – 12
Erythrocytes (10^{12} L^{-1})	5.54 ± 0.19	5.82 ± 0.02	5 – 10
Hemoglobin (g dl^{-1})	9.36 ± 0.26	9.05 ± 0.28	8 – 15
PCV (%)	25.28 ± 0.72	26.20 ± 0.22	24 – 46
MCV (fl)	46.05 ± 1.20	45.22 ± 0.36	40 – 60
MCH (pg)	17.09 ± 0.48	15.89 ± 0.24	11 – 17
MCHC (g dl^{-1})	37.18 ± 0.52	35.45 ± 0.04	30 – 36
Platelets (10^9 L^{-1})	355.63 ±46.58	393.72 ± 20.02	100 – 800
Band neutrophils (%)	4.06 ± 0.58*	6.05 ± 0.32*	0 – 2
Mature neutrophils (%)	46.44 ± 1.32	45.33 ± 1.04	15 – 45
Eosinophils (%)	2.13 ± 0.39	2.25 ± 0.29	2 – 20
Basophils (%)	1 ± 0	1 ± 0	0 – 2
Lymphocytes (%)	37.18 ± 2.89	39.59 ± 1.72	45 – 75
Monocytes (%)	7.06 ± 0.67	6.64 ± 0.62	2 – 7

[1] Adapted from M. C. Kahn and S. Line (2005).
* $p<0.05$

On the 28th day postpartum, an increased number of band neutrophils and lymphopenia had remained and was more expressed in cows with RFM ($p>0.05$). A significant difference ($p<0.05$) between the groups of cows was observed in terms of platelet count, but the parameters were within the normal values in control group - 269.94±31.14 (10^9 L^{-1}), but in cows with RFM - 416.20±5.23 (10^9 L^{-1}) (Table 4).

Table 4

Blood morphological parameters in cows with or without retained fetal membranes on the 28th day postpartum

Parameters	Cows without retained placenta	Cows with retained placenta	Standard[1]
White blood cells (10^9 L^{-1})	8.86 ± 0.49	10.06 ± 0.53	4 – 12
Erythrocytes (10^{12} L^{-1})	5.41 ± 0.20	5.84 ± 0.09	5 – 10
Hemoglobin (g dl^{-1})	9.12 ± 0.27	9.32 ± 0.12	8 – 15
PCV (%)	24.84 ± 0.76	26.04 ± 0.50	24 – 46
MCV (fl)	46.39 ± 1.21	45.03 ± 0.20	40 – 60
MCH (pg)	17.00 ± 0.36	16.00 ± 0.09	11 – 17
MCHC (g dl^{-1})	36.77 ± 0.44	35.63 ± 0.26	30 – 36
Platelets (10^9 L^{-1})	269.94 ± 31.14*	416.20 ± 5.23*	100 – 800
Band neutrophils (%)	4.44 ± 0.68	5.24 ± 0.92	0 – 2
Mature neutrophils (%)	43.44 ± 1.87	43.18 ± 0.70	15 – 45
Eosinophils (%)	2.38 ± 0.53	2.81 ± 0.28	2 – 20
Basophils (%)	1 ± 0	1 ± 0	0 – 2
Lymphocytes (%)	42.81 ± 1.69*	40.66 ± 0.45*	45 – 75
Monocytes (%)	6.75 ± 0.54	7.07 ± 0.34	2 – 7

[1] Adapted from M. C. Kahn and S. Line (2005).
* $p<0.05$

Table 5

Blood biochemical parameters in cows with and without retained fetal membranes

Parameters	Cows without retained placenta	Cows with retained placenta	Standart[1]
Total bilirubin (μmol L^{-1})	4.77 ± 0.34*	6.19 ± 0.65*	0.7-14
Direct reacting	1.24 ± 0.27*	2.26 ± 0.17*	0-0.34(5.0)
Indirect reacting	3.54 ± 0.36	4.06 ± 0.45	0 – 8.55
Cholesterol (mmol L^{-1})	2.24 ± 0.15	2.36 ± 0.04	1.6-5.0
Protein total (g L^{-1})	66.38 ± 1.18	69.19 ± 1.89	62-82
Albumin (g L^{-1})	29.43 ± 0.65	29.7 ± 0.25	28-39
Albumin/globulin ratio	0.81± 0.04	0.78 ± 0.02	0.84-0.94
AST (U L^{-1})	118.9 ± 9.38	109.80 ± 9.70	45-110
Ca (mmol L^{-1})	2.1 ± 0.08	2.1 ± 0.04	2.1-2.8
P (mmol L^{-1})	1.7 ± 0.16	1.6 ± 0.18	1.4-2.5
Glutathione peroxidase (U L^{-1})	36270.06±2269.53	34447.57 ± 3499.46	25994-29840

[1] Adapted from M. C. Kahn and S. Line (2005).
* $p<0.05$

Blood for biochemical examination was sampled from cows within 48 hours postpartum in order to evaluate the functional condition of liver in milking cows (Table 5). The obtained biochemical data showed that AST reached its highest normal values or was above them, but the difference between cow groups was insignificant ($p>0.05$). During parturition, contractive intensity of muscles is increased and this is also a kind of stress that might cause the increase of AST (Liepa, 2000; Liepa, 2004). In both of the investigated groups of cows, the blood albumin/globulin ratio was slightly below the range of normal values, and the difference between the two groups was insignificant. According to literature data, the albumin/globulin ratio may decrease at liver diseases as well as acute inflammations (Stockham and Scott, 2008; Liepa, 2000).

A significantly higher ($p<0.05$) total and direct reacting bilirubin was observed in cows with RFM, although it was within the range of normal values. The obtained data coincides with those previously studied (Antāne et al., 2000).

The mean calcium level in the blood of cows was within the lowest range of normal values, and significant differences between the cow groups were not observed. Also Y. Akar and H. Yildiz (2005) report that there are no differences in calcium level between cows with normal calving and those with dystocia that is followed by RFM. Phosphorus level was within the lowest range of normal values ($p>0.05$).

Glutathione peroxidase is an important parameter showing the selenium level in the animal body. The activity of glutathione peroxidase in the red blood cells of ruminants has a direct correlation with selenium concentration in blood (Enjalbert et al., 1999; Koller et al., 1984). M. Kankofer's et al. (1996) studies show evidence that the level of glutathione peroxidase is higher in cows with RFM. In the present research, the mean glutathione peroxidase level among individual animals was different, although comparing the mean parameters in cows of control group (3627.06 U L^{-1}±2269.53) and in cows with retained fetal membranes (34447.57 U L^{-1}±3499.46) differences were not significant ($p>0.05$).

Conclusions

1. In cows postpartum, haematological analyses show a shift to the left and lymphopenia with a tendency to get normal within six weeks.
2. On the third week postpartum, in cows with retained fetal membranes the band neutrophil count increases significantly ($p<0.05$) indicating that the inflammation process has flared up.
3. In cows with retained fetal membranes, biochemical parameters are within the range of normal values showing that, in all, the liver functional condition and metabolic processes are not affected.

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INTRAUTERINE FLUID SECRETION IN MARES AFTER ARTIFICIAL INSEMINATION

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Abstract. Reduced fertility associated with fluid accumulation has been recognized for many years in broodmares. Fluid present in the uterus after ovulation is often associated with mare susceptibility to endometritis. Objective of this study was to determine amount of intrauterine fluid secretion and endometrial oedema in mares at the time of artificial insemination (AI), 6 h, 25 h, and 48 h after AI and at the time of ovulation. A total of 22 cycling light breed mares from MTT Agrifood Research, Ypaja, Finland, were used in the study. Relaxation of the cervix, the number and size of follicles, corpus luteum, and the degree of endometrial oedema were examined by transrectal palpation and ultrasonography every other day. According to the closing and opening time of the cervix which was regulated using Bivona catheter mare,s were distributed into 3groups. Group A (n=7): immediately after artificial insemination (AI) the catheter was inserted into the uterus. After 25 h, the catheter was opened and the fluid drained. Group B (n=8): immediately after AI, Bivona catheter was inserted into the uterus. After 6 h and 25 h the catheter was opened and the fluid drained. Group C (n=7)-control group: no catheter was inserted into the uterus. According to our investigation, we concluded that the amount of intrauterine fluid accumulation (IUFA) in mares increased within 25 h after AI. Mares with delayed uterine clearance had a significantly larger amount of intrauterine fluid than mares with normal uterine clearance. Open cervix during oestrus period is important for adequate clearance of intrauterine fluid in mares. Opening of intrauterine catheter at 6 h post AI didn't diminish intrauterine fluid accumulation at 25 h post AI.
Key words: Mare, intrauterine fluid, endometrium fold, oedema.

Introduction

Endometritis is considered an important cause for low fertility in some mares. Endometrial inflammation is a physiological event in mares after insemination or natural breeding (Kotilainen et al., 1994) and serves to eliminate excessive sperm and bacteria introduced into the uterus during breeding within 48 h (Troedsson, 1995). The influx of polymorphonuclear neutrophils (PMN) starts approximately 30 min after artificial insemination (AI) (Katila, 1995) and peak of endometrial inflammation is reached 6 to 24 h post breeding. If uterine clearance fails, pregnancy rates are reduced (Adams et al., 1987). It has been proven that fluid accumulation detected with ultrasonography during oestrus (Pycock and Newcombe, 1996; Squires, 1993) and dioestrus (Adams et al., 1987; Ginther et al., 1985; McKinnon et al., 1987, 1988; Newcombe, 1997) reduces fertility of mares. Fluid present in the uterus after ovulation is often associated with mare susceptibility to endometritis (Brinsko et al., 2003; Maloufi et al., 2002). During oestrus, uterine fluid may be spermicidal (Reilas et al., 1997) or may represent an ideal media to support bacterial proliferation after breeding (McKinnon et al., 1987). When present during dioestrus, it may cause premature luteolysis or embryonic death (Adams et al., 1987; McKinnon et al., 1987; Squires et al., 1989). S.P. Brinsko et al. (2003) concluded that the presence of more than a 2-cm depth of fluid during oestrus was a predictor of susceptibility to mating-induced endometritis as a result of impaired clearance of inflammatory products.

Reduced myometrial contractions, poor lymphatic drainage, large and overstretched uterus and cervical incompetence are predisposing factors for persistent mating-induced endometritis. Parity may have a greater influence than mare age on the level of uterus location (LeBlanc et al., 1998). Delayed uterine clearance of intrauterine fluid after mating is most commonly seen in pluriparous mares older than 14 years and rarely in nulliparous mares. Uterine content can be removed by two ways – via lymphatic or through the cervix during oestrus. No matter which way uterine content is drained, uterine contractions are necessary in this process (LeBlanc et al., 1998). Susceptible mares have been shown to have decreased electrical activity of the myometrium (Troedsson et al., 1993) and intrinsic myometrial deficiencies (Rigby et al., 2001).

Nowadays, it is commonly believed that the effectiveness of uterine drainage mechanisms determines whether a mare is able to recover from the endometritis within 48 h or whether she remains infected.

One of the most striking characteristics visualized at ultrasonography is the appearance of the endometrium during the oestrus cycle. During dioestrus in normal mares, individual endometrial folds are not detected; the uterus has a homogeneous echo texture. During oestrus, individual endometrium folds can be visualized (Ginther and Pierson, 1994) and they become oedematous as a result of increased concentrations of circulating estrogens (Hayes et al., 1985). Detection of endometrial oedema is a reliable indicator of oestrus in the mares. Mares that are susceptible to persistent post breeding endometritis involves intrauterine fluid accumulation (IUFA), possible lymphatic stasis and because of that increase of endometrial oedema which is not as reliable oestrus indicator in this category of mares compared with normal mares.

The objective of this study was to describe the intensity of intrauterine fluid accumulations and endometrial oedema in mares at the time of artificial

insemination, 6 h, 25 h, and 48 h after AI and at the time of ovulation.

Materials and Methods

A total of 22 cycling light breed mares from MTT Agrifood Research and Equine College, Ypaja, Finland, were used in the study. Mares were 3–17 years old (mean 9.6 years), had no history of reproductive failure and were clinically normal. This study was carried out from the beginning of April to early September, year 2007.

Mares were followed for three consecutive oestrus cycles. Before oestrus and artificial examination (AI), relaxation of the cervix, the number and size of follicles, corpus luteum and the degree of endometrial oedema from 0 to 3 (0 - no oedema, 1 - small, 2 - moderate, 3 - strong oedema) were examined by transrectal palpation and ultrasonography (Sono Site Vet 180 plus with a 5- MHz probe; Sono Site Inc., Bothell, WA, USA) every other day. Oestrus was synchronised with 0.25 mg of cloprostenol i.m. (Estrumate vet., Schering- Plough A/S Farum, Denmark).

During the 1st and 3rd oestrus, a uterine swab was obtained. During the second oestrus, when a pre-ovulatory follicle of ≥35 mm was detected in association with uterine oedema and cervical softening, mares were inseminated with 500 x 10^6 progressively motile sperm extended with skim milk (20 ml/AI; semen pooled from 2 stallions with proven fertility). All mares received an intravenous injection of 1500 IU of human chorionic gonodotrophin (hCG, Chorulon®, Intervet International B.V., Boxmeer, The Netherlands) right after AI to synchronize ovulation. Subsequently, mares were scanned daily until the ovulation was detected. All inseminated mares were stabled for 25 h. An approximate assessment of the amount of intrauterine fluid accumulation (IUFA) was made by measuring the length (height (mm) x width (mm) of any pools of fluid at the time of AI (0 h) and 6 h, 25 h and 48 h after AI, and at the time of ovulation with ultrasound.

During the second oestrus, mares were randomly assigned to one of 3 groups: A (n=7), B (n=8), and C (n=7). Bivona intrauterine catheter (65 cm in length, 33fr diameter; Equivet, Kruuse, Marslev, Denmark) was placed in the uterus of mares of groups A and B. Immediately after its insertion, the cuff of the catheter was filled with a 80 ml of air so that no fluid could escape from the catheter. In group A mares the catheter was opened after 25 h and the fluid drained into a sterile Falcon cylinder. In group B mares, the catheter was opened after 6 h and 25 h. Group C was control group - no catheter was inserted into the uterus. At 25 h after AI, 500 ml of Ringer's solution (Ringer-Acetate Viaflo, Baxter) were infused into the uterus in all groups. After 2 min of equilibration, the fluid was allowed to drain back into dispensing bag, and the catheter from groups A and B was removed. All mares were given 10 IU oxytocin i.v. after lavage to induce uterine contractions and allow a better uterine clearance.

The amount of intrauterine fluid accumulation (IUFA) in control and treatment groups was analyzed with the Mann –Whitney test for 2 independent samples using the statistical program SPSS for Windows 11.5 (SPSS Inc. Microsoft cooperation) to detect significant ($P<0.05$) differences between groups.

Results and Discussion

One mare from group B was excluded from the study because of cervical fibrosis detected in 3rd oestrous period during swabbing. One mare from group A and 3 mares from group B lost their catheters.

There was no bacterial growth and polymorphonuclear neutrophils (PMNs) were not found in uterine swabs in the 1st and 3rd oestrus in any of the study mares except one mare from group A which had low number of mixed Staphylococcus spp. growth detected in the first oestrus. The results showed that it was a possible contaminant during culturing. The same mare showed 1-10 neutrophils per 10 fields 400 x magnification in the 1st and 3rd oestrus. One mare from control group showed 1–10 neutrophils per 10 fields 400 x magnification in the 3rd oestrus period.

Figure 1 shows the changes in IUFA mm^2 (area of fluid pools measured by ultrasound), ultrasound in mares in 2nd oestrus period (mean ± standard error of means (SEM)) at the time of AI (0 h), 6 h, 25 h and 48 h after AI and at the time of ovulation.

At all times, control group had the least amount of IUFA. There were no IUFA accumulation in control group at the time of AI (0±0) compared with group A and group B where the amount of IUFA was respectively 516.7±124.3 mm^2 and 683.8±448.1 mm^2. 6 h after AI, control group had lower accumulation of IUF (753.6±171.2 mm^2) compared with group A (1170.3±205.3 mm^2) and group B (1500±589.4 mm^2). The highest amount of IUFA was detected 25 h after AI in all groups (A – 3125±338.7 mm^2; B – 3037.5±459.7 mm^2; and C- 1307.1±148.9 mm^2). There was a significant difference between groups A, B and C 25 h post AI ($p< 0.05$). G.P. Adams et al. (1987) study shows that peak of endometrial inflammation is reached 6 – 24 h post breeding. Our results show that the amount of IUFA increases at 6 h and 25 h after AI in all groups and that group A and B accumulate more intrauterine fluid because of delayed uterine clearance via the cervix. Whereas Liu (reviewed by Allen W.R., 1993) has suggested that impaired uterine drainage through the cervix may be a reason for excessive fluid accumulation and that the initially sterile intrauterine fluid may provide an ideal media for bacterial growth. Our study shows that impaired uterine drainage via cervix after AI increases IUFA in mares, especially 25 h after AI, showing the importance of the cervix in uterine clearance mechanism after AI. E.L. Squires et al. (1989) also proposed that IUFA has a direct effect on spermatozoa. After 25 h when the catheter was removed to allow free fluid drainage via cervix and oxytocin was injected to allow fluid drainage, the amount of IUFA decreased in all mare groups as follows: A - from 3125± 338.8 mm^2 to 495± 68.5 mm^2;

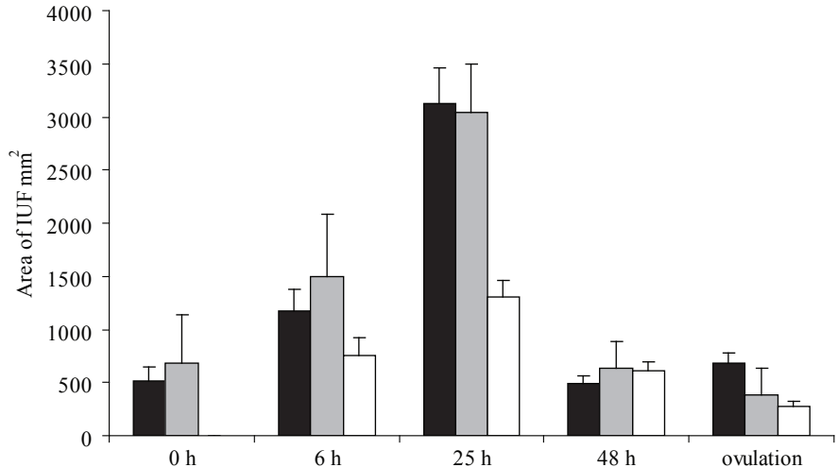

Figure 1. Estimate of area occupied by intrauterine fluid (mm^2) in ultrasonographic evaluation of mares in the 2nd oestrus period (mean ± SEM) at the time of AI (0 h), 6 h, 25 h, and 48 h after AI and at the time of ovulation: ■ A – intrauterine catheter closed for 25 h, ▒ B – intrauterine catheter closed and opened at 6+25 h, □ C – control group.

B - from 3037.5± 459.7 mm^2 to 637.5± 245.5 mm^2, and C - from 1307.1± 148.9 mm^2 to 607.1± 86.4 mm^2. The amount of IUFA at the time of ovulation compared with 48 h after AI was similar in all groups. Of course, the contractions of myometrium are much of importance in uterine clearance after sperm induction into the uterus has occurred. A.M. Risco et al. (2009) in her study showed that the group of mares who received oxytocin treatment 4 h, 8 h and 25 h after AI had very little accumulation of IUF at any time of sampling demonstrating that myometrial contractions are important in removing IUF after AI.

Endometrial folds first become visible at the end of dioestrus, become more prominent as oestrus progresses, and generally diminish from approximately 2 days from ovulation until the day of ovulation, when oedema may have disappeared. In our study, during oestrus and AI, endometrial oedema varied from 0 to 3 degrees (Figure 2) and decreased after 6 h post AI. Endometrial oedema was not associated with the amount of IUFA. It is thought that endometrial folds become oedematous during oestrus as a result of increased concentrations of circulating oestrogen (Hayes et al., 1985).

Conclusions

1. The amount of intrauterine fluid accumulation in mares increased within 25 h after artificial insemination. Mares with delayed uterine clearance had significantly larger amount of intrauterine fluid than mares with normal uterine clearance.
2. Open cervix during oestrus period is important for adequate clearance of intrauterine fluid in mares.
3. Opening of intrauterine catheter at 6 h post artificial insemination didn't diminish intrauterine fluid accumulation at 25 h post artificial insemination.
4. Changes of intrauterine fluid accumulation during oestrus and post artificial insemination have no effect on the degree of endometrial fold oedema.

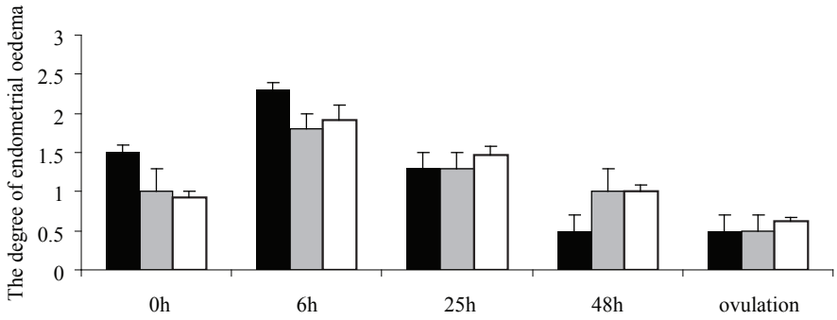

Figure 2. The degree of endometrial oedema (0-3) in mares in the 2nd oestrus period (mean ± SEM) at the time of AI (0 h), 6 h, 25 h, and 48 h after AI and at the time of ovulation. 0 - no oedema, 1 - small, 2 - moderate, 3 -severe oedema: ■ A – intrauterine catheter closed for 25h, ▒ B – intrauterine catheter closed and opened at 6+25h, □ C – control group.

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PERINATAL ONTOGENESIS OF GASTRIC MUCOSA IN THE OSTRICH *(STRUTHIO CAMELUS VAR. DOMESTICUS)*

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Abstract. There are several unique features in the anatomy of the stomach in African ostrich in comparison with other birds. The goal of this study was to determine changes in the main morphometric parameters and histological features of gastric mucosa in ostrich chickens from the 38th day of embryonal development until 60 days of age. For the study, 6 embryos (38th day of development) and 36 chicks (1, 3, 7, 14, 30, and 60 days post hatching; 6 chicks per time point) of both sexes were obtained from African ostrich farm in Latvia during May - October, 2009. Tissue samples were investigated in Preclinical Department, Faculty of Veterinary Medicine. The total area of proventricular mucosa (cm^2) and surface area of deep glands (cm^2) was measured. Tissue sections for histological assessment were stained with: hematoxylin and eosin and alcian-blue pH 2.5 - periodic acid – Schiff reaction. Thickness of proventricular and ventricular mucosa, depth of proventricular superficial glands as well as surface area of parenchyma occupied by deep glands were measured in histologic sections. As the chick age increased, there were changes in the ratio of areas occupied by proventricular superficial and deep glands with relative decrease in area occupied by deep glands. Proventricular deep glands developed rapidly after hatching; at the age of 30 days deep glands histologically resembled glandular structure of adult birds. Gastric mucosal epithelial cells of 38 days old ostrich embryos and of just hatched ostrich chicks contained neutral, acidic, and mixed mucopolysaccharides. Meanwhile, in the pyloric region of ventriculus acidic mucopolysaccharides predominated.
Key words: ostrich, proventricular glands, histochemistry, ontogenesis.

Introduction

Stomach of African ostrich (*Struthio camelus* var. *domesticus*), similarly to stomach in other birds, consists of two compartments: glandular part or proventriculus (*pars glandularis*), and muscular part or ventriculus (*pars muscularis*); however, there are several unique features in the anatomy of gastrointestinal tract of ostrich that are related to adaptation of this species to life in the climatic conditions characteristic to natural geographical distribution (desert) and relatively high content of fiber in ration (Sales, 2006). In comparison with other bird species, ratites (*Ratites*) have well developed proventriculus which in adult African ostrich is 2-2.5 times larger than ventriculus (Порческу, 2007). Within the proventriculus of ratites there is a region of deep glands (*gll. proventriculares profundi*) that produces hydrochloric acid and pepsin, and a region of superficial glands (*gll. proventriculares superficiales)* that produces secretion containing mucopolysaccharides (Cho et al., 1983; Порческу, 2007; Bezuidenhout and Wan Aswegen, 1990; Catroxo et al., 1997). In African ostrich, deep glandular region occupies a relatively small portion of the proventricular mucosa, and among ratites this relative deep gland area is comparatively the smallest (Cho et al., 1983; Cooper and Mahroze, 2004).

Histology of gastric mucosa of hens and chickens had been studied in detail in the middle of the past century; however, there is relatively scant research regarding this subject in ostriches. Several authors (Bezuidenhout and Wan Aswegen, 1990; Illanes et al., 2006; Wang et al., 2007) have described histology of gastric mucosa in African ostrich starting from 2 months of age until adulthood; however, there are no data regarding gastric mucosal development during perinatal period. Thus, the goal of this study was to determine changes in the main morphometric parameters of gastric mucosa as well as to determine histological characteristics of gastric mucosa in ostrich embryos and chickens from 38th day of embryonal development until 60 days of age.

Materials and Methods

For the study, six African ostrich embryos (38th day of development) and 36 chickens (1, 3, 7, 14, 30, and 60 days post hatching; 6 in each age group) representing both sexes were used. Ostrich eggs were obtained and incubated at ostrich farm „Ozoliņi AB" located in Jekabpils region in Latvia during May-October, 2009. Starting from the 4th day post hatching, the chickens were fed commercial ostrich chicken feed *Strus Premium - Strus 1*. Feed and water were supplied *ad libidum.*

Birds were anesthetized with intramuscular injection of 0.5 ml of 10% ketamine combined with 0.5 ml of 2% xylasine solution after which they were euthanized with intracardiac injection of 0.5 ml of pentobarbitol solution. Tissue samples were investigated in Preclinical Department, Faculty of Veterinary Medicine. Immediately after euthanasia, tissue samples for histological assesment were collected from the deep and superficial glandular regions of proventriculus, lateral walls of ventriculus and from pyloric region and were fixed in 10% neutral buffered formalin for 24-48 h in room temperature. The total area of gastric glandular part (cm^2) and area of deep glands (cm^2) was determined using planimeter method (Sokkia KP-90N).

Samples for histological analysis were dehydrated in the tissue processor (TISSUE-TEK II) and embedded in paraffin blocks. Tissue sections were cut (4-5 μm) and stained with hematoxylin and eosin

for morphological assessment (Carson, 1997). For the identification of epithelial mucoid secretions, the following special stains (reactions) were used: periodic acid-Schiff reaction (PAS) for identification of neutral mucopolysaccharides; alcian blue with pH 2.5 (AB) for identification of acidic mucopolysaccharides, and alcian blue pH 2.5-periodic acid-Schiff reaction (AB-PAS) for identification of mixed mucopolysaccharides (Carson, 1997; Kiernan, 2008). Tissue sections that were obtained from embryos and 1, 3, and 7 days old chickens were incubated in 1% amylase solution for 30 min in room temperature prior to staining with PAS. This was done to eliminate interference of intracellular glycogen with staining for neutral mucopolysaccharides (Carson, 1997).

Measurements of proventricular and ventricular mucosal thickness (μm), the depth of tubules of superficial glands in the proventriculus (μm), and area of deep glandular portion of proventriculus (μm^2) were obtained using light microscope (Leica DM500B) and microscopic image analysis program Image-Pro Plus 6.1. The thickness of gastric mucosa was measured at 30 sites in each tissue sample taking measurement from the apical aspect of epithelial cells on the mucosal surface to submucosal layer (5 fields, 6 measurements taken in each field). The depth of tubules within superficial glands was measured from the basal aspect of epithelial cells at the base of the glands to the apical aspect of the epithelial cells on the surface taking measurements of 30 tubules which were optimally oriented (the entire tubule visable in the tissue section). The area of deep glands was measured in 5 fields of view in each sample and compared with the total area included in 5 fields of view. Measurements were averaged to get mean parameter value for each chicken (Microsoft Excel, 2007), and results were evaluated for statistical significance using SPSS 11.5 with ANOVA Post Hoc data analysis tool.

Results and Discussion

In all birds used in this study, gastric proventricular and ventricular mucosa was covered with koilin (*Cuticula gastrica, s.coilin),* which in embryos and 1-3-day old chicks was bright green, rather thin and easily separable from mucosa, while in older birds it was thicker and green-yellow. M. M. Shanawany (1996) indicated that dark brown-green pigment in koilin comes from bile reflux from duodenum into stomach. It is reported that 7-12-week old ostrich chicks similarly to other birds have duodenogastric reflux (Degen et al., 1994). Results of our study show that bile secretion and its flow into duodenum and retrograde into gastric ventricular and proventricular compartments occurs as early as 38th day of embryonal development.

Examining glandular mucosa under the koilin, grossly visible is raised, well delineated region of deep glands which is spanning from the entrance of esophagus extending caudally along dorsolateral wall of stomach; within this region well visible are papillae (*papilla proventricularis*) with the central opening for deep glandular ducts. Well delineated region of deep glands as a unique feature of ratites is mentioned by P. Cho et al. (1983) who point out that specifically in African ostrich proventriculus is developed the best (2-2.5 times larger than ventriculus) (Порческу, 2007); however, deep glandular area is smallest in comparison with other species comprising only 25% of total proventricular mucosal area.

Proventricular mucosal area rapidly increases as ostrich chicks grow older, and between 30 and 60 days of age it increases in size 2.5 times ($p<0.001$); meanwhile the area of deep gastric glands increases slower – between 30 and 60 days of age its size has only doubled ($p<0.001$). Unproportion growth of both gastric mucosal regions is underscored also by the relative size measurements of deep gastric gland region. For example, in newly hatched chickens relative portion of deep gastric glands comprises 22% of the total area of proventricular mucosa and during maturing it decreases to 14% ($p<0.01$) at 60 days of age (Table 1).

Table 1

Macromorphometric measurements of gastric proventricular (*pars glandularis*) mucosa in ostrich chickens of various ages (mean ± SD)

Age, days	Mucosal area, cm^2	Region of deep glands	
		Area, cm^2	Relative area, %
38 (embryos)	24.7±7.2	5.4±1.3	22.5±3.7
1(chicks)	32.1±4.3	7.1±1.8	22.0±4.2
3(chicks)	43.6±6.7	8.8±1.6	20.1±2.0
7(chicks)	74.0±8.7	14.4±1.8	19.6±2.5
14(chicks)	131.3±29.9	22.7±3.8	17.8±3.4
30(chicks)	183.5±40.3	30.8±6.0	17.0±2.4
60(chicks)	459.6±63.7	64.6±9.8	14.0±0.8

The mucosa of the proventricular superficial glands is folded, and the wall is thinner than the wall in deep glandular region.

Koilin layer covering ventricular mucosa is thicker, mucosa underneath it is smooth, and crypts are hardly visible. A.J. Bezuidenhout and G. Wan Aswegen (1990) and G.S. Porchesku (2007) (Порческу, 2007) described that in adult ostrich crypts are grossly easily seen and that they contain ducts for tubular glands producing secretion which becomes koilin. In the pyloric region, mucosa is folded and covered with a thinner koilin layer.

Mucosa of **proventriculus** (*tunica mucosa*) is covered by a single layer of columnar epithelium which is covering folded lamina propria (*lamina propria*) thus forming simple tubular glands – superficial glands *(gll. proventriculares superficiales)* of proventriculus (Bezuidenhout and Wan Aswegen, 1990; Illanes et al., 2006; Порческу, 2007).

On the 38th day of embryonal development, tubules of the superficial glands are short, and the epithelium

lining them is low columnar but at the base of the glands – cuboidal. The nuclei of the cells are located basally while apical portion of the cytoplasm contains many mucous-filled granules which react positively with neutral, acidic and mixed mucopolysaccharides. The number of mucous-filled granules increases in the direction of the neck of the glands, and single cell often contains granules with several types of mucopolysaccharides.

On the day of hatching, tubules of the superficial glands are deeper (in comparison with 38th day of hatching), and with increasing age, their length also increases. Beginning with day 3 of age, branching of isolated glands is noted, but on day 14 of age branching is seen in many glands, their lumina are wider and they produce secretion that consists of neutral and acidic mucopolysaccharides forming koilin layer on the surface. Cells that are closer to the neck of the glands mostly contain neutral mucopolysaccharides while the cells located deeper in the glands contain acidic and mixed mucopolysaccharides. Similarly, in domestic chickens, neutral and acidic mucopolysaccharides are detected in the epithelium of superficial glands of proventricular mucosa (Jamroz et al., 2006).

It needs to be mentioned that in most birds, including domestic birds, architecture of superficial glands is simple and branching is not observed (Catroxo et al., 1997; Samuelson, 2007; Aughey and Frye, 2001; Bacha, and Bacha, 2006; Порческу, 2007); however, studies of other (Bezuidenhout and Wan Aswegen, 1990; Illanes et al., 2006; Wang et al., 2007) indicate that in ostrich superficial gland architecture varies from simple to branching tubular glands. Thus, results of our study are in agreement with previously published reports.

The depth of superficial glands in the proventriculus of adult ostrich varies around 742 μm, but the width is 22 μm (Порческу, 2007). Results of our research show that in ostrich chicks the depth of superficial glands in the proventriculus, similarly to mucosal thickness in this region, increases proportionally with increasing age of chickens. At the age of 60 days, the depth of gland is 342.4±50.2 μm, which is significantly increased in comparison with the 38th day of embryonal development and day of hatching ($p<0.01$), while the thickness of mucosa is 701.0±151.0 μm ($p<0.05$) (Figure 1). Epithelium lining glands becomes taller, and low columnar to cuboidal cells are only observed at the base of the glands.

In the dorsolateral wall of the proventriculus there are located deep glands (*gll.proventriculares profundi*). In adult birds they are composed of many rounded, angular or polymorphic lobules which are arranged in clusters. Each lobule is composed of tightly packed tubules which through tertiary or secondary ducts open into the central cavity of the gland. Central cavity of the gland is lined by one type of epithelium – single layer of cuboidal or low columnar epithelial cells which produce hydrochloric acid and pepsin (Randall and Reece, 1996; Bezuidenhout and Wan Aswegen, 1990; Samuelson, 2007; Rossi et al., 2005).

On the 38th day of embryonal development, these tubuloalveolar gland clusters already represent largest part in the entire gastric wall in the corresponding region. Glandular groups consist of poorly developed rounded polymorphic lobules separated by connective tissue fibers and smooth muscle cells. In the periphery of the lobules there are short, poorly developed tubules which connect to short, poorly developed tertiary ducts followed by secondary ducts which open into the center of the lobule. Secondary ducts as well as central cavity are lined by a single layer of low columnar epithelium that does not contain mucous-filled granules. Glandular tubules are separated by cuboidal glandular epithelial cells with large round vesicular nuclei and granular cytoplasm. The papillary ducts (primary ducts) through which the central cavities of groups of lobules open onto the surface are lined by a single layer of columnar epithelium; the apical portions of these cells contain abundant mixed mucopolysaccharide-filled granules. Between groups of glands there is a relatively thick

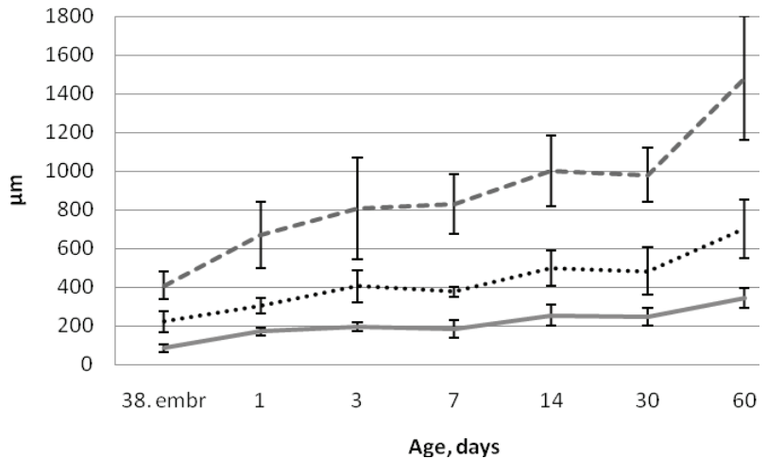

Figure 1. Thickness of gastric mucosa and depth of superficial glands in μm (mean±SD) in ostrich chickens from the 38th day of embryonal development until 60 days of age: ----- *pars muscularis*; ····· *pars glandularis*; ——— superficial glands.

connective tissue layer with abundant blood vessels and nerve fibers as well as individual mesenchymal cells and lose connective tissues. Smooth muscle cells are also observed.

On the day of hatching, lobules are more prominent and the amount of connective tissues between lobules is smaller. Tubules of the glands are relatively short with narrow lumen. Glandular epithelium forms longer rows of cells thus forming tubules. Between the rows of epithelial cells, capillary endothelium prominently stands out.

Beginning with day 7, smooth muscle fibers predominate between lobules, but between the groups of glands - mostly loose connective tissues, large blood vessels, and nerve plexuses are seen. Tubules that form the lobules of the glands are longer and their lumina wider. The borders between lobules are well delineated by smooth muscle fibers. The outline of the lobules is multiangular. Tertiary ducts are short. In this age group, in the epithelium that lines lumen of the lobules a few neutral mucopolysaccharide - containing granules are noted.

Beginning with day 14, tubules of the glands are well developed. Crossection of the lobule is mainly occupied by tubules lined by cuboidal glandular epithelium. The central cavity of the lobule with tertiary and secondary ducts are present in the center of the lobules.

At the age of 30 and 60 days, there is a small amount of connective tissue and many blood vessels between glandular lobules. In each cluster of glands there are many variably sized lobules. Long, well developed tubules continue as tertiary and secondary ducts. Between the rows of glandular epithelium there are wide tubular lumina. The cytoplasm of epithelial cells lining central cavity of glands and primary ducts contain neutral polysaccharides. In this age group, the histology of deep glands already resembles deep glands of adult birds.

A.J. Bezuidenhout and G. Wan Aswegwn (1990) noted that mucous-containing granules are only present in the epithelium lining primary ducts; however, the results of our study show that beginning from day 7 of age, neutral mucopolysaccharides containing granules are present in a few epithelial cells that line central cavities of glands and the number of these cells increases with age.

The measurements of deep glandular parenchyma relative to the entire glandular area (Figure 2) show that proportion of deep glandular area markedly increases between the 38th day of embryonal development and the day of hatching ($p<0.05$) as well as between 3rd and 14th day of age ($p<0.05$), which is the time when the birds start to eat on their own and begin to consume feed intensively. At 60 days of age, deep glands already occupy 92% of glandular area. Mucosal muscle layer within the region of superficial glands is rather poorly developed but within deep glandular region it surrounds lobules of the deep glands.

Within the gastric ventricular mucosa, similarly to other birds, there are simple as well as branching tubular glands (*gll. ventriculares*) which extend into mucosal lamina propria and open onto the mucosal surface in the wide crypts (Bezuidenhout and Wan Aswegen, 1990; Randall and Reece, 1996). In an adult ostrich, 8-28 tubular glands open into a single crypt (Порческу, 2007). The base of the glands is formed by a single layer cuboidal epithelium (basal cells) with large, round vesicular nuclei and pale cytoplasma. Glandular tubules are lined by low prismatic epithelial cells (chief cells) with round or oval nuclei. These cells produce mucoid secretion. Cytoplasm of these cells distally from the nucleus is filled with poorly staining small secretory granules. The surface of the mucosa and crypts is covered by a single layer of prismatic epithelium (surface epithelial cells). Apical portion of the cells is filled with rough eosinophilic secretory granules which closer to the nucleus stain basophilic. On the surface of the crypts, exfoliated cells are present as well as cells with degenerative features. Within basal aspect of the glands there are small numbers of scattered pyramidal cells (entero-endocrine cells) (Bezuidenhout and Wan Aswegen, 1990).

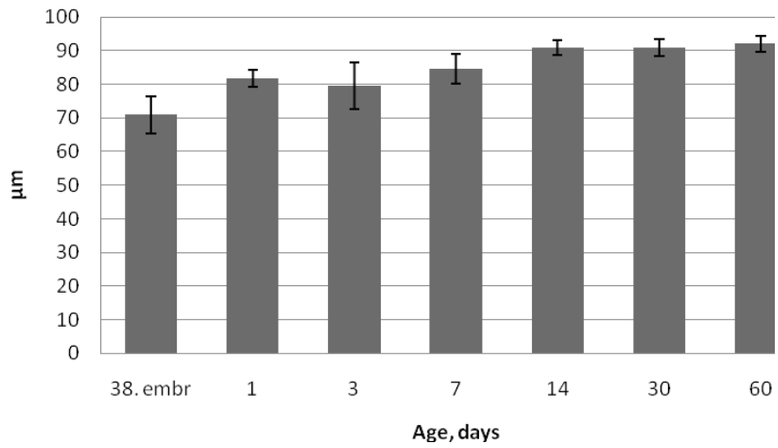

Figure 2. Proportion of deep glandular parenchyma (μm^2) relative to 100 μm^2 of glandular mucosal area (mean±SD) in ostrich chickens from the 38th day of embryonal development until 60 days of age.

Our research shows that in ostrich chicks on the 38th day of embryonal development glandular tubules are poorly developed, they are short, convoluted, and open onto mucosal surface as a single tubule or in groups up to three. Superficial epithelial cells contain mainly neutral mucopolysaccharides, but cells that contain acidic and mixed mucopolysaccharides are also observed. In the direction toward pyloric region, the epithelium covering surface contains relatively numerous cells producing acidic mucopolysaccharides, but in the transitional zone between stomach and duodenum mucosa forms folds which are covered by a single layer columnar epithelial cells that contain abundant amount of mixed and neutral mucopolysaccharides. Within mucosal lamina propria there are convoluted tubular glands formed by low columnar to cuboidal epithelium with large round nuclei (*gll.pyloricales*). Similar histological structure is described in hens (Aitken, 1958), in which numerous gastrin and somatostatin-positive cells are seen (Aksoy and Cinar, 2009; Rawdon et al., 1999).

Secretion produced by glands within the ventricular mucosa contains mostly neutral mucopolysaccharides, but secretion produced in pyloric region contains mostly acidic mucopolysaccharides. With increasing age glandular tubules become longer, and at 14 days of age they almost reach submucosa (*tela submucosa*); the volume of glands in the pyloric glandular transition zone increases. With increasing age there are no substantial changes in the epithelial cell mucopolysaccharide content and in the qualitative content of secretion.

The thickness of mucosa within ventriculus (Figure 1) in a newly hatched chick composes 668.9±170.0 μm, which is twice thicker than gastric wall within proventriculus (305.4±40.6 μm). At two months of age it is significantly increased and in the ventricular part it is 1480.8±318.4 μm ($p<0.001$), but in the proventricular part- 701.0±150.9 μm ($p<0.01$). G.S. Porchesku (Порческу, 2007) indicates that in adult ostrich mucosal thickness in the various regions of ventriculus varies from 0.5 to 1.5 mm.

Conclusions

1. As the chick age increases, there are changes in the ratio of areas occupied by proventricular superficial and deep glands with relative decrease in area occupied by deep glands.
2. Proventricular deep glands develop rapidly after hatching and at the onset of feed consumption; at the age of 30 days deep glands histologically resemble glandular structure of adult birds.
3. Gastric mucosal epithelial cells of 38-day old ostrich embryos and of just hatched ostrich chicks contain neutral, acidic and mixed mucopolysaccharides, but with increasing age there is increase in the relative proportion of neutral mucopolysaccharides; meanwhile, in the pyloric region of ventriculus acidic mucopolysaccharides predominate.
4. Granules of neutral mucopolysaccharides are observed in the epithelial cells lining central cavity of deep glands of 7-day old chicks and there is trend for these granules to increase with increasing age.
5. On the 38th day of embryonal development, ventricular mucosa is twice thicker than proventricular mucosa, and this ratio is maintained as the ostrich chicks grow older.

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ENUMERATION OF *LISTERIA MONOCYTOGENES* IN DIFFERENT RIPENING STAGES OF COLD SMOKED SAUSAGES

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Abstract. The non-spore forming gram-positive bacterium *Listeria monocytogenes* is a food pathogen bacterium and the causative agent of listeriosis. The aim of study was to determine the survival limits of *L. monocytogenes* inoculated in manufactured cold smoked sausages depending on water activity (a_w) and pH values. Enumeration of *L. monocytogenes* colony forming units per gram (cfu g^{-1}) was done according to ISO standards. The decreasing water activity conditioned by moisture (weight) loss during ripening and pH decrease ensured negative exponential growth rate of inoculated *L. monocytogenes* lg cfu g^{-1} - 0.44 each day. A significant Pearson's correlation ($p < 0.01$) was established between decreased values of *L. monocytogenes* count, a_w (0.99), pH (0.92), moisture % (0.96), and weight loss (0.93) in sausages during ripening. The experiments were done at the Faculty of Veterinary medicine of the Latvia University of Agriculture and in a sausage manufacturer's laboratory.
Key words: *Listeria monocytogenes*, cold smoked sausages, water activity, pH.

Introduction

Listeria monocytogenes is an ubiquitous bacterial pathogen that can be found in a large number of food products. Meat and processed meat products such as cold smoked sausages are part of major products associated with listeriosis (Thevenot et al., 2005). Unlike many other food pathogens, *L. monocytogenes* infection has a high mortality rate - 20 - 30% (Farber and Peterkin, 1991). The infective dose of *L. monocytogenes* to susceptible human risk groups – children, elderly, immunocompromised people, and pregnant women - is not known. Therefore, in the United States, a zero tolerance of *L. monocytogenes* in ready-to-eat foods has been prescribed for several years (Shank et al., 1996), but the European Union regulation exceeded concentration of *L. monocytogenes* in ready-to-eat food to 100 colony forming units (cfu) per gram (Anonymous, 2005). In storage of fresh foods, such as raw meat or partly fermented sausages, pathogens are normally of lesser concern since the gram-negative spoilage bacteria present grow much more rapidly (Jeppesen and Huss, 1993). Under temperature abuse, spoilage of the product occurs before pathogens can proliferate. However, in products, cooking, preservation ingredients, and storage atmosphere inhibit the native gram-negative organisms, resulting in a longer shelf life. K. Glass and M. Doyle (1989) found out that *L. monocytogenes* decreasing level in fermented sausages and ham would be 1-2 lg (sausages) in 14 days, and 2-3 lg (ham) in 28 days. This enhances the growth conditions of psychotropic pathogens such as *Listeria*, allowing them to grow to dangerous levels (Francis and O'Beirne, 1998). Because lactic acid bacteria can grow under the same storage conditions as *Listeria* spp. (Bērziņš et al., 2007), many studies have been conducted to investigate if these gram-positive organisms can provide adequate competition against the pathogenic organisms that are also present.

L. monocytogenes may be found in plants, soil, or water, and has been isolated from many mammalian and bird species. *L. monocytogenes* is a short, gram-positive, non-sporeforming rod, with tumbling end-over-end motility at room temperature (Brooks et al., 1998). It is a catalase positive, oxidase negative, facultative anaerobe with slight β–hemolysis on blood agar. *L. monocytogenes* has been known to survive refrigeration, freezing, heating, and drying, which creates obstacles for the food industry (Center for food…, 2001). It has optimum growth at 32-35 °C, but can survive and multiply at refrigeration temperature (Lunde´n et al., 2003).

L. monocytogenes post-processing contamination may occur because the organism is so resilient in the environment. The largest meat recall in history occurred in USA in October 2002, when 27.4 million pounds of fresh and frozen turkey and chicken products were recalled after a multi-state listeriosis outbreak. Eight states reported a total of 53 culture-confirmed cases, all in immunocompromised individuals, resulting in eight deaths and three stillbirths or miscarriages (Center for Disease…, 2002).

L. monocytogenes strains may persist in food-processing plants for months or even years despite regular sanitation procedures (Miettinen et al., 1999; Lunde´n et al., 2003, 2005) and are to be categorized into persistent strains according to the frequency of the strain and duration of the contamination. The persistent strains showed higher tolerance to acidic conditions (Lunde'n et al., 2008). Today, 13 different serotypes of *L. monocytogenes* have been identified of which serotypes 1/2a, 1/2b, 1/2c, and 4b hold for over 95% and are isolated from food and patients (Doumith et al., 2004).

The safety of cold smoked sausages depends on the presence of factors such as concentration of sodium nitrite and salinity, relatively low water activity (a_w), low pH value, and application of probiotics (Lahti et al., 2001), like lactic acid bacteria used in fermented meat products (Bredholt et al., 2001).

For *L. monocytogenes*, large variation in stress tolerance is observed under different conditions of salinity, acidity, and temperature in both culture broth

and in different kinds of food products.

Previous studies were focussed on modelling the growth limits of the organism at a combination of temperature, pH, NaCl concentration, and lactic acid for two strains (Tienungoon et al., 2000), or a cocktail of five strains (Vermeulen et al., 2007). In other studies, the effect of combination treatments with lactic acid and hot water on a five-strain cocktail of *L. monocytogenes* (Koutsoumanis et al., 2004), or the growth and cell wall properties under acid and saline conditions of two strains of the pathogen were investigated (Bereksi et al., 2002). In these cases, no link was made between the sero-type or origin of isolation and the stress tolerance. A limited number of studies are available in which serotype or isolation differences were investigated. D. Liu et al. (2005) investigated the inactivation kinetics of three virulent and three avirulent strains at various pH and salt concentrations. Their results highlight that acid, alkali, and/or salt treatments, commonly used in food product processing, may not be sufficient to eliminate *L. monocytogenes*.

Listeria monocytogenes is able to multiply in many foods because it can survive and thrive at relatively low water activity (a_w). R.E. Petran and E.A. Zottolla (1989) observed the growth of *L. monocytogenes* at the minimum a_w of 0.92. Below these minimum a_w levels, cell death is proportionate to water activity (Miller, 1992). These results were again confirmed by J. Farber (1992) using ternary soy broth and sucrose for an observed minimum a_w of 0.92. A study using a model meat system considered the influence of the relationship of water activity and other factors on the growth of *L. monocytogenes* Scott A (Chen and Shelef, 1992; Vermeulen et al., 2007).

L. monocytogenes is capable of survival and growth over a wide range of storage temperatures. While the optimum growth temperature is 30-37 °C, lower and upper limits for growth are 1 °C and 45 °C, respectively (Farber et al., 1989). Growth has also been observed in chicken broth at temperatures as low as -0.1 °C to -0.4 °C (Walker et al., 1990). Because of this resilience, *L. monocytogenes* has been found to survive and multiply in refrigerated processed meat products, including ham, bologna, frankfurters, sliced turkey and chicken, and sausages stored at 4.4 °C (Glass and Doyle, 1989). Another study performed on frankfurters alone found 65.6% of inoculated samples stored at 5 °C under vacuum for 28 days and supported growth of *L. monocytogenes* (McKellar et al., 1994). Although the lower growth limit of *L. monocytogenes* has been estimated to be around 0 °C, it has been found to survive lower temperature extremes for extended periods of time. The organism has also been shown to survive at temperatures exceeding its upper growth limit at 45 °C. A study by J. Novak and V. Juneja (2003) found that heat-shocking *L. monocytogenes* in ground beef at 46 °C for 60 minutes caused D_{10}-values to increase 1.4-fold when compared to non-shocked controls. Further storage under refrigerated conditions did not change this heat resistance. Because of the temperature fluctuation that occurs during the display, purchase, transfer, and storage of a refrigerated food product, there is a high risk of increasing pathogen populations.

Important consideration to the growth and survival of *L. monocytogenes* is pH. The organism has a possible range of growth from pH 4.1 to 9.6, with an optimum range of 6.0 - 8.0 (Jay, 2000). This pH range is dependent upon various factors, including incubation temperature, available nutrients, moisture % content, and product composition. M. Parish and D. Higgins (1989) found that lower pH had a deleterious effect on viability of *L. monocytogenes*, although a lag period occurred at 4 °C before cell reduction occurred. They concluded that low pH products were of concern in *L. monocytogenes* outbreaks under contamination followed by consumption of the product soon after purchase, as the lag effect would prevent immediate cell death.

Studies previously mentioned observed a synergistic relationship between acid and osmotic shock responses in *L. monocytogenes* (Le Marc et al., 2002; Vialette et al., 2003; Faleiro et al., 2003) also researched a combination of factors to find the growth limits of *L. monocytogenes*, including pH and organic acid concentration at set temperatures. They observed that combinations of low pH, high concentrations of weak organic acid, and low temperatures are effective inhibitors of *Listeria*. Because most meat products fall in a pH range of 5.1 - 6.4, depending on the origin of an animal and the way the meat is processed (Jay, 2000), contamination with *L. monocytogenes* and subsequent risks of illness from eating meats are of major concern to food safety experts.

According to literature data, many recent studies in food safety have investigated non-thermal processing of ready-to-eat food products, but there is little information about survival of *L. monocytogenes* found in different ripening stages of cold smoked sausages when water activity and pH values support *L. monocytogenes* growth.

To be able to reduce pathogen counts, in this case *L. monocytogenes* would be beneficial to both processors and consumers.

Therefore, the aim of the study was to determine the survival limits of *L. monocytogenes* inoculated in manufactured cold smoked sausages depending on water activity (a_w) and pH values.

Materials and Methods

The experiments were done at the Faculty of Veterinary medicine of the Latvia University of Agriculture and in a laboratory of a sausage manufacturer in 2009 - 2010.

Individual pieces of cold smoked sausages, in initial weight mean value of 0.394 kg, were inoculated internally with a cocktail of local (domestic) strains of *L. monocytogenes*, in different stages of maturation. Inoculated samples were stored in laboratory conditions

(20 °C, 75 - 80% RH) for 2 and 48 hours and detected for *L. monocytogenes* count then, cfu g^{-1}, according to adapted in Latvia Standard LVS EN ISO 11290-2:1198 A:2005 "Microbiology of food and animal feeding stuffs. Horizontal method for the detection and enumeration of *Listeria monocytogenes*. Part 2: Enumeration method". Three batches of cold smoked sausages were investigated (a total of 60 samples) and the mean values of $lg_{cfu\ g\text{-}1}$ were estimated each other, and in addiction of pH, moisture % content, and water activity (a_w) changes at the ripening time. Each experimental batch was free of *L. monocytogenes* before culture inoculation. Inoculation was prepared from persistent *L. monocytogenes* strains originally isolated from surfaces and meat products of the mother factory (Bērziņš et al., 2007). *L. monocytogenes* strains were incubated in half-Fraser base medium for 18 h at 37 °C. The fresh concentrated culture of the selected strains was prepared with sterile half Fraser broth (CM0895, SR0166E, Oxoid) to obtain approximately 8.0 lg (cfu ml^{-1}), and then samples of cold smoked sausages inoculated portionaly (1 ml of inoculate in 100 g of sample), according to the scheme of the experiment. The samples were analyzed by numbering *L. monocytogenes* after 2-h and 48-h exposition with the nine-tube most-probable-number (MPN) method. For analysis, 10 g of a carefully mixed cold smoked sausage sample were blended with 90 ml of sterile buffered peptone water in a laboratory blender (Stomacher 400, Interscience, France) for 1 min. Decimal dilutions were made to obtain samples of 1, 0.1, 0.01, 0.001, and 0.0001 g. To determine the MPN, three consecutive dilutions were used. Afterwards, 0.1 ml of each target dilution was outspreaded on two LM-selective plates (PALCAM, Oxoid) and incubated for 48 h at 37 °C. For confirmation of *L. monocytogenes*, five typical colonies from two selective plates at each sampling time were streaked on sheep blood agar plates and incubated for 24 h at 37 °C. Catalase-positive, gram-positive rods, produced hemolysis on sheep blood agar (CAMP-test), were considered *L. monocytogenes* (McKellar, 1994). Total count (cfu g^{-1}) of *L. monocytogenes* in cold smoked sausage samples were calculated with classical formula given in Enumeration method standard. Microbiological experiments were done in triplicate on days 0, 3, 7, and 10, when water activity decreased below 0.90.

Weight loss and moisture content measuring. Sausages were weighed after stuffing (day 0) and on days 3 (after smoking), 7, 10, 14, 17, and 21 with laboratory balance KERN-45N (Gotl. Kern and Sohn, GmbH). Moisture content analysis was done according to LVS ISO 1442:1997 "Meat and meat products. Determination of moisture content (Reference method)".

pH measuring. pH was measured at 0, 48, 72, and 96 h, 7 and 10 days of maturation. Three individual pieces of sausages were measured each time, and then mean pH value was calculated. The pH-meter Testo 205 (Testo AG Germany), with automatic temperature compensation, was applied. Meter calibration was done according to 2 point method with pH standard solutions 4.01 and 7.00.

Ingredients of a 100-kg-cold-smoked-sausage raw material were: pig meat - 30 kg, beef - 10 kg, bacon 35 - kg, structural emulsion - 25 kg. Salt and species summary - 3.25 kg and starter culture 'Optistart Plus' - 0.02 kg (control No. L9694599, prepared by Raps GmbH and Co.KG).

Water activity was measured with PawKit (Decagon) water activity meter. Calibration of device was done with saturated NaCl (sodium chloride) 6.0 molal standard solution (0.760 a_w at 20 °C). Samples for water activity measuring were collected in original polyethylene vessels with caps and measured immediately after collecting.

Statistical analysis. All experiments were reiterated three times, and tests were triplicated. The results represent the mean ± standard deviations. Means were compared by Student's t test. Differences were considered statistically significant when $p < 0.05$. Statistical analysis was conducted with SPSS 17.0 (SPSS, Chicago, Ill., USA). Tables and chart figures were done with MS Excel 2007 appliances.

Results and Discussion

Mean value of weight losses over 21 days of ripening, when relatively constant weight was reached at 75-76% of relative humidity of air (RH) in the storing room, was 104 g (26.4% of initial weight). Losses movement significantly correlated with the mean value of moisture % content, decreasing from 42.56 ± 0.28 to 20.69 ± 1.82 percentage of sample weight ($p < 0.001$).

The mean value of initial water activity was 0.95 (Table 1) which decreased in the product from 0.95 ± 0.004 to 0.86 - 0.87 ± 0.006 in 10 days while enumeration of *L. monocytogenes* was determined. Decreasing trends are shown in Figure 1.

According to F.K. Luecke (2000), the 'shelf-stable' meat products have a $pH < 5.2$ and $a_w < 0.95$.

The samples from this study had finally $pH < 4.7$ and $a_w < 0.89$. Such values guarantee not growing of *L. monocytogenes* (Table 1.). The changes in pH mean values are shown as linear (pH) in Figure 2. The measurements of water activity show that *L. monocytogenes* growth would have been theoretically stopped on 7 day of ripening when a_w decreased to 0.90 according to A. Vermeulen et al. (2007).

Table 1

The changes in mean values (quantity ± SD) of inoculated *L. monocytogenes*, cfu g^{-1}, during different ripening stages of cold smoked sausages, and the appropriate mean values of water activity (a_w) and pH

Process signs	Parameters	Baches and exposure time					
		L023		L025		L027	
		0 h	48 h	0 h	48 h	0 h	48 h
raw material	lg (cfu g^{-1})	6.6 ± 0.02	5.6 ± 0,01	6.6 ± 0.01	5.6 ± 0.01	6.6 ± 0.02	5.6 ± 0.01
	pH	5.8 ± 0.04	5.3 ± 0.12	5.8 ± 0.04	5.2 ± 0.12	5.8 ± 0.04	5.1 ± 0.12
	a_w	0.95 ± 0.004		0.96 ± 0.004		0.95 ± 0.004	
after cold smoking (72 h)	lg (cfu g^{-1})	6.6 ± 0.02	5.3 ± 0.25	6.6 ± 0.01	4.8 ± 0.25	6.6 ± 0.02	5.3 ± 0.25
	pH	5.0 ± 0.09	4.8 ± 0.10	5.1 ± 0.09	4.7 ± 0.10	4.9 ± 0.09	4.7 ± 0.10
	a_w	0.93 ± 0.003		0.93 ± 0.003		0.93 ± 0.003	
on 7th day of rippening	lg (cfu g^{-1})	6.6 ± 0.02	3.3 ± 0.32	6.6 ± 0.01	3.9 ± 0.32	6.6 ± 0.02	3.8 ± 0.32
	pH	4.7 ± 0.07	4.6 ± 0.04	4.6 ± 0.07	4.6 ± 0.06	4.5 ± 0.07	4.6 ± 0.05
	a_w	0.91 ± 0.005		0.90 ± 0.005		0.90 ± 0.005	
on 10th day of rippening	lg (cfu g^{-1})	6.6 ± 0.02	2.3 ± 0.28	6.6 ± 0.01	2.0 ± 0.28	6.6 ± 0.02	2.5 ± 0.28
	pH	4.6 ± 0.06	4.7 ± 0.09	4.5 ± 0.06	4.5 ± 0.06	4.6 ± 0.06	4.5 ± 0.10
	a_w	0.88 ± 0.006		0.86 ± 0.006		0.87 ± 0.006	

Decreasing trends of water activity in cold smoked sausages are shown in Figure 1.

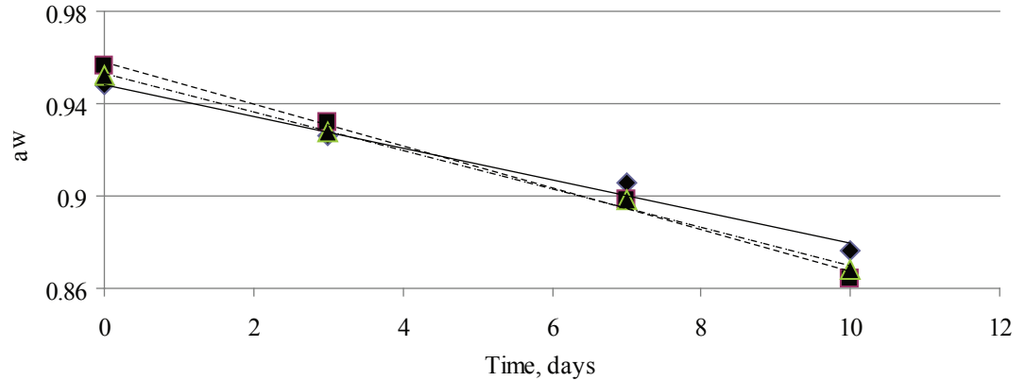

Figure 1. Water activity (a_w) changes in cold smoked sausage batches in the first 10 days of ripening: —— linear L023 (R^2 = 0.98), - - - - linear L025 (R^2 = 0.99), -·-·- linear L027 (R^2 = 0.96).

The samples of cold smoked sausages had a mean initial pH value of 5.82 ± 0.04, which agrees with the results found by V. Paleari et al. (2003). A rapid decrease in pH was observed during the first three days of fermentation. The final pH of the fermented sausages had a mean value of 4.56; this drop in pH was due to lactic acid production by the starter culture used for fermentation (Vermeiren and Debevere, 2004). Lactobacilli are the major producers of lactic acid responsible for the decrease in pH and the increase in acidity during fermentation (Schillinger et al., 1991). Lactic and acetic acids are often suggested to be major contributors to the acid aromas and tastes and the development of the texture of fermented sausage (Visessanguan et al., 2005).

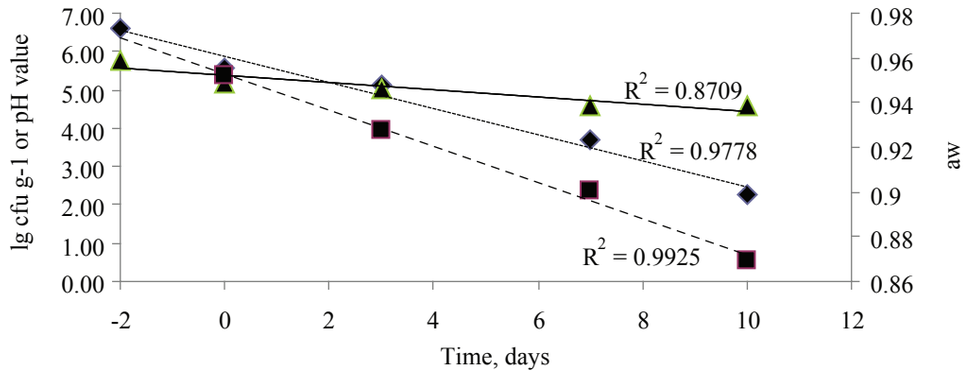

Figure 2. The linear regression trends of *L. monocytogenes* count - lg (cfu g^{-1}) ····· , pH ——, and water activity (a_w) --- values in cold smoked sausages, well-disposed time for bacterial spoilage.

The initial *L. monocytogenes* inoculations concentrations averaged 6.6 lg cfu g^{-1} were significantly reduced at any ripening stage in comparison with control samples. As shown in Table 1, the inoculated dose of *L. monocytogenes* culture was significantly reduced by interior conditions of cold smoked sausages at each ripening stage: lg - 1.0 (15.6%) in raw material, lg – 1.47 (22.1%) at the 3rd day, lg - 2.9 (44.2%) on the 7th day, and lg - 4.35 (66%) on the 10th day (Figure 3.) according to ripening time ($p < 0.05$).

The mean values of the decrease rate in *L. monocytogenes* count are bigger than those K. Glass and M. Doyle (1989) found in sausages without added lactobacilli cultures.

All measured physical and chemical parameters significantly ($p < 0.05$) correlated with the decreased *L. monocytogenes* count. The correlation coefficient 'r' values are shown in Figure 4.

In our experiment, the exponential growth rate of inoculated *L. monocytogenes* culture was negative, averaging lg - 0.44 day^{-1}. Theoretically, the *L. monocytogenes* should not be detected by the MPN method on the 15th day of ripening, if the initial count in raw material is not bigger than 6.6 lg (cfu g^{-1}).

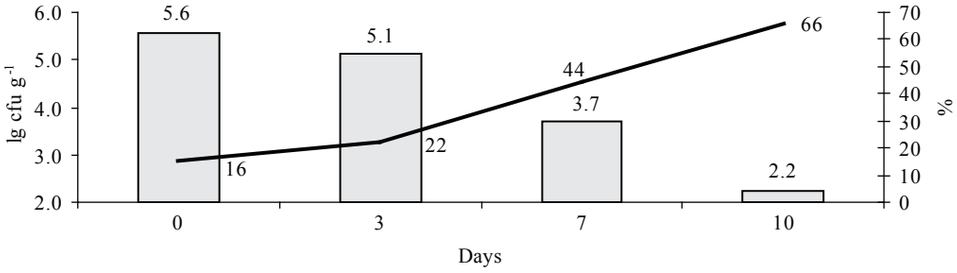

Figure 3. Residue count lg (cfu g^{-1}) of *L. monocytogenes* inoculate (column) and conformable % decrease (trend) in cold smoked sausages in the first 10 days of ripening.

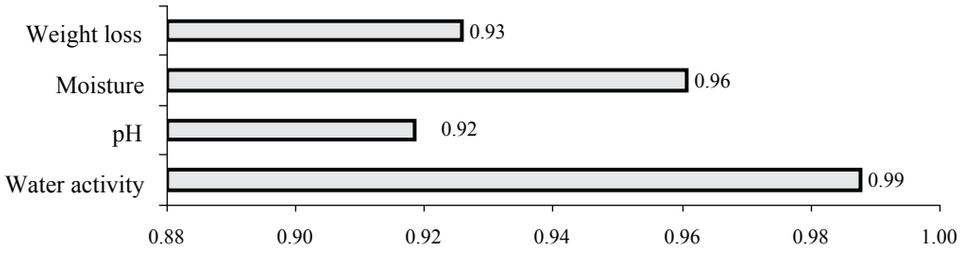

Figure 4. The linear correlation coefficient 'r' between *L. monocytogenes* count - lg (cfu g^{-1}), water activity (a_w), pH, moisture %, and weight loss in cold smoked sausages.

Conclusions

1. The water activity of sausages decreased from 0.95 ± 0.004 to 0.86 – 0.87 ± 0.006 in 10 days.
2. The main parameters, maintained negative exponential growth rate of *L. monocytogenes* in cold smoked sausages are a_w and pH, and its value decrease. The samples from this study had finally pH < 4.7 and a_w < 0.89 with guarantee *L. monocytogenes* not growing.
3. A negative exponential growth rate of inoculated *L. monocytogenes* was 0.44 lg cfu g^{-1} each day.
4. A significant Pearson's correlation ($p < 0.01$) was established between the decreased values of *L. monocytogenes* count, water activity, pH, moisture %, and weight loss in sausages during ripening.

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COMPARATIVE STUDY OF BREEDING BULLS DAUGHTERS MILK QUALITY INDICATORS

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Abstract. The aim of the work is to investigate raw milk from different bulls' daughters to clear up the influence of cows' genetic predisposition to milk microbial contamination and somatic cell count (SCC). Particular attention is paid to develop productive cow milk yield, milk fat, milk protein and in recent years, the SCC heredity. The literature describes a variety of lines and families, representatives of the resistance to certain diseases (leucosis, mastitis, tuberculosis, brucellosis, foot disease), it shows the determination of a genetic factor for this trait. If the selection results show increased resistance to a disease, then this indicates a genetic disease resistance and shy. The paper focuses on microbial contamination of raw milk at 7 different studies of bull daughters in the same line for housing, feeding and conditions of use. Raw milk samples were obtained from the breed *Latvian brown* (LB) from dairy cows shed of cattle shed Saujas, which belongs to SIA Palsa and is located in the civil parish Varini, Smiltene county in the year 2008/2009. Compared between the lines of bulls' daughter milk yield of the sample average value of the uniformity of variance analysis shows that they significantly differ (F=2.452, p=0.039). Comparing each line of bulls' daughters SCC of the sample average value of the uniformity of variance analysis showed that the SCC was statistically significantly different (F=2.083, p=0.075) of the various lines of bulls daughters.
Key words: cow milk, microbial contamination, predisposition.

Introduction

In recent years the Latvian dairy farming has had new actual topical issue of raw milk quality. The most difficult requirements of milk quality for manufacturers to fill – is the total number of bacteria and somatic cell count SCC. The amount of bacteria in regularly purchased milk is usually counted only in buying companies. Farmers have an opportunity to sell their raw milk by direct marketing. However, the milk may become dangerous; it can be distributed to people containing harmful microorganisms: *Salmonella spp., Listeria monocytogenes, Staphylococcus aureus, Staphylococcus spp. (*Coagulase negative staphylococci*)*, *Escherichia coli* and coliform bacteria, *Enterococcus spp*. In practical life these indicators are not counted in milk. There are 75% cows of Latvian brown LB breed. It is therefore important to assess dairy farming LB cattle, which genetically have a higher udder disease resistance inheritance directly along the lines of bulls.

Dangerous milk microbial contamination is caused by *Staphylococcus aureus*. It causes difficulties to treat mastitis, and milk consists of enterotoxins whose range is from 13.8% (Cenci-Goga et al., 2003), up 67.8% (Katsuda et al., 2005). The research work in Latvia indicates that the most often prevalent micro flora in milk is *Staphylococcus aureus* 62.5%, *Streptococcus agalactiae* 21.88%, *Escherichia coli* 12.50%. T*hey* have close connection with the bulls' daughters when evaluating the results along the lines (Jemeļjanovs et al., 1998). *Staphylococcus aureus* is resistant against sanitary measures, survives in hard external environment and continuously maintained milking equipment (Myllys, 1995). *Staphylocccus aureus* pathogenicity is determined by an ability to bind to the teats and udder epithelial tissues, in materials of milk ducts, tanks, milk cooling and storage pools (Hermann et al., 1988; Timmerman et al., 1991). Coagulasis factor, fibrogenas, collagens and other fiber protein are factors to increase virulence of *Staphylococcus spp.* Virulence is increased by an ability to form capsules, the ability to produce the polysaccharide layer, which prevents function of polinuclear cells and contributes *Staphylococcus* attracting a host organism and surfaces (Pulver and Peters, 1987). *Staphylococcus spp.* produces different enzymes, at the same time increasing its virulence. *Staphylococcus spp.* produces toxins, which cause haemolysis. *Listeria monocytogenes* and other species of the *Listeria* genus are occurring on plants, therefore, may come in animal feed, particularly silage. Eating the feed containing *Listeria monocytogenes,* cows become carriers of the bacteria and start to spread it in the environment, out of the isolated farm with feces and milk (Eley, 1996). The presence of *Escherichia coli* and coliform bacteria, *Enterococcus spp*. in milk refers to inadequate sanitary status of facility, lack of hygienic measures, and poor milking hygiene practices. One of the most dangerous food born pathogen is *Salmonella spp.* Therefore, the presence of it in milk used in food is not allowed. These microorganisms are widely found in the external environment and they are continuously in contact with the cow's body; therefore, it is important to clarify the relationship of bacterial contamination of milk to a separate breeding daughter. It is therefore important to assess dairy farming LB cattle, which genetically have a higher udder disease resistance inheritance directly along the lines of bulls.

The goal of the work is to evaluate the inheritance of resistance of a separate line of breeding bulls. The objectives of the work are to identify: 1 - productivity, 2 – somatic cells count (SCC), 3 - bacterial contamination of raw milk for individual breeding bulls' daughters.

Table 1

The bloodiness indicators of bulls, used in experiment

Bull	Alter Disak	Primate Punčs	Hoibru Bits	Aks Moments	Lani Moments	Ryttargard Kvarnakra	Orkels Rudi
Bloodiness %	DS 68.75 SV 31.25	DS 75.00 SV 25.00	DS 59.37 SV 4.38 HS 6.25	HS 50.00 DS 43.75 SV 6.25	HS 50.00 DS 25.00 SV 25.00	PS 87.50 NS 12:50	AN 50.00 HS 50.00

Materials and Methods

The work problem defined and addressed in order to obtain high-value milk from healthier animals, high-bred daughters, which have genetic predisposition to provide a sufficient resistance to bacteriological contamination in milk. Raw milk samples were obtained from the breed Latvijas Brūnās (LB) from) dairy cows shed of cattle shed Saujas, which belongs to SIA Palsa and is situated in the civil parish Varini, Smiltene county in the year 2008/2009, from 52 LB breed cows. Totally 174 raw milk samples were aseptically obtained from the morning milking after milking machine removal and disinfection of the teat end. Samples were delivered to the laboratory in the cooling-bag at 5 °C temperature. The bacteriological examination of raw milk samples was performed in the Scientific Laboratory of Biochemistry and Microbiology (LATAK-T-038-07-99-A) of Research Institute of Biotechnology and Veterinary Medicine „Sigra", in accordance with EN ISO standard methods. Raw milk was researched for the following parameters: the total number of bacteria, *Salmonella spp., Listeria spp., Staphylococcus aureus,* coagulase negative staphylococci, *Escherichia coli* and coliform bacteria, *Enterococcus spp.* Different breed daughters were deliberately chosen to compare and identify productive brood stock by different genotype and phenotypic characteristics, evaluating the daughters of each bull group, and the results were compared. Productivity of dairy cows, SCC (ISO 13366 – 3:1997), bulls bloodiness figures obtained from the V/A "Lauksaimniecības Datu Centrs" ("Agricultural Data Centre") database. The data characterizing the bull's bloodiness are depicted in Table 1.

Table 1 shows pedigree indices in % indicators of 7 groups of bulls. Variety names: DA - Danish Red, SV - Schwyz, HS - Red Holstein, ZS - Swedish Red and White, NS - Norwegian Red, AN - Angler variety. An animal falls to variety, if 75% of background comes from the pedigree (V / A LDC).

To process the data of this research, we used statistical data program MS Excel (Microsoft® Office Excel 2003). P – values less than 0.05 were considered to be statistically significant.

Results and Discussion

It is important to the variety development to examine and release the lines and families, which would be animals with high productivity, a congenital disease resistance and strength of predisposition (Петухов et al., 1985). A suitable sires model - indicators derived solely from his offspring - daughters has been used. In husbandry of dairy cattle, genetic evaluations are assessed on productivity traits: milk yield, fat content, protein content and milk quality ratio in the SCC *(https://info.ldc.gov.lv/dzreg2.php*). It is more important to assess the animal's genetic resistance to disease. Earlier studies have shown that different breeds of bulls' daughters those genetic characteristics have inherited differently. Dairy cow productivity rates are genetically inherited from parents. Breeding value of bulls and inheritance of genetic traits are determined by the bulls' daughters. Latvian breeders union specialists regularly develop LB breed cattle genetic resource conservation programs for LB breed improvement and conservation of the breed. There were 58 538 LB cattle in Latvia, 2008. LB is the most widespread cattle breed in Latvia, but with a lower average yield – 5103 kg and with the average amount of protein in milk – 33.6 g kg^{-1} (Brunovska and Līdaks, 2009). For cows included in our experiment in 305 days of the year 2008 productivity indices were derived from the V / A LDC database. The highest milk yield for dairy bull Lanis Moments daughters was 8194 kg, for breeding bull Aks Moments daughters - 7553 kg. According to the literature data, to increase the yield one of the productive intersections are LB x ZS (Strautmanis, 1997; Kairiša et al., 2001). The highest yield standard deviation was found for Primate Punčs daughters, and it is 1 244.6 kilograms (Strautmanis, 1997). Checking the statistical hypothesis about the sample mean value equation to analysis of variance, it was found out that daughters of different bulls average milk yield has statistically significant differences ($F=2.452$, $p=0.039$).

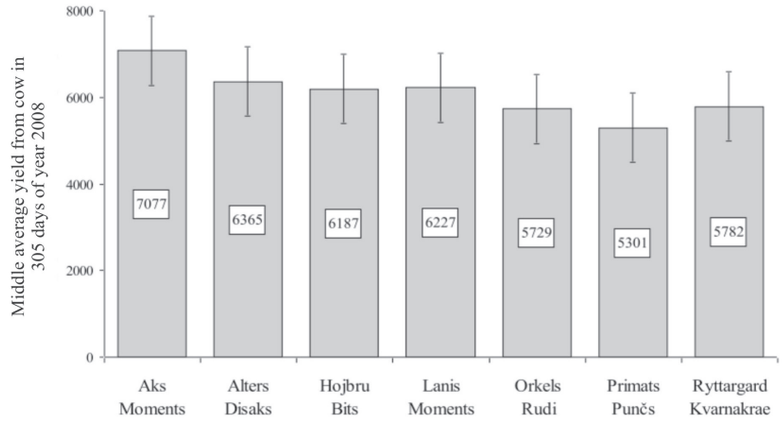

Figure 1. Average yield (kg) from the bull's daughters in 305 days of lactation of the year 2008.

With higher average yields of cows group, analyzing the father of the line, the best results had breeding bull Aks Moments whose daughters' average yield was 7077 kg, a subsidiary of Alter Disaks contrary to data in the literature (Strautmanis, 2003) has shown the 2nd best yield - 6365 kg. The 3rd best yield was for the breeding bull daughters Lanis Moments - 6227 kg. Similar data in 2003 got D. Strautmanis. Testing the experimental group of cows for the statistical hypothesis about the sample mean value equation with dispersion analysis variance, we found out that the daughters of different bulls average milk fat content does not differ statistically significantly (F=1.784, p=0.124). Primate Punčs showed the best milk fat - 49.5g kg^{-1}, Hojbru Bits showed the lowest results – 41.8 g kg^{-1}, which coincide with the literature data (Strautmanis, 2003). Other results were mixed. According to the milk protein data in the literature, the highest index is for DS x LB bovine variety, as well as AN x LB pedigree blood cows and for cows bred ZS. The lowest milk protein index was for LB x DS x HS and LB x DS x SV groups breed cows (Strautmanis, 2003). Examining the statistical hypothesis about the sample mean value equation with analysis of variance, we found out that the daughters of different bulls for an average protein content of milk differ statistically significantly (F=2.338, p=0.047). The highest protein content was for Primate Punčs daughters – 34.8 g kg^{-1}, which is in accordance with literature data (Paura and Grīslis, 1999). The second major protein in daughters' milk was for breeding bull Lanis Moments – 34.7 g kg^{-1} - in contrast to literature data (Strautmanis, 2003; Kairiša, et al., 2001). The lowest milk protein ratio was for breeding bull Ryttargard Kvarnakra daughters – 32.3 g kg^{-1}, which does not coincide with the literature data. In experimental group, the highest average milk yield was for breeding bull Aks Moments, Alter Disaks and Lanis Moments daughters, and the lowest yield for Primate Punčs daughters, the highest milk protein for Primate Punčs and Lanis Moments bulls" daughters. One of the milk quality parameters is SCC in milk. In milk the somatic cells located at all times, but their number characterizes udder health. The number of SCC in milk is affected by the type and time of milking, lactation period, season, animal productivity, animal age, health status and genetic predisposition. By checking the statistical hypothesis about the sample mean value equation to analysis of variance, it was found out that in milk of daughters from different bulls, somatic cell count statistically is not significantly different (F=2.083, p=0.075). The average count of SCC in 1 ml of milk for the experimental group of cows in the year 2008 is shown in Figure 2.

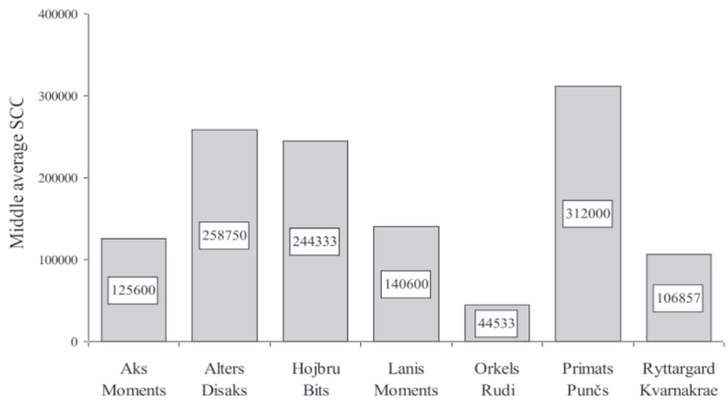

Figure 2. Bulls' daughters' average values of SCC in milk in the year 2008.

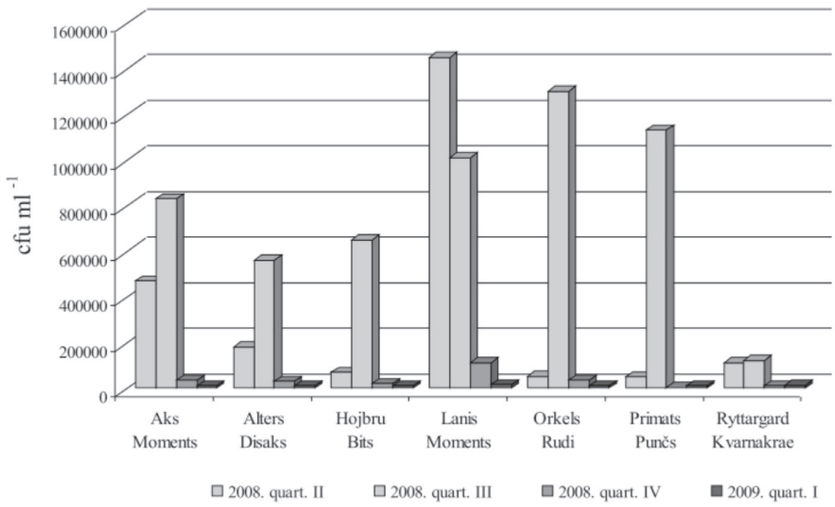

Figure 3. The total number of bacteria in cfu ml^{-1} in milk of daughters of bulls in the years 2008 and 2009.

For breeding bull Orkels Rudi daughters' the lowest average SCC in group was 44 533; the 2nd lowest SCC was for the bull Ryttargard Kvarnakra daughters - 106 857 per ml of milk. Good SCC figures are for breeding bull Aks Moments -125 600 and for Lanis Moments -140 600 bulls daughters in groups. The highest SCC rates detected for the bulls with DS blood supremacy, for example, in the group of breeding bull Hojbru Bits daughters SCC was 244 333; for the bull Alter Disaks daughters group SCC was 258 750; for the bull Primate Punčs daughters group SCC was 312 000 per ml of milk. These data support the hypothesis that the breeding work with bulls allows to select the individuals whose subsidiaries produce better results in productivity, and fewer of them are sick with mastitis, according to the count of SCC found in milk (Strautmanis, 2003; Schukkan, 1992; Sanore, 2000; Olesen, 2000). Compared to the previous research results of the year 2005 in the author's work ''Steers of Heritable Changes in the Effects of SCC in Milk'' with the indicators mentioned above, there is a coincidence that the lowest SCC compared to red cattle breed, was for daughters of ZS variety bulls. The highest milk fat index is for the group of cows AN x LB pedigree, pure LB and ZS. The highest fat content in milk in the line of red varieties in Latvia is for AN breed cows. The lowest fat content is for cows of DS breed group (Strautmanis, 1997). To evaluate the different line of bulls, to identify their genetic inheritance or resistance to microbiological contamination of milk, a total of 52 daughters of 7 bulls' as well as 174 raw milk samples were examined.

The total number of bacteria per provisional findings set out in fresh milk sample. Examination result show that, for all *Salmonella spp*. samples there are not found, *Listeria spp.* isolated in sample 1, *Staphylococcus aureus* in 3 samples of fresh milk (twice per cow), *Staphylococcus* species, or coagulase negative staphylococci isolated in 167 raw milk samples, coli forms in 17 raw milk samples, *Enterococcus spp*. in 75 samples. Strongly high number of *Staphylococcus* genus or coagulase negative staphylococci isolations – in 167 raw milk samples, led to focus relationship of the number of SCC, milk yield and coagulate negative staphylococci. In addition to the 5 dairy cows with increased SCC, there were isolated *Staphylococcus spp., Streptococcus spp.* (hemolisating), environmental staphylococci, and gram-negative micro flora (Joffe et al., 2006) in obtained milk samples. The most dangerous milk contamination is that of pathogenic microorganisms: Salmonella, listeria, mesophile bacteria, milk-specific micrococcus, coli forms and enterococci, various staphylococci causing mastitis, as well as hazardous contaminants in milk which are dangerous for consumer: dysentery agents, salmonellosis and proposing shigelloses agents (Jemeļjanovs et al., 1998; Konošonoka et al., 2008). For successful animal breeding in practice it is necessary to distribute both the resistant and susceptible varieties of representatives to differentiate individual animals or a related group of animals who are ill or do not occur with mastitis, leukemia, or are barren. However, it is hard to determine the signs of genes as well as it is difficult to define a sharp boundary between the genetically inherited disease resistance and susceptibility (Петухов et al., 1985). The bacteriological examinations of fresh milk carried out during the experiment are depicted in figure 3.

The year 2008 figures obtained from 33 samples, with the largest total number of bacteria were for bull's daughters Lanis Moments in April and June - 1 484 889 cfu ml^{-1} milk. Comparing with SCC numbers, we can conclude that the largest SCC, which was the maximum value, is 378 000 of 1 ml of milk. The total number of bacteria found for Lanis Moment's daughters in pasturage period was in June. Lanis Moments daughters are characterized by markedly large, low udders, big, thick teats, soft - milking, broad

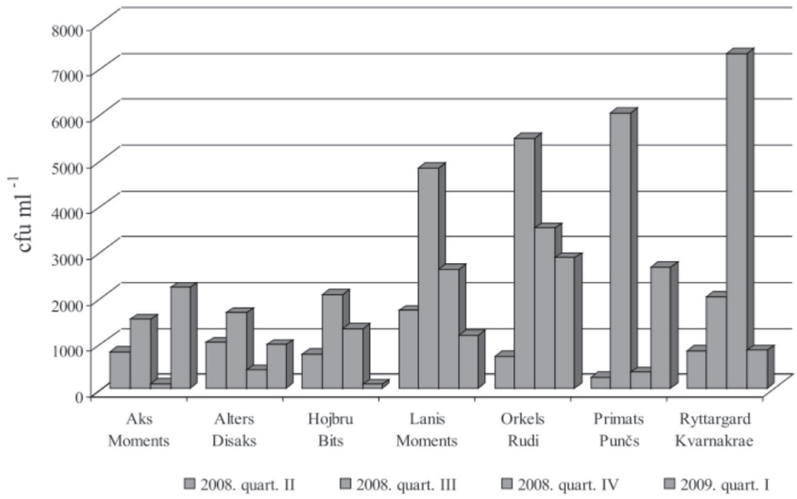

Figure 4. The total number of coagulate negative staphylococci (cfu ml^{-1}) in bulls' daughters milk in years 2008 and 2009.

teat hole, and a strong jet of milk during milking. Lanis Moments daughter group which is one of the oldest experimental groups of cows consists of 10 animals (Буткус and Буткус, 1985). In the year 2009, four daughters from Lanis Moments experimental groups were infected with mastitis and eliminated, suggesting Lanis Moment's daughters' low resistance to disease agents and genetic predisposition to mastitis, which has been inherited through the father line. In recent years, challenge for coagulate negative staphylococcal contamination of raw milk samples has been actual. In most cases coagulate-negative staphylococci cause subclinical udder inflammation without apparent clinical change and characteristic increase of somatic cell count and milk yield decrease. The total number of bacteria obtained in fresh milk during the examination is depicted in Figure 4.

As we can see from the Figure 4, counts of coagulate negative staphylococci in milk increased in August and September, resulting in milk samples of all experimental groups of cows. Shed litter sawdust was changed instead of the previous year's poor winter straw. Feed ration during milking continued to be hay of previous year, the air temperature dropped, cows spent nights at a farm paddock. As a result of breeding, the bull Primate Punčs daughters rose in coagulate-negative staphylococci in fresh milk - 6113 cfu ml^{-1} in September for Primate Punčs daughters rapidly increased SCC in milk till 981 000. Orkels Rudis coagulated negative staphylococci - 5575 cfu ml^{-1}, Lanis Moments - 4967 cfu ml^{-1}. Breeding bull Aks Moments coagulate negative staphylococci compared to the second quarter with the third quarter, it increased almost twice from 898 cfu ml^{-1} to 1612 cfu ml^{-1}. In breeding bull's Aks Moments daughter milk in the fourth quarter of 2008 (October - December) SCC rose sharply - 981 000 per ml of milk. In the rest of the bulls' daughter groups, increasing the number of coagulate negative staphylococci in milk, SCC in milk did not change significantly. Due to the fact that SCC did not change, udder disease resistance genetic predisposition was found in a separate line of bull daughters. Larger amount of coagulate negative staphylococci causes cow's sharper immune response, resulting in the increase in SCC (Konošonoka, 2005).

Conclusions

1. The highest average yield was recorded for breeding bull Aks Moments daughter group - 7077 kg, the lowest average yield was for breeding bull Primate Punčs daughters - 5301 kg. The maximum highest yield was shown for bull's Lanis Moments daughters - 8194 kg and for bull's Aks Moments daughters - 7553 kg. The lowest yield - 3339 kg and higher standard deviation of 1244.6 kg was observed in breeding bull Primate Punčs daughters.
2. Average somatic cell count in milk was statistically significantly indifferent. The lowest SCC per ml of milk was found for the bull Orkels Rudis daughters and the highest SCC was for the bull Primate Punčs daughters, but in bad housing and feeding conditions SCC dramatically increased only for two lines of bulls' daughters milk - Alters Disaks and Primats Punčs.
3. The highest total number of bacteria was found in fresh milk of Lanis Moments and Orkels Rudi daughters.
4. The coagulate negative staphylococcal contamination of milk significantly increased for the breeding bulls Lanis Moments, Orkels Rudi and Primats Punčs' daughters in September, bur for the breeding bull Ryttargard Kvarnakrae daughters in December suggesting reduced resistance of bulls' daughters genetic potential.

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FINANCING MECHANISMS FOR RESEARCH INSTITUTES IN THE FIELD OF AGRICULTURE IN LATVIA

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Abstract. Latvia is a territorially small country with small open economy, and its main and the most competitive recourses are highly educated society and well developed science which is based on research, innovation and modern technologies. To create a well functioning innovation system as a part of knowledge-based economy, several conditions has to be met to insure that all parts of national innovation system effectively work together. This article is dedicated to analysis of financing mechanisms that can be used by research institutes in the field of agriculture in Latvia to ensure sustainable rural development. The research in the field of agriculture in Latvia is mainly performed by the state research institutes and research agencies of Latvia University of Agriculture. To provide favourable environment for development of research and science, there is set legislation framework and financing mechanisms such as base financing from the state budget, state research programmes, European Commission Framework Programmes, and the European Union (EU) Structural Funds assistance. The analysis has shown that support of EU Structural funds has positive impact on number of applied research carried out in research institutes in the field of agriculture in Latvia. EU Structural funds assistance helps to develop fundamental research activities and innovative approach to the science that is one of the preconditions for the development of states' competitiveness. In conclusion, the authors resume that it is necessary to establish a strong link between higher education institutions, research institutes, and entrepreneurs in the process of building effectively working national innovation system.
Key words: research policy, financial mechanisms, research institutes, innovation.

Introduction

Latvia is considered to be a country in transition between efficiency driven and innovation driven economy according to Global Competitiveness report 2009-2010. This means that the development of the country soon would be impossible by improving productivity adopting existing technologies or making incremental improvements in other areas. The role of country's competitiveness will be in its ability to innovate. Firms in these countries must design and develop cutting-edge products and processes to maintain a competitive edge. This requires an environment that is conducive to innovative activity, supported by both public and private sectors. In particular, this means sufficient investment in research and development (R&D) especially by the private sector, the presence of high-quality research institutions, extensive collaboration in research between universities and industry, and the protection of intellectual property. In the period of crisis, it will be important to resist pressures to cut back on the R&D spending both at the private and public levels that will be so critical for sustainable growth going into the future (Global Competitiveness..., 2009).

There are several authors in Latvia that have been writing about innovative activities (Boļšakovs, 2008), innovation process and system (Dimza, 2003), knowledge society (Karnītis, 2004), higher education institution's role in economic development (Sloka and Vilciņa, 2009), (Mazūre et al., 2009), Many studies on the research policy topic are carried out in the world about – interactions between technology imports, educational attainment and local R&D efforts (Teixera and Fortuna, 2010), more educated society and introductions of new technology (Hanushek, 2004), science, technology, innovation and growth systems, and choose between neutral versus non-neutral instruments (Aghion et al., 2009), science policy issues (Beeseley, 2003), national innovation systems (Freeman (1995), learning organisation and national systems of competence building and innovation (Nielsen and Lundvall, 2002; Lam and Lundvall, 2007), multilevel system approach for analysing national innovation systems (Smith et al., 2010), but there is lack of studies in the field of research policy that concentrates on Latvian national research system as a part of national innovation system.

One of five science priority areas stated in the direction issued by the Cabinet of Ministers of Latvia on the science priority areas in basic and applied research financing for the year 2010-2013 is the sustainable use, new products and technologies on local resources (subsoil, forests, food and transportation).

Regarding this, it is topical to perform research about financing mechanisms that are available to research institutes whose scientific activities are performed in the field of agriculture int. al, forest, and food.

In order to establish preconditions for prosperous growth of innovative actions, the authors are of the opinion that deeper research is needed about research institutes' abilities to develop in Latvia. To illustrate the Latvian research policy, the authors, as an example, use research institutes in the field of agriculture and their facilities to take advantage of available financial mechanisms.

The aim of the study is to detect obstacles that impede the use of financial instruments that are

available for research institutes operating in the field of agriculture.

To reach the aim the authors set the following targets:

Analyse current situation as well as political, economic, social, and technical aspects that influence research institutes operating in the field of agriculture.

Investigate external threats and opportunities, as well as internal strength and weaknesses of the research institutes operating in the field of agriculture.

Organise two questionnaires to find out financial mechanisms that are currently used, and what the research institutes plan to use in the near future. Evaluate and analyse the results of the survey.

Elaborate suggestions for use of various financing mechanisms that are available for the research institutes in the field of agriculture to enhance their development.

The research in the field of agriculture in Latvia is performed by six state research institutes, four research agencies of Latvia University of Agriculture, and seven private research institutes. This article concentrates on analysing state research institutes and state university research institutes performing research in the field of agriculture. Five out of ten state research institutes and Agencies of Latvia Agricultural University are located in Riga region; other research institutes are spread around all regions of Latvia except Latgale – two in Vidzeme, two in Zemgale, and one in Kurzeme.

There are several financial instruments available for research institutes which differ by source and aim. The main financial instrument that the government uses to implement the research and development policy is base funding. The aim of base funding is to ensure scientific activities and development in the state research institutes and state university research institutes, as well as to cover maintenance costs of research institutes and salary expenses for scientific staff. Considering the regulation of the Cabinet of Ministers of Latvia on the base financing appropriation for the state research institutes, state higher education institutions, and state higher education institution's research institutes Ministry of Education and Science calculates the base funding yearly on the ground of previous year performance of research institutes and taking into account qualitative indicators, such as variety and number of projects implemented, researchers employed, number of scientific publications, patents registered, doctoral and master theses elaborated, and percentage of young scientists employed.

Other funding provided by the state budget are grants of Ministry of Agriculture to support education, science and information dissemination in the field of agriculture and livestock breeding and grants supported by Latvian Council of Science to ensure definite project implementation awarded in competitive conditions. State budget alternative is financial support from European Structural Funds and Framework Programme 7. State loan is an option available for state research institutes to borrow financial resources to ensure developmental project completion also as substitute to commercial bank loans. The result of collaboration with entrepreneurs and investors from private sector can conclude contracts and attract additional financial resources to the research institutes.

Materials and Methods

The authors investigated situation of research institutes in Latvia and research institutes facilities to attract available financial mechanisms using PEST (Political, Economic, Social, and Technical) and SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. PEST analysis which measures market and operation potential according to external factors was used to understand the political, economic, socio-cultural and technological environment affecting research institutes (SWOT alongside PEST/PESTLE can be used as a basis for the analysis of business and environmental factors). Using PEST analysis results, the SWOT analysis provided a framework for reviewing current research institutes development strategy, position and direction. As follows the authors did elaborate alternative suggestions for development of research institutions.

The research methods envisaged to detect the article is a monographic descriptive method; analysis and synthesis are used in the paper to study the problem elements and synthesize coherence. The authors studied legal framework in Latvia and scientific publications in research policy. Induction method is used for summarising individual facts in general statements, but deduction method for theoretical explanations and logical synthesis of the empirical study.

The investigation of research institutes in Latvia is based on statistical data obtained from Central Statistical Bureau of Latvia, Eurostat and the information included in research institutes' reports (year of 2008) acquired from Ministry of Education and Science during the last available period.

The authors organised two questionnaires in December 2009 during annual general meeting of Latvia Academy of Agricultural and Forestry Sciences in Jelgava and during informative seminar of the European Union 2007-2013 planning period ERDF activity 'Support to international co-operation projects in research and technologies (EUREKA, 7th FP, etc.)' in Riga, whose target group was employees and heads of the research institutes, as well as experts working at the state universities. Total number of questionnaires respondents is 40. Random set is representative because respondents work mainly at research institutes in the field of agriculture (63% of respondents). Age structure shows that less than half (45% of respondents) – scientists, leading researchers, project managers, directors working at universities and research institutes, also state research institutes were above 55 years, 26% respondents were above 65 years, and 26% respondents working in institutes or writing a project for university or research institutions were aged between 25 and 34 years. The number of

women and men participants is almost equivalent (respectively 19 women and 18 men, 3 respondents answers were incomplete).

All data analysis was performed using the statistical methods. Comparative, analytical and historical methods have been mainly used in the paper, taking into consideration the large amount of scientific literature.

Results and Discussion

Using the PEST analysis which measures market and operation potential according to external factors the authors outlined the political, economic, socio-cultural and technological environment affecting research institutes.

The main **political** factors that have an impact on research institutes' ability to develop are: structural reforms carried out in order to accomplish external creditor requirements, level of bureaucracy and corruption, tax policy, and forthcoming parliament elections in October 2010.

Economical factors that mostly influence research institute operation potential are: stage of economic cycle – economic downturn with sharp decrease of gross domestic product growth (the year 2009 - 18% comparison to previous year (Eurostat)), and unemployment rate increase (22.9% unemployed persons as a percentage of the labour force in January 2010 (Eurostat)), with sharp decrease of vacant work places, inflation rate 3.3% year 2009 (Eurostat), decrease in R&D investments both public and private, as well as distribution of the EU structural funds, small size of market for innovative products, low level of solvable consumers.

Socio-cultural factors that influence research institutes' advancement are: ageing of population, ageing of scientists working at research institutes, education system, employment patterns that show that scientists are mainly employed in the public research institute and rarely in the private sector, R&D personnel constituted just 0.54% of the labour force in 2008 (Eurostat), prestige of the science and public opinion about the scientific activities.

The influence of the **technological** environment to the research institutes can be described by those factors – emerging technologies, exports of high technology products as a share of total exports 4.205% in the year 2006 (Eurostat), patent applications to the European Patent Office (EPO) - number of applications per million inhabitants (refer to applications filed directly under the European Patent Convention) 9.84 year 2006 (Eurostat), gross domestic expenditure on R&D in the year 2008 business enterprise sector 27%; governmental 47.3%; higher education sector 2.5%; abroad 23.1% (Eurostat), orientation to science-intensive production, and the increasing role of science-intensive and interdisciplinary areas.

In order to elaborate suggestions for further sustainable development of research institutes in the field of agriculture, the authors did SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. External threats and opportunities were summarised from previously described PEST analysis, but internal strengths and weaknesses were concluded after detailed analysis of research institute reports for the year 2008.

Strengths: highly qualified researchers and scientific stuff, good practise and elaboration of researches performed, good international reputation, in programming period 2004-2006 of the EU structural funds the infrastructure of research institutes has been improved (the total amount of EU structural funds assistance to the modernisation of the research institutes in the programming period 2004-2006 was 14'347'029 LVL), some of research institutes are strong in patenting.

Weaknesses: a lack of experience in project implementation (lack of the procurement specialist, project managers), lack of public relations activities, week traditions of technology transfer, lack of collaboration with entrepreneurs, lack of practicality, market, and production oriented research, ageing of scientists working at research institutes, brain drain of young scientists.

Opportunities: education system, high proportion of labour force with higher education - 27% of labour force (15-74 years) in 2008 (Labour force..., 2009), opportunity to switch orientation to science-intensive production, availability of the EU structural funds assistance to support practical research projects promoting the integration of research and production and the use of research results, to ensure the development of the capacity of research institutions, development of new co-operation projects and participation in technological platforms, to improve scientific and research equipment and provide the relevant infrastructure in order to ensure a modern material and technical base for research activities at the leading national and regional research centres, develop information system, data basis and academic data transmission network of Latvia, provide science and research resources and their accessibility, thus, promoting the development of the intellectual potential of research and involvement of Latvia science in the unitary European science – total amount of the assistance 188'738'293 LVL in the EU structural funds programming period 2007-2013 (Operational programme..., 2007).

Threats: decrease in R&D investments both public and private, unfavourable tax policy to entrepreneurs investing in R&D, small size of market for innovative products, low level of solvable consumers, comparatively low prestige of the science, and public opinion about the scientific activities, that results in the insufficient number of doctoral students to assure alternation of researchers generations.

There has been no research on all the state funded research institutes in the field of agriculture carried out yet, but Kaufmane et al. (2007) as strength of agro-biotechnology field in Latvia mentions good scientific traditions, research potential and competence in the basic research, as well as good international reputation

and relations. The authors agree with these statements and apply them to all the research institutes in the field of agriculture, while the statements that the partnership of NGO's facilitate the researches, and the researchers working in Latvia the field of agro-biotechnology have a comprehension of technology transfers significance to states economic growth are not fully applicable to all research institutes in the field of agriculture.

If we compare our SWOT analysis of state funded research institutes to the strengths, weaknesses, opportunities, and threats that Beļšikovs S. mentions in his monograph *The Innovative Actions in Latvia* (2008) describing SWOT of Latvian national innovation system such statements as highly qualified researchers (strength), low private and state investment in R&D (weakness), opportunity to switch to orientation to science-intensive production are overlapping with our findings.

One of suggestions is to enhance activities of public relations of research institutes, which would help with communication, community relations, crisis management, customer relations, employee relations, government affairs, industry relations, investor relations, media relations, mediation, publicity, speech-writing, and visitor relations.

Other alternative that would increase the research institutes activity's effectiveness is the structural reform including amalgamation of research institutes in the field of agriculture, establishment of a department of development, with the main functions to develop strategy outline and its implementation, to carry out activities in the field of public relations, to build a dialogue with entrepreneurs and investors, to establish collaboration with the producers, to administrate as well as partly implement institute's projects.

In order to explore the scientists' attitude and vision of the research institutes they represent, collaboration experience with entrepreneurs, use of available financial instruments for research institutes evolution, and to detect obstacles that impede the research institutes development, the authors organised the questionnaire.

Questionnaire results approve assumption that many of the state financed research institutes rely on basis financing and do not see a private funding as a considerable source of funding. The most common answers to the question about research institutes financial resources in the future are the EU structural funds financing, followed by Latvian Council of Science grants and national research programs, and the state budget financing through the basis financing. In regard to that, the government expenditure is reduced, and European Union funds promoted as substitute to the state budget with planning period 2004-2006 experience, research institutes take challenge to apply and implement the projects. Latvian Council of Science grants and other financial resources from the state budget are more easily to be obtained than EU structural funds and other foreign financial assistance.

Analysing reports (year 2008) submitted to Ministry of Education and Science by research institutes operating in the field of agriculture, the authors ascertain that proportion of base funding from the state budget at total funding varies from 5.70 to 46.36% (Table 2).

Table 2

Funding for State Funded Research Institutes in the Field of Agriculture in Latvia, 2008

Research institute	Total funding, LVL	Int.al. base funding from state budget, LVL	Proportion of base funding from state budget at total funding, %
Institute of Agrarian Economics of Latvia	2 435 980	138 800	5.70
Latvia State Institute of Fruit-Growing	1 044 955	175 568	16.80
Latvia State Institute of Wood Chemistry	2 041 600	403 900	19.78
Latvia State Forest Research Institute 'Silava'	2 640 476	354 768	13.44
State Priekuli Plant Breeding Institute	779 926	92 391	11.85
State Stende Plant Breeding Station	757 444	113 308	14.96
Agencies of Latvia University of Agriculture			
Research Institute of Agricultural Machinery	270 001	122 356	45.32
Research Institute of Agriculture	295 453	115 691	39.16
Research Institute of Biotechnology and Veterinary Medicine 'Sigra'	912 482	158 879	17.41
Research Institute of Water and Land Management	137 913	63 942	46.36

Source: research institute reports (year 2008) submitted to Ministry of Education and Science

Table 3

Collaboration with entrepreneurs and impact on research institute development

		Collaboration with entrepreneurs				Total
		bad	neutral	good	very good	
Impact on research institutes' development	none	0	0	0	0	0
	low	0	2	0	0	2
	a little	1	2	9	0	12
	fairly sufficient	2	7	7	0	16
	sufficient	0	1	4	3	8
Total		3	12	20	3	38

According to legislation calculating amount of base finance incorporate research institutes' effectiveness indicators including collaboration with entrepreneurs, and realised projects. Research shows that the most commonly used policy instrument is the public provision of basic research that potentially creates positive externalities that favour industrial applications over the long run (Peneder, 2008). In two questionnaires, the question about obstacle impeding the development of research institutes was organised in two different ways. This question was given as a closed question with a possibility to choose two of the main obstacles mentioned to the first part of respondents. The answers showed that 80% of respondents chose the cut of basis financing from the state budget as one of liability and the second obstacle that impedes the research institutes to develop was the legislation framework (44.45%) and the lack of collaboration with entrepreneurs (44.45%). But the second part of respondents had to answer the same question in an opened way. Then the answers varied more, and 38.18% of respondents named the lack of funding, 16.36% of respondents think that one of the obstacles that delay the research institutes development is the lack of young scientists, 10.91% blamed the legislation framework, 9.09% the lack of collaboration with entrepreneurs, but 25.45% of respondents gave other different answers.

This part of the research approves that assumptions made during SWOT analysis were topical to respondents mind as well.

The data in matrix displayed in Table 3 show that all respondents, except one have pointed out that their research institute collaborates with an entrepreneur. The analysis shows that nearly 60% of respondents consider that resent collaboration with entrepreneurs was positive (very good and good), 32% neutral and 8% as bad. To 63% respondents' opinion, research institute's collaboration with entrepreneurs has a positive impact (fairly sufficient and sufficient) on development of research institute.

Although almost only one tenth of respondents considered previous collaboration with entrepreneurs as negative, there is no definite attitude whether it can impact institutions further development, as well as respondents who considered collaboration as good – estimations vary from a little to sufficient. Most frequent answer was good present collaboration with little impact on research institute development.

The European Commission also underlines that the co-operation with business has to be strengthened. A broad range of research and innovation related actions may be funded, such as regional and transregional clusters, poles of excellence, technology transfer, business support services and actions to develop human capital and help workers and enterprises anticipate and adapt to economic change. Member States can use the EU structural funds in a flexible manner to help to meet their specific needs and exploit the synergies with Framework Programme 7. Innovative actions will also be co-financed by European Agricultural Fund for Rural Development to develop new high quality and value added products and to promote the sustainable use of natural resources. Member States are invited to take full advantage of the EU structural funds and the European Agricultural Fund for Rural Development to strengthen and build strong research and innovation systems (More Research..., 2007).

Therefore, the authors of the research anticipate the growing necessity to make a strong fundamental for national innovation system that would include effectively working research system in collaboration with universities and entrepreneurs that would increase the competitiveness of Latvia.

Questionnaire results denote that research institutes identify changes or improvements needed to ensure the development of scientific activities in Latvia that are related to increase of state budget funding and reduction of bureaucratic barriers or lighten the administrative burden on research institutes as project implementers. Dependence on state budget should be diversified and substituted with other financial mechanisms. More common legislative framework and reduction of bureaucratic barriers in the field of economics and science could promote the collaboration with entrepreneurs.

Conclusions

1. According to the study that is carried out, the authors conclude that the research institutes operating in the field of agriculture mainly use financing from state budgets appropriation as a

base financing and Latvian Council of Science grants and other financing from the state budget that is more easily to be obtained in the current situation.

2. The SWOT analysis showed that the main weaknesses such as lack of co-operation with entrepreneurs, lack of experience in the project implementation, and ageing of scientific staff in the research institutes operating in the field of agriculture as well as threats – decrease in the R&D investments, low prestige of scientific activities, and unfavourable tax policy to entrepreneurs investing in R&D should be diminished using internal strength - highly qualified researchers and scientific stuff – combined with opportunity to switch orientation to science-intensive production and availability of the EU structural funds assistance (total amount 188.74 million lats).
3. The authors of the research propose to enhance public relations activities of research institutes' that would help to establish and develop communication, community relations, customer relations, government affairs, industry relations, investor relations, media relations, publicity. Therefore, a structural reform is needed in order to increase the research institutes activity's effectiveness. This reform should include amalgamation of research institutes in the field of agriculture, establishment of a department of development, whose main functions would be the development strategy outline and implementation, activities in the field of public relations of the research institute, the building of dialogue with entrepreneurs and investors, the establishment of collaboration with the producers, administration and part of implementation of institute's projects.
4. The study shows that one of the main obstacles that impede the research institute development after restricted amount of funding is lack of young scientists. The authors suggest strengthening collaboration between the universities in the field of research involving more and more students of all levels (starting from bachelor to doctoral level).
5. The research shows that in order to attract young scientists to the research institutes, they have to be involved in the implementation of research projects and the mentoring approach could be used to gain good results in the alternation of researchers' generations. The EU structural funds assistance is available to the doctoral students and young scientists.
6. The authors conclude from research that dependence on state budget should be diversified and substituted by other financial mechanisms.
7. In the current situation, the experience of successful examples abroad has to be studied and systemic market oriented national research system established. Moreover, there is a need for the further research about reorganising national education system, national research system, as well as national innovation system that could guarantee sustainable economic development and improve states competitiveness.

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INNOVATION CAPACITY – PROBLEMS AND SOLUTIONS FOR SUCCESSFUL DEVELOPMENT

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Abstract. Innovation capacity has to be viewed as a consequence of properly operating innovation system. Well established and functioning innovation system is a result of enhanced by government innovation policy. In comparison with other European Union (EU 27) countries, innovation capacity indicators in Latvia remain low and considerably underperform, reflected in the 'European Innovation Scoreboard 2008', where Latvia took the 30th place among 32 countries. Problems and solutions are illustrated to represent innovation capacity in Latvia.

This article consists of the following parts: first - theoretical aspects are selected to describe the essential definition of the analyzed subject. In the second part, experience from abroad is described, at the end – Latvian innovation policy and situation is analyzed and suggestions for further needs are formulated.

The main results of analysis show that only a few elements of innovation capacity building are functioning at Latvian enterprises, whose aim is to build a base for the innovation capacity of the country.

Key words: innovation capacity, innovation system, innovation policy.

Introduction

The article focuses on innovation capacity issues and illustrates innovation systems in Latvia and abroad. One of the components of the system – entrepreneurship is also researched. Innovation capacity is defined by several authors, but it can have a different meaning if applied to national or organizational level. Meanwhile, it doesn't change the importance of the term, being one of driving elements of national economy development. Country's development is dependent on properly functioning national innovation system. Countries with highly ranked innovation capacity like Sweden and Finland have leading innovation institution, which leads and actively develop innovation capacity.

Latvian national innovation system still needs a lot of improvement, with the main idea to improve cooperation among National innovation system elements, boost knowledge of those elements and have more coordinated actions from governance institution.

According to the statement of Ministry of Economics representative A. Burka from the department of Industry and Innovation, based on the meeting held on 1st of July, 2010, national innovation capacity indicators in 2010 do not have positive impact and Latvia still stays in catch up countries group. It is also admitted that Latvia lack locally executed researches, which would clearly state reasons and obstacles for innovation capacity problems. The same is also reflected in the 'Global Competitiveness Report 2009 – 2010', published by World Economic Forum, among 134 countries, Latvia ranked in 68th place.

As innovation capacity depends on external and internal determinants, it has to be defined which have key priorities to be stimulated.

Materials and Methods

The main hypothesis of the article is to identify regularity between innovation capacity innovation system and one of its elements - entrepreneurship; functioning level of activity and direct mutual influence.

The aim of the article is to analyze innovation capacity of Latvia and illustrate linkage between national innovation system and policy, identify main issues and propose solutions for improvement. The innovation capacity can be directly measured by EIS (European Innovation Scoreboard yearly research), in context of this research EIS has used a base quantitative indicator, to illustrate Latvia's position in comparison to EU 27.

From the qualitative perspective national innovation system structure can be measured in comparison to international systems and correlation of EIS innovation capacity data can be accordingly correlated.

Scientific problem – unsolved innovation capacity issues can be found in different materials and researches stated by Latvian institution documents, European Commission or international documents, for example, by the European Commission, Innovation Policy Progress Report, 2009. The scientific problem consists of practical challenges to develop innovation system for boosting innovation capacity of the country, by creating adequate innovation policy.

Main tasks of the article – 1) make review of international experience in innovation capacity development; 2) analyse the current national innovation system in Latvia; 3) review one of the main national innovation system elements – entrepreneurship – and its current situation from innovation capacity perspective. Main data sources used for analyses and comparisons: researches, statistics, programs and policies for development of entrepreneurship and innovation in Latvia and abroad.

2 discussions with acting in innovation system participants - Latvian Investment and Development Agency representatives Mr. M. Elerts and Mr. V. Zeps (24 of February, 2010) and Latvian Technological Center director Mr. J. Stabulnieks (2 of March, 2010) were carried out.

Author's practical interpretation of specific innovation capacity determinants were provided. Solutions and conclusions were represented to summarize article findings of innovation capacity provided.
An article provides analysis and comparison for the time period 2006 – 2009.

Results and Discussion

Innovation capacity and innovation system definition.

Innovation capacity has been mentioned by several authors K. Pavitt (1982), M.E. Porter (1990) and L. Suarez –Villa (1990), all of them claim rights of a term invention. L. Suarez -Villa defined similar concept of innovation capacity, but named it innovative capacity, measuring the level of invention and the potential for innovation in any nation, geographical area or economic activity. Measuring innovative capacity over time can provide important insights on the dynamics of any economic activity, nation or geographical area. Declining level of innovative capacity for any industry or activity can serve as an early warning of future difficulties and decline. Porter has defined innovative capacity as a potential of economy, which is protractedly used to create a flow of commercial innovations. Innovation capacity is not only dependent from the level of technology and quality of human resource, but also from priorities settled by government.

While assessing innovation capacity, internal and external determinants – micro and macro environment (Bell, 1984) – many factors, inside and outside the company can impact innovation capacity and are important. See detailed explanation of determinants, figure 1 'Internal and external determinants of innovation capacity', the author's developed classification.

Innovation capacity can be defined at 2 levels: macro or a national level and micro or a company level. National innovation capacity can be only viewed as a result of properly functioning innovation system.

The national innovation system approach has been introduced in the late 1980s by C. Freeman (1987), Dosi et al. (1988) and further elaborated in the following years (Lundvall, 1992; Nelson, 1993; Edquist, 1997). A national innovation system can be perceived as a historically grown subsystem of the national economy in which various organizations and institutions interact and influence each other in the carrying out of innovative activity.

Nowadays, definition and concept hasn't changed a lot, the World Bank (2007) defines innovation system as a network of organizations focused on bringing new processes and new forms of organizations into social and economical use. National innovation system is formed by innovation policy at country or regional level. National innovation system consists of 4 elements: 1) research and development; 2) entrepreneurship; 3) finance system; 4) legislation.

Both groups of determinants are important for successful development of innovative capacity of enterprise, but some of them have to be more admitted.

Absorptive capacity is linked to innovative capacity in a way that absorbed knowledge can or can't be transformed into successful innovation.

Knowledge and competence are determinants, which on the level of small and medium enterprises - SMEs always raise problems to be delivered. At least two major channels are identified how those can be obtained. W. Cohen and D. Levinthal (1990) suggest that some firms develop the capacity to adapt new technology and ideas and are therefore able to appropriate some of the returns accruing to investments in new knowledge made externally. In contrast, D. Audretsch (1995) proposes shifting the unit of observation to the unit of the individual – the scientists, engineers, and other knowledge workers – as agents endowed with new economic knowledge.

Innovation system and governance role.

In examining role of government in national innovation system, 3 indicators are crucial: leadership,

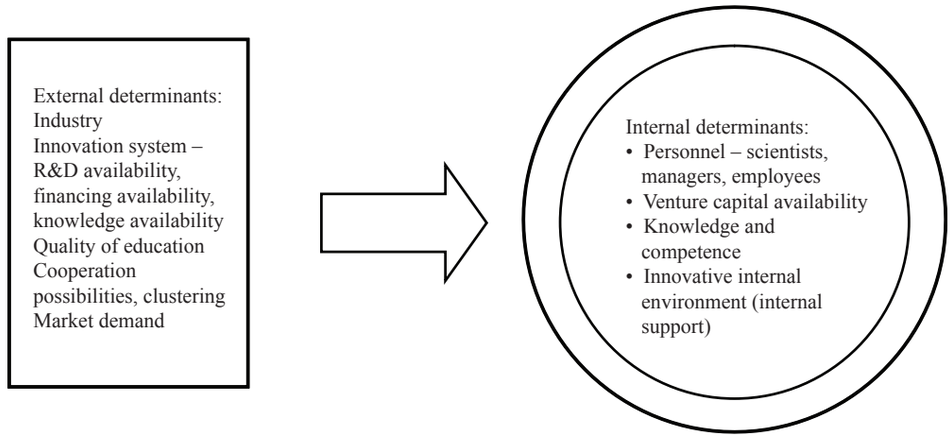

Figure 1. Internal and external determinants of innovation capacity.

Source: the author's classification.

execution and review: 1) leadership – the main idea is to lead and develop national priorities and articulation of desirable outcomes; 2) execution – formulation of rules and programs to deliver outcomes; 3) review – ongoing process of monitoring outcomes.

Organization for Economic Cooperation and Development - OECD (2005) points to range of barriers coherence in national innovation systems, including freezing policies, complexity and fragmentation. A common problem for many governments is that they use yesterday's institutions to meet tomorrow's problems. To achieve the coherence, flexibility and common sense of innovation system, innovation policy has to be developed by leading, central institution, responsible for innovation. Institution has the following matters to deal with:

ability to determine national innovation system priorities;
to have clear helicopter-view over overall innovation environment in country;
initiate supportive actions (programs, legislation, elements, support instruments) for innovation system development;
coordinate and guideline implementation of supportive actions;
audit results and continue follow up innovation system improvement process.

Innovation systems in countries with high innovative capacity like Finland and Sweden, the national innovation system is a lead in following way: 1) Finland: the Finnish national innovation system has always had a strong focus on regional development through technology transfer, and there is a diverse range of capital providers for innovation, both private and public. SITRA – The Finnish Innovation Fund is one of them and provides capital for start-up technology firms, always as a minority investor, as well as services to match SMEs. Ministry of Employment and the Economy is responsible for the national innovation policy.

As an example, Finnish national innovation system development process in the year 2009 is described. The practical preparation of the strategic work was carried out by the Ministry of Employment and Economy. The strategy was prepared involving the extensive consultation of specialists, stakeholders and citizens. Eleven workshops, focusing on the key challenges of innovation policy, were held in the autumn of 2007. Nearly 800 specialists gave their views in the workshops and online. A steering group, chaired by Esko Aho, President of SITRA was appointed for the actual preparation of the innovation strategy. In Sweden there are two ministries, namely, the Ministry of Industry, Communication and Employment and the Ministry of Education and Culture that share the main responsibility for innovation policy. Although the concept of innovation policy has been developed since the end of the 1990's, it wasn't clearly defined until 2001, when the new institutional structure (organization of research system) was introduced. In order to focus on coordination between economic growth policy and research policy, the Swedish Agency of Innovation Systems (VINNOVA) was established. VINNOVA has a mission of promoting sustainable economic growth by financing research and technology development (R&D) and developing innovation systems. In 2004, the Swedish Government (Ministry of Industry and Ministry of Education) introduced its main innovation policy document "Innovative Sweden". The formulation and implementation of technology and innovation policies are passed by the government to its agencies. The agencies create a number of programs and fund them mainly using co-funding from other sources (both state and private). The main agencies in this area are VINNOVA, The Swedish Agency for Business Development (NUTEK), the Space Agency (Rymdstyrelsen), the Energy Agency (STEM).

Showing importance of innovation in Australia, innovation is included as a part of ministry and Minister for Innovation, Industry, Science and Research is dedicated to develop innovation system. The same approach is in Canada where the Ministry of Research and Innovation coordinates the national innovation system.

It wouldn't be fair from the economy development point of view to compare Latvia, for instance, with Sweden or Finland, but it is adequate to compare it to Estonia, where the development of innovation capacity and environment has very similar starting point. The closest neighborhood country - Estonia has made a step towards a change in innovation capacity development. Enterprise Estonia and special tool called Estonian Development Fund, established in 2007 by the Riigikogu (Estonian Parliament) with the purpose of initiating and supporting changes in the Estonian economy and society, perform functions of the innovation capacity development and support in the country level. Development Fund performs risk capital investments into the starting and growth-oriented technology companies together with the private sector and carries out socio-economic and technology foresight. The goal of the Development Fund's investment activities is to develop Estonia's venture capital market. In order to serve that purpose, the Development Fund makes venture capital available to start-up growth companies, encourages business angels to invest into start-up companies and popularizes venture capital among entrepreneur. Estonia has a clear vision and action plan how to make positive change in innovative capacity building through funding, support and a clear action plan for SMEs.

Innovation policy in Latvia.

The main body coordinating Innovation policy development is the Ministry of Economics with further submission of policy documents to the Cabinet of Ministers. The main document currently, in 2010, coordinating the national innovation system development and implementation is 'Entrepreneurship Competitiveness and Innovation Promotion Program for 2007-2013'.

Innovation policy in Latvia, at a current stage, covers only particular areas with an unclear vision of the weakest elements in the system to be supported. The leading body of the innovation policy development and coordination is the Ministry of Economics, represented by a structure called 'Industry and innovation division', consisting of 6 people, according to officially available information on the Ministry of Economics home page. The number of personnel employed is insufficient, and it is a clear weakness in terms of innovation policy formation. Dealing with administrative functions and documentation, and legislation adaptation in accordance with the EU standards and requirements is a consuming function, which does not provide much time for strategic innovation policy planning.

According to Innovation Policy Progress report (2009), 'External assessments point to the fragmented nature of a policy formulation and there is room for improved inter-ministerial coordination in Latvia as well as the need for a closer integration of R&D and innovation policy. While in numerical terms the number of organizations involved in the innovation governance system of Latvia seems sufficient, there is a continuous lack of a high level coordinating body in this domain'.

Until the mid year of 2009, similar to Europe or closer neighbourhood practice - Estonia, Latvia has executed innovation system enchantment under Latvian Investment and Development Agency (LIDA), by the department concentrated on innovation, called - ZINIS. It was established in 2006 with the main aim to improve policy of innovation system, coordinate national innovation system action plan execution and promote cooperation between government institutions, industry and research and development sector. Even it has to be admitted that for a successful innovation system development there has to be done more, liquidation of this department, due to budget costs, from the national perspective is arguable. Its main functions were delegated to the Ministry of Economics.

Capacity of a small division to make radical decisions and lead the national innovation policy in a way to provide sustainable and successfully development of innovation system is questionable.

Entrepreneurship in Latvia.

In the country, where 99.4% of enterprises are classified as SME, the analysis of the innovation capacity has to be viewed in correlation to dominant form of entrepreneurship. In 2007, the total number of entrepreneurs was 69 863 thousands, where micro enterprises constitute 78.6%, small enterprises – 17.3% but medium - 3.5% - according to the Central Statistics Bureau of Latvia. The total number of enterprises, self employment, peasant and fishermen farms were not accounted. Besides SME form, economy is largely driven by self-employment, which counts for 62% of total economically active statistic units, see Figure 2 'Economically active statistic units in Latvia, 2006 – 2008'.

As micro enterprises are leading forms of the country economy, the development of innovation capacity has to be concentrated on proper support of micro enterprises, besides that also self-employment has to be stimulated as in a long run it can gradually become SME entrepreneurship.

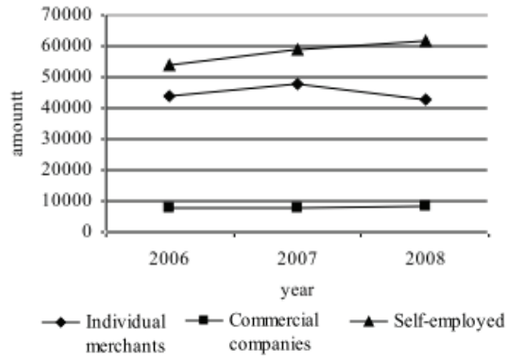

Figure 2. Economically active statistic units in Latvia, 2006 – 2008.

Source: Central Statistical Bureau of Latvia
Comments: Provisional data, 2008

In the context of innovation capacity, analysis of statistical data was important due to the reason that small business tend to have very limited financial resources not sufficient for investments in innovation as well as limited knowledge base, even about basic processes for innovation. The most of SME are able to develop new processes, products or services accessing external source (Tyson, 1993). External knowledge has to be adopted with SME internal activities. SME is not always able to find sources of knowledge, even if it is done, they might find difficult to adopt newly gained knowledge in an organization. The ability of SME adopt knowledge is called absorptive capacity (Zahra and Georg, 2000).

Based on extracted statistical data facts where SMEs are dominant, the innovation capacity strongly depends on government support and provision tools, instruments and programs to support 2 crucial conditions: finance availability (external) and knowledge base (internal) determinant. In Latvia, both at the moment are at a low level among entrepreneurs, even if financing somehow can be fixed (through bank support - Hipoteku banka, Imprimatur Capital, Baltcap), knowledge base may take years to develop the level, needed to create valuable innovation.

An entrepreneur in Latvia has to possess much more than just a definition of innovation. There has to be a complex of knowledge acquired like commercialization, prototyping, market research, export, cooperation, negotiations and more. An idea can remain an idea and never get commercialized if not properly handled.

Research conducted among 306 (122 from districts and 184 from Riga and suburb) enterprises 'Analysis

of innovation need of small and medium enterprises in Latvia, 2007' done by Latvian Technological Center indicates that less than 20 have used Riga Technical University services, even less used University of Latvia (LU) and Latvia University of Agriculture (LLU) services, and only few named Rezekne Higher Education Institution. The number of enterprises, who used services and assured cooperation between research and industry, is critically low. General trend is very clear – there is still no cooperation between enterprises and universities. More than 200 respondents, as the main obstacle in cooperation, name lack of information about services provided by universities. As traditionally universities are perceived as educational institutions, research and development, is not associated as a service to be provided. This hypothesis has to be confirmed in a specific study regarding entrepreneurs and their perception of innovation, research and development. As the second obstacle, with less than 200 replies, 'passive' attitude from research institutions is mentioned.

Moreover, according to the same analysis, the situation in Latvia shows that entrepreneurs are not willing to cooperate with research and development personnel from universities due to the opinion that knowledge they own is theoretical and do not suit current market situation. The same document states also that 'there is a lack of highly qualified and motivated personnel, which decrease innovation capacity of entrepreneurs. This point also reflects the fact that SME are rather micro-companies or self-employed, and there is not a chance for massive knowledge of innovation including product development and commercialization process. Answering the question about presence of the innovation process in organizations, 126 enterprises (41.2%) have made positive statements, but 180 enterprises agreed that there is no innovation process, or didn't give any reply. The research conductors assure that the number of enterprises with innovation processes in line is even smaller. Based on replies from respondents**,** it was clear that respondents do not understand what innovation and innovation process are.

Based on statements made by the research executers, there is a weak, or no understanding regarding innovation management in the largest part of Latvian enterprises. These statements can be also confirmed by all other related data from the same research, (cooperation with universities, number of patents etc.,) which directly shows enterprises' ability to assure innovation management. Even if some of elements might be managed properly, there is no system that would guarantee professional innovation management within the enterprise.

Following steps of research and inspecting the drivers for innovation (combining internal and external), 115 enterprises (91.3%) from total that have innovation process as driving force mentioned their own, internal sources; 68 of enterprises have started innovation process as an initiative from a customer or consumer; 51 – based on owners initiative and 12 – based on initiative from international enterprise. It should be mentioned that universities and R&D institutions have initiated innovation process in just three enterprises. Based on this data, the assumption can be made that networking, especially, international networking, is a weak area in Latvian enterprise. The lack of networking leads to a lack of knowledge acquisition and to a low level of innovation.

The results of innovation measured as percentage of turnover, has made no effect in 25 enterprises, 25 enterprises see that a new product or service generates around 1-5% from the total turnover; 26 – answered that amount is 5-25% and only 9% that more than 50%. Assuming that innovation can be incremental or radical, depending on the age of the company and nature of business, it is acceptable that there may be different levels of generated results, including unsuccessfully introduced innovation, but the average number of enterprises with ranges 5-25% new profit generation, has to be higher by at least half.

176 enterprises (57.5% from all surveyed) have mentioned new market acquisition as the main condition for the development. 163 enterprises (53.3%) have experienced growth as a result of new product developments and 158 (51.6%) as optimization of the company and its costs balancing**.** Six main development factors show that enterprises' plan to find new markets in Latvia and Europe, develop new products, optimization of company operations and costs cutting.

Cooperation and networking are mentioned among the least important factors for development and are ranked as number 14 with 55 votes or (18%). Also an indicator, - willingness to improve internal competence is ranked only as the 8th. The latter two (low interest in cooperation and internal competence improvement) show that an enterprise still does not understand the importance of knowledge, which has to be generated inside the enterprise or acquired externally. Enterprises are only concentrating on final steps of successful innovation, but do not understand how to organize efficiently internally, enter new markets, or develop new and successful products.

Innovation capacity in Latvia.

Innovation capacity indicators in Latvia, remain low and considerably underperform in comparison with the European Union (EU 27) countries. The same is also reflected in 'European Innovation Scoreboard 2008', where Latvia occupied the 30th place among 32 countries. Innovation Policy Progress report (2009) also admits that the level of innovation capacity is low. Low level of innovation capacity is also stated by other institutions: 1) according to the Central Statistical Bureau of Latvia in 2008, only 19.5% of enterprises were innovative and developed or commercialized new products. Average level in Europe is around 45-50% according to Innobarometer 2009 data; 2) according to the data 'European Innovation Scoreboard 2008' high tech sector proportion in export portfolio, stands only for 23.9%, while in the EU 27 it is 48.1%; 3) the 'Global Competitiveness Report

2009 – 2010', published by World Economic Forum, among 134 countries, Latvia ranked in 68th place. While analyzing more deeply 12th pillar: 'Innovation', level of innovation capacity is low and driven by several indicators: 1) capacity of innovation – rank 68; 2) company spending on R&D – rank 95; 3) government procurement of advanced tech products – rank 102; 4) university - industry collaboration in R&D – rank 86.

After summarizing data on innovation capacity, it is clear that it is low and in correlation with not properly functioning innovation system and based on a low functioning of one of its elements - entrepreneurship. External determinants are not enough stimulating, also internal determinants problems persist, meaning absorption capacity and knowledge of SME. Proposals for improvement and conclusions are made further in the abstract.

Proposals for improvement.

National innovation system has to obtain a leading institution, not to coordinate, but actively lead and develop national innovation system by implementing accordant national innovation policy;

Positive experience of countries like Estonia, Finland and Sweden, has to be benchmarked and implemented in the development of national innovation system in Latvia; a leading specialist in the national innovation system from abroad has to be invited to contribute for policy development;

While planning innovation capacity of a country – entrepreneurship abilities have to be analyzed and support tools developed in accordance; especially knowledge share, development and building activities.

Cooperation among enterprises and universities has to be enhanced and popularized by creation financed programs to support active and productive cooperation.

Assessment and ranking of importance of internal and external determinants of innovation capacity in Latvia, has to be done at national level. Based on results, national innovation policy has to include solution instruments categorized by importance.

Investments in human resources are necessary (SME managers, owners and employees) with an aim to increase absorption capacity (training courses, foreign languages, online materials).

Conclusions

1. This research is a present evidence of the fact, that innovation capacity is a measuring indicator of efficiency of national innovation system. Taking into account weak performance of national innovation system, which can be characterized by weak cooperation among system elements, lack of knowledge of innovation management in Latvian enterprises, lead to low level of innovation capacity.
2. Creation of adequate and properly functioning national innovation system with leading innovation institution is a must, to improve innovation capacity of the country. In comparision to closer countries, Estonia, Finland and Sweden, it is obvious that several elements of national innovation system – specific agencies or instruments have to be implemented to promote innovation capacity.
3. There are many determinants which influence innovation capacity in the company, and the role of National Innovation system is to create environment with positive impact of external determinants of innovation capacity and also lead execution. Those are currently due to lack of finance not executed in full speed and amount.
4. Latvian economy mainly consists of SMEs 99.4% where majority are micro companies. In respect to this, the leading institution of innovation system and policy development, the Ministry of Economics has to have a clear vision about targeted support of financing SMEs and knowledge enhancement. Executed actions so far are limited and do not provide massive positive impact.
5. Learning from the leading countries in innovation capacity building and policy development, would be the main objective in medium term period of 3 -5 years for Latvia to assure national innovation capacity increase.
6. Situation of innovation capacity in Latvia at the moment can be described as weak, and this conclusion is supported by various, independent sources of information listed in research. Correlations can be made between low level of innovation capacity in enterprises, reflecting low level national innovation capacity.

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RURAL-URBAN AND REGIONAL APPROACH COMPARING HUMAN VALUES IN LATVIA

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Abstract. Regional development should not be a unified process even for a small country such as Latvia. There is a stereotype that people living in big cities and rural areas differ in their values and behaviour. This study compares the human values of Riga, the Riga district urban area and different rural regions in Latvia. During the last three years - 2007, 2008 and 2009 the survey of 1450 inhabitants showed no substantial difference in peoples' social values; comparing rural and urban locations. Rather, a noticeable difference in human values between people living in different regions of Latvia was observed. It was also observed that the set of values expands in different directions over time, forcing a future increase in fragmentation and segmentation of the population in the country.
Key words: human values, Latvia, rural, urban.

Introduction

Interest in economic, political and academic society regarding how a person's decision making is influenced by human values continues. Human values are "desirable trans-situational goals, varying in importance, that serve as guiding principles in the life of the person or other social entity" (Schwartz, 1994). Knowledge of peoples' values provides political, social and economic decision makers with guidance to: strategic development of communication with the society and each target group and tactical selection of development alternatives. Fundamental work on values was done by Rokeach (1968, 1973). He defines value as "an enduring belief that specific mode of conduct or end-state of existence is potentially and socially preferable to alternative modes of conduct or end-states of existence" (Rokeach, 1973). Rokeach argues for the importance of the value construct over the attitude construct since value is a determinant of attitude as well as of behaviour. Additionally, since it is assumed that an individual possesses many fewer values than attitudes, then using the value concept is a more correct way of describing and explaining the similarities and differences among individuals and groups (Rokeach, 1968).

To evaluate direct and indirect relationships between human values and importance in value attributes, Allen and his colleague (Allen, 2000; Allen and Ng, 1999) proposed a complex evolutional model. Four commonly used human value scales are Rokeach Value Survey (1973), the Schwartz Value Survey (1990, 1994), Social Values Inventory (Braithwaite, 1982), List of values or LOV (Kahle, 1983). The Schwartz Value Survey was developed from Rokeach Value Survey and designed to be equally applicable to Western and non-Western cultures. Moreover, in contrast to the Rokeach Value Survey, the value groupings or subscales outlined by Schwartz have strong empirical and theoretical foundation (Allen, 2001). Schwartz determined eight value domains which have been used in the study, slightly rephrased, as a guideline:

- Hedonism (comfortable life, a pleasurable life);
- Achievement (accomplishment, ambitious)
- Self-direction (independence, intellectual, imagination, self-centered)
- Social power (recognition, influence, control)
- Conformity (politeness, empathy, peaceful)
- Security (family and relatives security, national security, domestic)
- Benevolence (forgiving, love, friendship)
- Universality (equality, harmony, social justice, peace, profound)

Value domains (or segments) defined by value systems rather than by a single value have both more reliability and greater interpretability (Kamakura and Novak, 1992).

The general idea of urban areas relates to a town or city that is free-standing, densely occupied and developed with a variety of shops and services. The concept of 'rural' is more complex and multidimensional. One problem lies in capturing the diversity of types of rural areas that exist. These can, for example, range from small settlements on the fringe of large towns and cities to remote villages and from agriculture to areas of extensive arable farming or grazing. The current research considers rural area all the territory of Latvia, except cities with official status (Riga, Daugavpils, Rēzekne, Liepāja, Ventspils, Jelgava, Jūrmala, Valmiera, Jēkabpils) and regional territorial units: towns with population over 5000 dwellers. Rural area is also the rural territory of a town with a rural territory and population over 5000 which is a regional territorial unit. They both have been marked in current research as "out of town". Towns with populations of more than 5,000 inhabitants have been marked in the study as a "town". All rural areas and towns have been grouped by administrative territorial districts of Latvia: Latgale, Vidzeme, Zemgale and Kurzeme, each with approximate population of 300,000 inhabitants. Riga and Riga district have been separated for comparison and considered as "urban" domain (1,100.000 inhabitants).

Over the last 20 years, Latvia has faced dramatic changes in people's political and economical paradigms. This has impacted human values.

The concentration of economic activity, decision making, labour, foreign investment, knowledge, and entertainment within metropolitan regions is substantial. The attractiveness of larger cities is also considerable, while rural areas in general remain in the shadow. Cities and urban areas are without doubt the main engines of economic development in Latvia. Processes related to urbanisation continue to grow and affect even the smallest village. Major current landscape transformations are the result of changing the relationship between an urban and rural way of life and their related forms of land organisation. Most of the driving forces nowadays have also a globalisation component which increasingly influences local changes. In the past different lifestyle habits and values in the countryside and cities were determined by the use of land and adoption to environment. Now more and more people living in the countryside have habits and use values similar to those of urbanites. With development of new informational and commuting technologies between urban and rural areas, the entire society is becoming increasingly urbanized and influenced by urban values and the urban way of life. Due to these changes, it could be supposed that urban-rural difference in human values is diminishing. However, changes in social behaviour do not occur quickly, or at a run of one single generation. Value changes occur with the exchange of generations.

This gives us an opportunity to determine current research objective: to explore how unified are human values comparing rural (the countryside) areas and urban metropolis in Latvia. The aim of this work is to create understanding of differences in values in relatively small geographical area. How do different districts of Latvia (even in close proximity of a few hundreds kilometres) differ or match between each other? Is this trend stable or does it fluctuates giving the shaking political and economical environment of Latvia in recent years?

The hypotheses for the research are the following:
Hypothesis 1: Human values in rural and urban areas of Latvia are not significantly different.
Hypothesis 2: There is a difference in priorities of human values among different regions of Latvia

Materials and Methods

During each of last three years: 2007, 2008, 2009, in September- October, around 1450 inhabitants of Latvia (age from 17 till 74 years) were interviewed. Respondents were selected proportionally to the size of population in the region. The survey was done by 70 trained interviewers. The survey asked respondents to rank the priority of 65 different values, selected from previous research and adapted to Latvia – Schwartz Value Survey, Rokeach Value Survey (English and Soviet versions), VALS (Values and Lifestyles), LOV (List of Values). Subjects were asked to rate sets of instrumental and terminal values on a 9-point scale ranging from 'of supreme importance' (7) to 'opposed to my values' (-1). One advantage of this inventory is its ability to measure those 'negative' values which individuals might normally avoid expressing (Schwartz, 1992), for example, social power and acceptance of one's position in life. Examining the impact of values on behaviour based on multiple-item indicators is more reliable than alternatives based on single values. The shared variance of items in a system creates a more valid measure of motivational goals. The survey took an average of 40 min. per respondent as face-to-face interviews.

Using the Schwartz value domains as a guide, scores for each participant were calculated. Eight value domains- segments were established as a reference to dominant values selected: Rational, Traditional, Peaceful, Domestic, Profound, Self-centred, Ambitious, and Maximalist. For example: 'Domestic' type of respondents highly ranked such values as: prosperity, safety of their relatives, well-established private life, trustfulness and keeping promises. 'Profound' type of respondents most valued: life in harmony with a nature, peace and love in the world, security of the country, kindness, and respect to religion. 'Self-centred' respondents ranked highest such values as: professional growth, exploiting full potential, power, creativity, and continuous search for new knowledge. In the comparison study all data is shown as percentage of difference from the sample mean (first two data columns in Table 1 and Table 2), with '-' (minus) sign difference is negative, without the sign- difference is positive.

Limitations of the current research include unclear delineations of the meaning or definition of different values in certain segments. For instance 'safety of relatives' can be attributed to both 'Domestic' or 'Traditionalist', or even 'Peaceful' segment of human values. Therefore, there is some fuzziness in such a determination. Another limitation is related to the number of 'out of town' respondents (34) in Riga district. Since it is not statistically significant, it is considered mainly as 'additive' to Riga city. In fact there is a daily involvement of these people with metropolitan lifestyle, infrastructure and close proximity to the capital. Although research results show few noticeable 'distortions' from sample mean, it is suggested to be cautious in drawing conclusions about this set of respondents.

In cross-national and cross-cultural research it is essential that the measurement of the relevant constructs is invariant, meaning that the same scores should have an interpretation independent of differences in Culture and Language. If invariance between countries is not tested, comparisons of countries are problematic (Davidov et al., 2005). For the comparative data analyses European Social Survey 2002-2003 was used in Huismans & Van Schuur research (Huismans and Van Schuur, 2009) and seven European countries: Israel, The Netherlands, Belgium, Germany, Spain, Poland, and Greece were selected. This survey incorporated 10 basic Value Domains of Schwartz, using 21 value items. Value Circle was used to assign scores in respect to an overall Value system combining Schwartz's Value Circle with an

innovative technique for locating people along the circumference of a circle. Since this methodology is different from one used in the current research, there is not possible to take direct comparison, rather observe deviations in values ranking among European countries. Huismans & Van Schuur research shows that among selected seven countries in Poland, Spain and Greece restrictive Conformity was dominant. Historically these countries are characterized by a dominant Roman Catholic and Greek Orthodox Christian tradition. The patterns Germany, Belgium and the Netherlands are strong in respect for Tradition values. The Israeli pattern is similar to the patterns of the West European countries but with more emphasis on Power and Security Values. It appears that Poland and Greece show relatively high preferences for the location of Conformity and Security Values.

In Latvia similar research has not been completed so far. There are few studies done by using Schwartz values. One of them was the research of attitude towards marriage and relationships between parents and children (Sebre et al., 2004). Human values in urban-rural context in Latvia unfortunately were not studied.

Results and Discussion

Generally, there has been a shift in values in Latvia towards relationship related values (Table 1). More than others, the 'Domestic' segment of values tend to represent the 'average' Latvian living in the urban and rural areas (19.1% and 20.5% respectively). Both 'Traditional' and 'Peaceful' segments of values (12-13%) ranked second. Leading position of these three segments of values has been observed during last three years. This manifests Latvians responsibility towards others, especially the family. Changing external environment also proclaims value of 'living today' among top priorities. The least attractive and typical segment is the value of 'Ambition' (2.15% respondents average in Latvia). A cross-comparison of rural-urban (Town vs. Out of town) values suggests that there is a quite similar attitude and no big difference between the segments, with few exceptions- in Vidzeme and Zemgale for 'Profound' segments of values. The remaining data show moderate to good correlation in similarities between people living out of town and cities. Riga and especially Riga district inhabitants have a more even distribution of all set of values. They tend to have no extreme importance of certain values over others. Another interesting observation is that urban and rural populations in Zemgale and Kurzeme have maximum preference concentration on "Domestic" segment of values, in contrast to Latgale, where the same values are much below the average (-2.6% for Town and -1.6% for Out of town respondents). Latgale inhabitants are much more concerned about 'Traditionalist' values (1.3% and 1.2%) - stability, continuity, rituals, religion traditions than are other regions. People in Kurzeme (living in both rural and urban areas) especially tend to 'Profound' (3.3% and 1.9% above the sample mean) set of values. They focus more on their private life, home, family and self-controllable space.

Table 1

Value preferences in rural-urban areas

Value segment	Sample Mean (%, in total)		Riga, Riga District (% to sample Mean)		Latgale (% to sample mean)		Kurzeme (% to sample mean)		Zemgale (% to sample mean)		Vidzeme (% to sample mean)	
	Town	Out of town	Town	Out of town	Town	Out of town	Town	Out of town	Town	Out of town	Town	Out of town
Rationalist	9.1	8.1	0.1	-0.6	0.5	0.6	0.2	-0.1	-0.4	0.7	-0.6	-1.0*
Traditionalist	8.9	8.2	-0.6*	-2.6*	1.3*	1.2	0.6	0.6	0.1	1.4*	0.6	-2.3*
Peaceful	12.1	12.5	-0.6*	-4.1*	-0.8	-1.0	2.8*	0.7	0.3	1.7*	0.9	-0.1
Domestic	19.1	20.5	-0.5*	-4.6*	-2.6*	-1.6*	5.3*	2.5*	2.5*	1.4*	-1.7*	-0.2
Profound	12.6	13.2	-0.4	-1.6*	0.1	-0.8	3.3*	1.9*	1.9*	-1.4*	-3.7*	1.5*
Self-centred	9.3	9.6	0.2	0.0	-0.3	-1.3	0.8	-0.2	-0.9	-0.2	-1.2	1.7*
Ambitious	2.3	2.0	0.2	1.5	-0.5	1.0	-0.5	-0.1	-0.6	-0.7*	0.9	-0.4
Maximalist	7.3	6.8	-0.1	1.9*	0.6	-0.2	-0.7*	0.3	-0.1	-0.7*	0.6	0.4
Sample size n	1074	393	581	34	142	87	127	66	100	114	124	92
	* difference from Sample Mean is significant at p<0.05											

Table 2

Dynamics of value preferences in different Latvia regions

Value segment	Sample Mean (%, in total)			Riga, Riga district (% to sample mean)			Latgale (% to sample mean)			Kurzeme (% to sample mean)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Rationalist	7.9	8.0	8.9	0.1	0.3	0.2	-0.2	0.4	0.4	-0.4	-1.1*	-0.1
Traditionalist	7.7	8.6	8.7	-0.5*	-0.5	-0.5*	0.6	2.1*	1.2*	-0.4	-2.3*	0.6
Peaceful	11.0	11.8	12.2	-1.5*	-1.6*	-0.9*	0.0	1.2*	-0.8	1.7*	-0.1	2.1*
Domestic	19.3	19.8	19.5	-1.0*	-1.1*	-1.1*	0.4	-1.3*	-2.1*	0.4	3.6*	4.4*
Profound	12.5	12.5	12.7	-0.4	-0.3	-0.5*	1.2*	-1.9*	-0.1	0.3	3.7*	3*
Self-centred	9.0	8.6	9.3	0.0	-0.4	0.2	0.6	0.0	-0.6	1.1*	3.2*	0.5
Ambitious	1.9	2.1	2.3	1.1*	0.7*	0.3	0.3	0.5	-0.1	-1.2*	0.2	-0.4
Maximalist	6.9	6.8	7.2	0.7*	0.7*	0.1	-0.4	-1.1*	0.2	-0.1	0.4	-0.4
Sample size n	1445	1425	1467	610	598	615	231	220	229	221	188	193
	* difference from the Sample Mean is significant at p<0.05											

Observation of the overall trends of preferences over values (Tables 2 and 3) in Latvia leads to a conclusion that the two leading segments ('Domestic', 'Profound') have been fairly stable during the last three years (aprox. 19.5% and 12.5% respectively). For 2009, the largest increase, compared with 2008, in importance of value, was for believers in Rationalists values (+0.9%).

Looking at the dynamics from the point of view of regional differences (Tables 2 and 3) suggests diminishing high ambitions in Riga, Riga district (1.1%, 0.7%, and 0.3%) during 2007, 2008, 2009 compared to the sample mean. Even more diminishing 'Domestic' values in Latgale (0.4%, -1.3%, -2.1%), and noticeable increase in the same set of values in Kurzeme region (0.4%, 3.6%, 4.4%). Vidzeme is losing their faith for "Traditionalist" and 'Peaceful' values. Riga and Riga district population is becoming less ambitious, more even in their traits.

Conclusions

1. In answer to the questions from the beginning of the research, it can be said that there is no statistically significant difference in human values between rural and urban areas of population in Latvia (Hypotheses 1 is approved). Still there is disproportion in unemployment, education, income and some other factors, but not in

Table 3

Dynamics of value preferences in different Latvia regions

Value segment	Sample Mean (%, in total)			Riga, Riga district (% to sample mean)			Zemgale (% to sample mean)			Vidzeme (% to sample mean)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Rationalist	7.9	8.0	8.9	0.1	0.3	0.2	0.0	-0.9*	-0.1	0.4	0.2	-1.0*
Traditionalist	7.7	8.6	8.7	-0.5*	-0.5	-0.5*	0.5	0.6	0.6	1.2*	0.5	-0.8
Peaceful	11.0	11.8	12.2	-1.5*	-1.6*	-0.9*	1.5*	2.2*	1.1	1.5*	0.9*	0.5
Domestic	19.3	19.8	19.5	-1.0*	-1.1*	-1.1*	1.5*	0.4	2.2	0.5	0.8	-0.8
Profound	12.5	12.5	12.7	-0.4	-0.3	-0.5*	0.4	-0.2	0.4	-1.5*	0.0	-1.3*
Self-centred	9.0	8.6	9.3	0.0	-0.4	0.2	-0.6	-0.9*	-0.4	-1.8*	-0.5	0.2
Ambitious	1.9	2.1	2.3	1.1*	0.7*	0.3	-1.4*	-1.5*	-0.8*	-1.1*	-0.9	0.2
Maximalist	6.9	6.8	7.2	0.7*	0.7*	0.1	-0.9*	-0.7*	-0.6*	-0.7*	-0.3	0.4
Sample size n	1445	1425	1467	610	598	615	206	209	213	168	210	217
	* difference from the Sample Mean is significant at p<0.05											

general human values. As concerns the regional comparison, it can be concluded that there is a noticeable difference in human values between Latgale, Vidzeme, Zemgale, Kurzeme and Riga, Riga district. Latgale has become more traditional value oriented with diminishing values of family. Vidzeme has some differences between influential towns and rural areas, which should be considered in discussing alternatives of regional policy aimed at reducing inequalities. We should assume that population in Zemgale generally tends to be a bit more relaxed. It seems that they comfortably adjust to the changes of external environment. Kurzeme population is a bit more centred on their daily needs and their own micro-environment (and this trend only increases over time). Although there are no dramatic discrepancies in human values between people living in different Latvia regions, we observed statistically noticeable trends. Therefore, we consider Hypothesis 2 being approved as well.

2. We can state, that the objective of the current research to explore how unified human values are whilst comparing rural (the countryside) areas and urban metropolis in Latvia is met. Obtained results and comparison analysis clearly indicated similarities and differences in both geo-social clusters. There are statistically representative results supported by explanatory notes. The aim of this study is to create understanding of differences in values. In ultimate perspective it is "the way" not a destination, and therefore cannot be achieved by traditional means. On the other hand, we can state that the first cornerstone of more comprehensive human value understanding in Latvia has been set and the goal of this research partially achieved.
3. Having willingness to establish broader goals, new objectives and values (expansion of segments' borderlines) have been observed over three years of the research. People are looking for some changes; their ambitions grow. Theoretically, such a trend might result in consumption increase or broad variety in social activities. However, it is doubtful that such outcome is possible, since economic turmoil began in 2009 and is continuing in 2010. The economic crisis is forcing people to reduce their ambitions and expectations. It becomes controversial to the overall 'value basket' expansion observed before. People might reconsider part of their newly (in fact formed during 2007-2008) established goals.
4. Furthermore, we observe three types of beliefs that have been chosen by Latvian population in this current situation, guided by their dominant values by population of different regions of Latvia:
   - Accept reality and rationally consider actions for future;
   - Search for the ultimate truth, but not change by themselves; it is better to search for adaptation;
   - Focus on oneself, not losing self-confidence and not caring about the problems of others.
5. Since these are a bit different traits, it is suggested looking at these phenomena closer. Further research could be established to continue to exploit particular applications for more unified goals and values of Latvia. Implementation of tools considering the current research findings is suggestible. It is believed that a more unified set of dominant values would be appropriate for the country in order to achieve sustainable development and growth. For managerial (or better to say governmental/ municipal) implication point, we suggest the following strategic and operational actions:
   - Change in the culture of agencies to pursue a common vision for rural areas that all departments in the government nationally and locally can sign up to.
   - Generate improved data about dynamics of human values in rural areas. The idea of a rural monitoring is a key to improving rural intelligence to shape more unified set actions.
   - Recognise the importance of understanding particular regions of Latvia and their interrelationships locally and nationally.
   - Reconfigure municipal and governmental responses reflecting: different scales of influence and people's needs rather than pre-designed and outdated top-down structures that characterise particular interests.

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ASSETS OF THE EUROPEAN UNION FUNDS ON THE REGION DEVELOPMENT IN LATVIA

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Abstract. Despite Latvia being a small country, it bears marked territorial or regional differences both between smaller administrative territorial units (local municipalities, republican cities and districts) and between larger territories – regions.
From 2004 till 2008 Riga received 50% of all European Union (EU) funding. Latgale received the smallest part of financing (10%); the rest of the funding was split almost equally among Zemgale (12%), Vidzeme (12%) and Kurzeme (13%).
As specific tasks for the development of specific territories or a balanced distribution of financing were not put forward for the strategy of acquiring funds, the fund investment has been attracted only to those territories where the yield could be the biggest or where the absorption capacity was the highest.
Key words: Structural Funds, financing, priority, activity.

Introduction

Economically underdeveloped regions is a problem for any country as, along with the increase of unemployment level, the level of crime, drug addiction, and alcohol addiction also rise. As a result social degradation sets in, which can take over the entire country and cause a deep economic crisis. In case of some EU Member States this situation is the heritage of the former centralized planning in economy. It is possible to agree with G.Anča and E.Lune that democratic and integrated regional development comprises many basic principles of economy development – sustainability, balance, participation, as well as a multisector development model. The region development is balanced if it fosters achieving balance between the preservation of cultural and social environment and development, human resource development, social welfare and economic growth (Anče and Lune, 2002). Therefore, it is important to apply a mix of EU structural policy tools and measures to promote economy growth, to enhance welfare in the underdeveloped region and to prevent the potential development of such unfavourable situations in the future. Iveta Šulca, the Manager of the European Commission (EC) Representative Office in Latvia, also admits that EU Structural Funds (EU funds) programmes directly supporting economic development, are meant for strengthening long-term sustainability and open an escape from an economic crisis. The more successful the acquiring of Structural Funds, the faster the escape from recession (Šulca, 2008).

Both the unfavourable territorial or regional differences and the different regional development potential (resources and opportunities) substantiate the need for a targeted national regional policy that would provide the regional development in the country. I.Vilka has also admitted that regional development policy is a part of common development policy of the country. Any regional policy has at least two aspects – economic and social (Vilka, 2004). Despite Latvia being a rather small country, it bears marked territorial or regional differences both between smaller administrative territorial units (local municipalities, republican cities and districts) and between larger territories – regions.

Along with joining the EU on May 1, 2004, the opportunities to participate in the processes of EU regional and structural policy were open to Latvia as one of the new Member States, with the goal to provide faster approaching of the economic and social indicators of Latvia to those of the average EU Member State levels. From 2004 till 2008 financial help in the amount of LVL 1.55 billion from EU and other foreign countries entered Latvia economic development. This funding arrived at the development of state and municipality infrastructure and was handed out as a support for enterprises, used to increase people's qualifications and in other fields (Ministry of Finance, 2009). A balanced territorial development has been determined one of the main Cohesion policy goals also in the current planning period from 2007-2013.

When studying regional development problems, most of the Latvian researchers, e.g. E. Vanags, I. Vilka, I. Vaidere (2006, 2008), I. Šķiņķe, P. Šķiņķis (1997), M. Pūķis (2002, 2005), D. Saktiņa (2008), I. Saulāja, L. Rasnača, Ž. Krūzmētra, D. Bite (2007), B. Rivža, P. Rivža M. Krūzmētra (2001) mainly state the existence of regional differences – identify problems in the employment, the entrepreneurial activity, infrastructure depreciation a.o. areas and how the situation differs when different regions are compared.

In the study of Latvia State Agrarian Economy Institute and the World Bank, Riga region and Zemgale were marked as the biggest winners from the EU and state support programme assets for agriculture and rural development (Saktiņa and Meyers, 2005). Slightly later it was also concluded by "PKC", Ltd. (2005).

As statistical data published by various institutions prove, so far the EU funds assets have reached the capital Riga and the territory in its area to satisfy their needs. But S.Keišs and the author's group question the opinion that the biggest emphasis in acquiring the EU

Structural Funds is placed on Riga, its area and the biggest development centres that also in the future will ensure high growth rates of the gross domestic product (GDP), which will enhance a continuous increase of the welfare level of the inhabitants of Latvia up to the level of an average affluent inhabitant of the EU Member States. A group of researchers continued to study this hypothesis also in 2008, performing monitoring observations and carrying out research on the unrealized opportunities in the country's regional development (Keišs et al., 2008).

Already in the 2004-2006 planning period several opinions about the effective use of the EU financing were put forward. As J.Brizga mentioned in her paper, these resources enhanced the hopes that Latvia would approach the welfare level of western countries faster than before. At the same time several issues related to the EU financing were set: Should the leading motive of fund acquiring be: "faster and more"? Does the inflow of large resources in the country automatically mean beneficial improvements? Will Latvia be able and manage to acquire the financial assistance it has the right to? Will the distribution of Structural Funds assets be open and fair? (Brizga, 2005).

It has to be agreed with E. Jermolajeva et al. that the impact of the EU assets on the country's development, including the development of its regions, can be evaluated not earlier than 2-3 years after the investment (Jermolajeva et al., 2008). Research to date indicates that regional possibilities and interests to acquire financing are not equal. The "reaction" of regional economy to the effectiveness of the invested resources is not identical either because various economic advantages and interests of economic development exist between regions (Saktiņa, 2008).

Therefore the formulated **research goal** is the assessment of the EU funds assets in the regions of Latvia.

To achieve the goal, the objectives were set:

1. to provide the characterization of the regions of Latvia;
2. to evaluate the use of the assets of the EU funds in the regions of Latvia;
3. to assess the use of EU funds in relation to economic indicators in the regions.

Materials and Methods

To study the theme the following were used: normative documentation of the Republic of Latvia – Single Programming Document (SPD), Programme Complement (PC) to the Single Programming Document, laws and regulations of the Republic of Latvia, Regulations of the Cabinet of Ministers on Introducing EU funds for 2004-2006, data summarized on the Ministry of Finance webpage, data of the Central Statistics Bureau of the Republic of Latvia, and studies of other researchers on region development problems and the EU funds.

Analyzing the resources of EU funds available to Latvia and their use, the priorities set for the 2004-2006 planning period and the financing allocated to them in the particular regions of Latvia were used: Riga region (hereinafter referred to as Riga), Kurzeme region (hereinafter referred to as Kurzeme), Vidzeme region (hereinafter referred to as Vidzeme), Zemgale region (hereinafter referred to as Zemgale) and Latgale region (hereinafter referred to as Latgale).

The main research methods applied: monographic descriptive method, testing content correspondence between documents of several levels, methods of analysis and synthesis to find out the problem elements and to synthesize interrelationship or to formulate regularities, acquiring and storing facts, statistical etc. data, specific information.

Results and Discussion

1. Characterization of the regions of Latvia

In total, according to the Human Development Index, which comprises life expectancy, literacy, level of education and GDP per capita normalized values all over the world, Latvia occupied the 50th place among 177 countries in 2002, the 48th place in 2003, the 45th in 2004 and 2005, the 48th in 2007. Thus, in general, the rise has been from place 50 in 2002 to 45 in 2005, but in 2007 Latvia fell to place 48 again. Latvia is the only Baltic state where the Human Development Index has improved from 2002 till 2005. In Estonia it has dropped from the place 38 to 44, rising to the place 40 in 2007, but Lithuania has changed its 39th place in 2002 to the 43rd place in 2005 and the 46th place in 2007. In comparison, Ireland occupied the 5th place in 2007, Sweden – 7th, Finland – 12th, Denmark – 16th, Germany – 22nd, Poland – 41st. Until 2005 Latvia's position improved because the newly born life expectancy increased, gross domestic product and level of education also increased. (State Regional Development Agency, 2009). It is a good achievement for the country but it cannot indicate to a big jump in the development of the country or its regions.

Based on the statistical indicators and comparing regions with the highest and the lowest social economic indicators, it is possible to characterise the differences between regions.

Table 1

Area of the regions of Latvia, number of inhabitants and GDP in 2007

Region	Territory		Population		Population debnsity	GDP	
	km²	Proportion,%	number (ths.)	Proportion,%	Inhabitants per 1km² of territory	ths. LVL	Proportion,%
Riga	10 435	16	1 098	48	105	9 854 483	67
Kurzeme	13 596	21	304	13	22	1 517 697	10
Zemgale	10 733	17	283	12	26	1 180 164	8
Vidzeme	15 246	24	238	10	16	990 399	7
Latgale	14 549	23	348	15	24	1 219 612	8
Latvia	64 559	100	2 271	100	35	14 779 810	100

Source: Data of the Statistics Bureau of Latvia (2009) and author's calculations

According to the territorial space, regions in Latvia are similar. The proportion of Riga is 16%, but Zemgale occupies 17% of the territory of Latvia. The proportion of the other three regions slightly exceeds 20%. If regions are similar based on the territory they occupy, then the differences are bigger in the number of population. The large number of the citizens of Riga is based on the fact that almost 48% of all the population of Latvia lives in Riga. Differences in the number of population are not big among the other regions. Latgale has 348 thousand inhabitants or 15% of the total population of Latvia, then comes Kurzeme with 304 thousand inhabitants (13%) and Zemgale with 283 thousand (12%). Vidzeme occupies one fourth of the total territory but only 238 thousand inhabitants live there, which is only one tenth of the total population of Latvia. Differences can also be observed when comparing regions according to the population density. Riga stands out with the highest population density – 105 inhabitants per km². This population density about 3 times exceeds the average in the country, and it exceeds the population density in Vidzeme 6.5 times. In other regions the population density is lower than the average in the country – 35. In Zemgale region it is 26 inhabitants per km², in Latgale – 24 and in Kurzeme region – 22 inhabitants per km². Vidzeme has the lowest population density – 16 inhabitants per km².

Looking at GDP indicators across the regions, it can be observed that most or 67% of the GDP in Latvia is for Riga. It is followed by Kurzeme with the GDP proportion of 10%, as well as Zemgale and Latgale with 8%, but the smallest part is made by Vidzeme with 7% of the GDP of Latvia.

To characterise and compare the social economic development in Latvia, a special region development index is used, which is a synthetic indicator that summarises indicators of particular territory groups, and it characterises the level of the territory development. It is calculated on annual basis.

According to the changes in the territory development index from 2002 till 2007, at regional level in Latvia, Riga showed good development dynamics, improving the good development index value (see Table 2). As the data summary for 2006 and 2007 indicates, the negative value of the territory development index slightly improved in Vidzeme, Zemgale and Latgale, though it was decreasing every

Table 2

Development index of the regions of Latvia in 2002-2007

Region	Riga	Kurzeme	Zemgale	Vidzeme	Latgale
2002	0.909	-0.303	-0.440	-0.835	-1.257
2003	0.975	-0.429	-0.469	-0.885	-1.31
Changes in 2003/2002	0.066	-0.126	-0.029	-0.05	-0.053
2004	0.995	-0.428	-0.533	-0.895	-1.339
Changes in 2004/2003	0.02	0.001	-0.064	-0.01	-0.029
2005	1.003	-0.431	-0.590	-0.877	-1.346
Changes in 2005/2004	0.008	-0.003	-0.057	0.018	-0.007
2006	1.011	-0.520	-0.574	-0.851	-1.341
Changes in 2006/2005	0.008	-0.089	0.016	0.026	0.005
2007	0.999	-0.647	-0.516	-0.853	-1.267
Base increase 2007/2002	0.090	-0.344	-0.076	-0.018	-0.01

Source: author: State Regional Development Agency, (2009) and author's calculations

year before that. Whereas in Kurzeme the negative value of the territory development index did not change, in the middle of the studied period, but it significantly dropped at the beginning of the period and over the last year. Comparing the values in 2002 and 2007, it can be observed that the value of the territory development index has increased only in Riga, whereas decreased in other four regions of Latvia. Differences in the social economic development of the planning regions have slightly increased over the five years, which is proved by the difference of the territory development index of the least developed Latgale region from the stronger Riga region. Based on the performed data analysis, it can be observed that the difference between Riga and Latgale was 2.166 in 2002, but it was 2.226 in 2007.

It has to be concluded that the overall tendencies in the country indicate that significant social economic differences between various territorial parts of the country exist in Latvia and have been preserved for a long time. The development dynamics of the last year indicators prove that Kurzeme is strengthening its position of the second strongest region, approaching Riga. Vidzeme has also outpaced Zemgale in several indicators over the last years although the development level of these two regions does not significantly differ. Several development indicators of Latgale (GDP, development index) indicate to a slight positive development dynamics; however, differences with other regions are significant.

2. Use of the assets of the EU funds in the regions of Latvia

Since Latvia's accession to the EU, the amount of the EU Funds that has flown into Latvia, mainly supporting the set priorities for the 2004-2006 planning period, comprises more than LVL 1 billion or on average 2% of the respective period GDP of the country. Over the given period, the EU funds supported Latvia with four financial instruments or funds – European Regional Development Fund (ERDF), European Social Fund (ESF), European Agricultural Guidance and Guarantee Fund (EAGGF) and Financial Instrument for Fisheries Guidance (FIFG).

In the period 2002 - 2007, the approaching of social economic development level of Latvia, including its regions to the EU level is clearly observed. Comparing with EU average indicators, GDP per capita made 41.4% in Latvia in 2002, but in 2006 it was 58.9% of theEU-27 level. In the period 2002-2004 Latvia approached the EU-27 level on average by 2 percent points, but in 2005, 2006 and 2007 it managed to lower the underdevelopment from the average level of the EU Member States by 4 percent points a year (Region Development in Latvia, 2008). The findings of the EC study from 1986 till 1996 also indicate that the GDP of the 10 poorest EU regions has increased from 41% of the average EU GDP to 50% over this period. In addition, over this period, the GDP grew considerably in the four poorest EU Member States – from 65% to 75% of the EU average. It is difficult to determine how big part of this increase is the result of closer economic integration and how big is the contribution of EU funds, but EC assumes that approximately half of the praise of this increase should go to the Structural Funds (Braun, 2002).

Based on the EC normative regulations, Latvia receives the assets EU funds as one region – state, not as separate its regions, as it is practised in most of the EU Member States. The 2004-2006 planning period finished on June 30, 2009. Currently it is already possible to start evaluating the achieved over the previous five years and to what extent the EU funds resources have met the set basic goal – to reduce social and economic differences between the EU regions, namely, to draw nearer the social economic indicators of Latvia, including its regions, to the average EU level.

Three main targets were set for acquiring EU funds in the 2004-2006 planning period: development of competitiveness and facilitating employment, development of human resources and infrastructure. Based on these targets, five priorities were determined:

- Priority 1: Facilitating balanced development (ERDF financing)
- Priority 2: Facilitating entrepreneurship and innovations (ERDF financing)
- Priority 3: Human resource development and facilitating employment (ESF financing)
- Priority 4: Enhancing agriculture and fishery development (EAGGF and FIFG financing)
- Priority 5: Technical support (ERDF and ESF financing).

Table 3 summarises the distribution of public financing of priorities among the regions of Latvia. As it can be observed, 3% of the financing was allocated to national scale projects – these are projects in the measures all of which are classified as national scale measures and also national scale projects are implemented in part of the territorial measures (result will have a positive impact on the entire country's territory). When analysing Priority 3, which was financed from ESF resources and directed at investment in human resources, it can be observed that 6% of the total priority financing is invested in national scale projects. When comparing the distribution across the regions, Riga occupies the front with 31% of Priority 3 financing, Latgale follows with twice less financing (17%). The financing for Zemgale and Kurzeme in Priority 3 is 16% and for Vidzeme – 14% of the financing allocated for Priority 3.

Performing the analysis of the public financing allocated for the EU funds projects according to the place of funding allocation, the author concludes that Riga has received 50% of all EU funding from 2004 till 2009. Latgale has received the least part of financing (10%), but the other resources have been almost equally split between Zemgale (12%), Vidzeme (12%) and Kurzeme (13%).

Table 3

Distribution of the allocated public financing* in the regions of Latvia, ths. LVL on 30.06.2009

	Riga	Kurzeme	Zemgale	Vidzeme	Latgale	National scale projects	Total
Priority 1	216 120	48 872	42 553	49 845	44 981	10 273	412 644
Proportion%	52	12	10	12	11	2	100
Priority 2	539 629	68 902	71 542	72 928	48 897	25 568	827 466
Proportion%	65	8	9	9	6	3	100
Priority 3	135 741	70 111	68 237	62 902	72 537	28 205	437 733
Proportion%	31	16	16	14	17	6	100
Priority 4	118 525	85 095	55 961	59 197	36 771	2 636	358 185
Proportion%	33	24	16	17	10	1	100
Priority 5	17 882	459	481	418	533	440	20 213
Proportion%	88	2	2	2	3	2	100
Total	1 027 897	273 439	238 774	245 290	203 719	67 122	2 056 241
Proportion%	50	13	12	12	10	3	100

Source: Data of EU Structural and Cohesion Funds Management Information System on 07.11.2009. and author's calculations

*Public funding – EU Structural Funds financing + national financing

The information summarized in Figure 1 presents a direct correlation between the amount of financing and the territory development index – the higher the social economic development index of the territory, the larger the attracted amount of financing. The distribution of EU funds across various parts of the territory corresponds to the strategy the country adopted for 2004-2006, namely, facilitating the overall country's competitiveness and growth and investing in those industries and territories the use of which would give the fastest effect on the economic growth of the country. Respectively, as the strategy for acquiring funds did not set any specific objectives for the development of particular territories or a balanced distribution of financing, the EU funds investment has been attracted to those territories where their yield could be the largest or where the absorption capacity has been the highest.

3. Assessment of the EU funds in relation with economic indicators in the regions

The author uses the public financing per inhabitant allocated for the EU funds projects as another indicator of regional effect of the distribution of the assets EU funds, as it can be considered a more objective

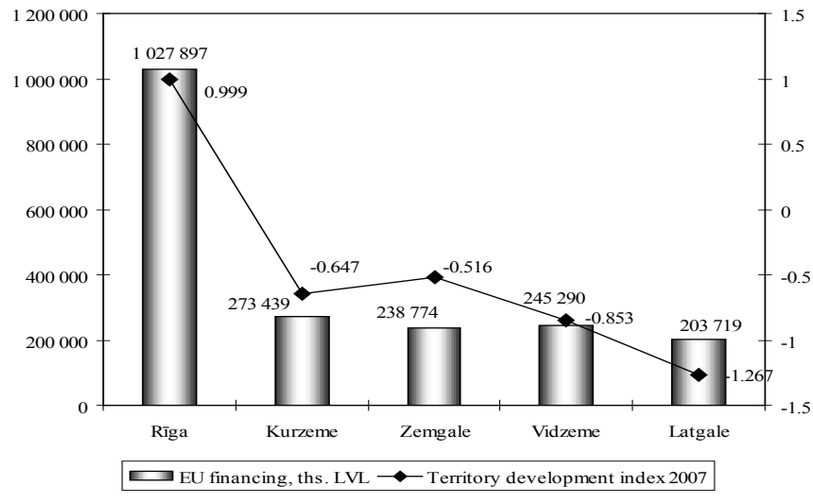

Figure 1. The public financing allocated for the EU funds projects in the regions of Latvia and the territory development index.

Source: Data of EU Structural and Cohesion Funds Management Information System on 07.11.2009. and author's calculations

Table 4

Public financing per inhabitant allocated for EU funds projects as distributed across the regions of Latvia (2004-2008) on 30.06.2009. (LVL)

	Riga	Latgale	Zemgale	Vidzeme	Kurzeme	Latvia
Public financing of EU funds	936	585	842	1 031	901	905
Proportion of EU funds/ inhabitants in the region	1.03	0.65	0.93	1.14	0.99	1

Source: Statistics Bureau of Latvia, (2009) and author's calculations

Table 5

Proportion of the EU Structural Funds in comparison with the proportion of income produced in the regions

	Riga	Kurzeme	Zemgale	Vidzeme	Latgale	Total
Proportion of regional income from the total income in Latvia (data of 2007)	66.7	10.3	8.1	6.7	8.2	100
Public financing of EU funds	53	13	12	12	10	100
Proportion of EU funds/income	0.8	1.3	1.5	1.8	1.2	1

Source: Ministry of Finance, Central Statistics Bureau, 2008 and author's calculations

comparison of regions (see Table 4). The number of population in 2008 was taken as the basis. After performing calculations and analysing data, it can be observed that Vidzeme has the highest indicator – LVL 1,031, which is followed by Riga and Kurzeme (LVL 936 and LVL 901 respectively). In Zemgale the EU funds financing per inhabitant is LVL 842, but the markedly smallest financing is for Latgale (LVL 585). The difference between the highest and the lowest indicator is 1.8 times.

Comparing the proportion of the assets of the EU funds allocated for a particular region with the proportion of the population in the respective region (see Table 4), the author analyses and relatively determines which regions have gained and which have lost. The result below 1 reflects the redistribution of funds resources against the benefit of the respective region, whereas the result above 1 indicates that the region has received more resources if compared to its number of population. It is possible to observe that Latgale and Zemgale were relative "losers" while Riga and especially Vidzeme were "winners".

When analysing the assets of EU funds according to the income produced by the respective region, another indicator of characterizing was created. As a result of this calculation, a very uneven distribution was achieved (see Table 5).

The data summarised in Table 5 indicate that resources were redistributed from Riga for the benefit of the rest of the regions, especially Vidzeme and Zemgale, which were the biggest "winners". Vidzeme and Latgale have received twice as much as in case the resources had been distributed according to the relative income.

Conclusions

1. The dynamics of the development of the indicators over the last years indicate that Kurzeme is strengthening its position as the second strongest region, approaching Riga. Vidzeme has also outpaced Zemgale on several indicators over the last years. Several development indicators of Latgale (GDP, development index) indicate to a slight positive development dynamics; however, the differences with other regions are significant. Common tendencies in the country indicate that considerable social economic differences between various parts of the country's territory exist and have been preserved for long time in Latvia.
2. Analysis of acquiring EU funds in 2004-2006 indicates that the distribution of EU funds across the regions is not even. The biggest proportion of the assets of EU funds is concentrated in Riga – 50% or LVL 1,027.897 thousand, but the smallest – in Latgale – 10% or LVL 203,719 thousand.
3. A direct correlation between the amount of financing and the territory development index can be observed – the higher the social economic development level of the territory, the bigger the amount of the attracted financing.
4. 6% of Priority 3 funding, which was financed from ESF resources and which facilitates human resource development, is invested in national scale projects the result of whichwill have a positive impact on the entire country's territory. Distribution across the regions in this Priority puts Riga in front with 31%, Latgale follows with twice less financing (17%), Zemgale and Kurzeme has 16% and Vidzeme has 14% of the financing allocated to Priority 3.

5. Analysis of the public financing allocated for the EU funds projects per inhabitant indicates that resources were redistributed from Riga for the benefit of the rest of the regions, especially Vidzeme and Zemgale, which were the biggest "winners". Vidzeme and Latgale have received twice as much as in case the resources had been distributed according to the relative income.
6. The strategy for acquiring EU funds for 2004-2006 did not set specific objectives for the development of particular territories or for a balanced distribution of financing, thus the investments of EU funds were attracted to the territories where their yield could be the largest or where the absorption capacity was the highest. Distribution across the various parts of the territory corresponds to the strategy the country had chosen, namely, facilitating the overall competitiveness and growth of the country and investing resources in those industries and territories where their use would give the fastest impact on the growth of the country's economy.

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STRATEGIC APPLICATION PRINCIPLES OF ENERGY RESOURCES FROM HEAT SUPPLY MERCHANT VIEW POINT

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Abstract. The study was accomplished in 2010. The applied research methods are based on the analysis of the studies by other authors, industry experts, statistic data and the (unpublished) information provided by the Latvian district heating merchant "xxx". Spearman's rank correlation coefficient was used for evaluating data regularity.
In 2020 the energy produced from renewable sources (Directive 2009/28/EC) in total energy consumption in Latvia has to reach 40%. Such an objective can be achieved by promoting the use of biomass at cogeneration (CHP) plants, the potential of which is the district heat supply system. Wood as an energy resource in its structure accounts for only 25-30%; therefore, the primary condition is the introduction of modern technology which would provide the possibility to diversify energy resources.
The calculations confirm that the realised amount of thermal energy indirectly affects profit; directly it is affected by the rate of thermal energy, so the structure of use of energy in heat supply enterprises is associated with lowering the cost of (restrictive) factors - the energy cost, specific production technologies, energy efficiency. Currently, the primary condition of heating companies is to find such energy resource(s) to ensure the approved schedule of temperature and thermal load. The next determining factor is the energy price.
In assessing the factors that will affect energy usage in the future, the main strategic principle of energy consumption will be linked to limiting the growth or even reducing heat tariff, by realising optimal efficiency and minimal environmental pollution during energy transmission.
Key words: Energy, district heating, energy resources, the strategic principles.

Introduction

Climate change, a limited amount of resources, an increasing competition and pricing, as well as political conflicts have influenced the increasing importance of energy in the European Union, which takes a leading role in sustainable policy making (Sprūdis et al., 2009).

During the period until 2008, the European energy policy was aimed at certain sectors - support renewable energy, cogeneration, market liberalisation, energy efficiency, etc. In 2009, the Third energy package was developed, in which the current Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC is the first attempt of the European Union at creating a comprehensive legal framework for renewable energy promotion in key energy sectors. This Directive in the European Union in 2020 implies the increase in the share of renewable energy in total energy consumption by 20% by stating its goals to be achieved (The Renewable Energy…, 2009).

In assessing the studies developed by the European Union "European Energy and Transport Trends to 2030-Update 2007", "Renewable Energy Technology Roadmap 20% by 2020" and Latvian developed research "Evaluation of the Usage Potential of Renewable Energy Sources in Latvia Until 2020", the authors concluded that in Latvia the emphasis of 2020 on the target - 40% renewable energy in total energy use - is associated with the potential of biomass and wind energy (Capros et al., 2008; Renewable Energy Technology…, 2008; Atjaunojamo energoresursu izmantošanas…, 2008).

The widest possible use of biomass in Latvia is the district heating, since it accounts for approximately 65% of the total heat load (about 70% of the district heat consumers in the household), while heat production is used for more than 30% of the Latvian annual energy consumption. District heating is associated with a decentralised energy production, local energy supplies and extensive cogeneration opportunities (Latvijas ilgtspējīgas attīstības…, 2009).

However, in order to assess the practical use of renewable energy in district heating plants, the strategic use of energy principles which determine the choice of heat production should be determined.

Hypothesis: Energy conditions for the use in district heating are primarily based on the strategic aspects of the use rather than accessibility.

Research aim: Identify the strategic principles of energy use in district heating in commercial activities.

Research tasks:

1. To evaluate heating in Latvia and energy used in its manufacture.
2. To determine profit-making principles from the heat operator's point of view, summarise the factors that determine heat production of the energy mix.
3. To create a combination of factors that will determine the strategic use of energy.

Materials and Methods

Research methods used in the paper: analysis, synthesis and monographic research method in analysing the research of other authors. Spearman's rank correlation coefficient $r_S = 1 - \frac{6 * \sum_{i=1}^{n} (X_i - Y_i)}{n(n^2 - 1)}$

was used for evaluating data regularity. A graphical method for statistical display of data and a model design were used. The study was accomplished in 2010. It is based on the analysis of studies by other authors, industry experts, and information published by the Central Statistic Bureau of the Republic of Latvia and the (unpublished) information provided by the Latvian district heating merchant "xxx".

Results and Discussion

1. Heat energy consumption and its production

Latvia is located in the climatic zone, where the heating season lasts more than six months, lasting an average 200 to 210 days, so this steam is one of the major components of Latvian energy (Vīgants, 2010).

The study "Evaluation of the Usage Potential of Renewable Energy Sources in Latvia Until 2020" explains the thermal energy consumption trends. The study concludes that the main factor influencing the consumption is thermal climatic conditions (average temperature). By contrast, factors such as gross domestic product (GDP), population and energy consumption intensity of heat affect it indirectly. The fact above explains the Figure 1. Heat energy consumption changed during the period when the Latvian economy experienced rapid annual GDP growth, but the heat consumption did not increase (Atjaunojamo energoresursu izmantošanas…, 2008).

Based on the Latvian District Heating association collected data (within 95% of the Latvian district heating merchants), the production of thermal energy is very different in several ways:

- In district heating overall proportion, wood compiles ~ 30%, but natural gas ~ 62%;
- In local and individual heating overall proportion, wood compiles ~ 55%, but natural gas ~ 25%;
- In boiler houses and cogeneration (CHP) cycle overall proportion, wood compiles ~ 18%, but natural gas ~ 82% (Siltumapgāde Latvijā, 2009).

Furthermore, the distribution of wood at district heating plants is not the same. Latvian regional averages of the total district heating consumption of wood are used most: 38% in Vidzeme, Kurzeme - 22%, Latgale - 21%, Riga region - 7%, and 7% in Zemgale. Described situation is explained by the natural gas supply system - in areas with no access to natural gas pipeline, wood is primarily used (Vīgants, 2010).

In assessing the share of CHP heat production (see Fig. 1.), it can be concluded that the upward trend is positive (regardless of the energy type, since a reduction in energy consumption compared to, where the heat and electricity produced in isolation, hence the emission reduction), with different authors' study of the potential of CHP cycle is directly related to heating systems. Some of the studies in which it is highlighted:

- "Latvian Sustainable Development Strategy until 2030 Project" concluded that the major energy and cogeneration possibility is the district heating supply (Latvijas ilgtspējīgas attīstības…, 2009).
- "Energy Efficiency Improvement of Heat Supply Business Opportunities" concluded that district heating is the most effective way of heating to justify a decentralised production of energy diversification opportunities and potential cogeneration (Turlajs et al., 2009).
- In 2008, Communication from the Commission to the European Parliament and the Council "Europe can Save More Energy by Combined Heat and Power Generation", has highlighted that the cogeneration technology is very effective and optimal for usage at the district heat supply (Communication Europe can…, 2008).

Assessing the use of wood and cogeneration development potential, it is concluded that the primary condition is advanced technologies for district heating, thereby using more energy range and with varying costs. The statement above is the fact of the Latvian

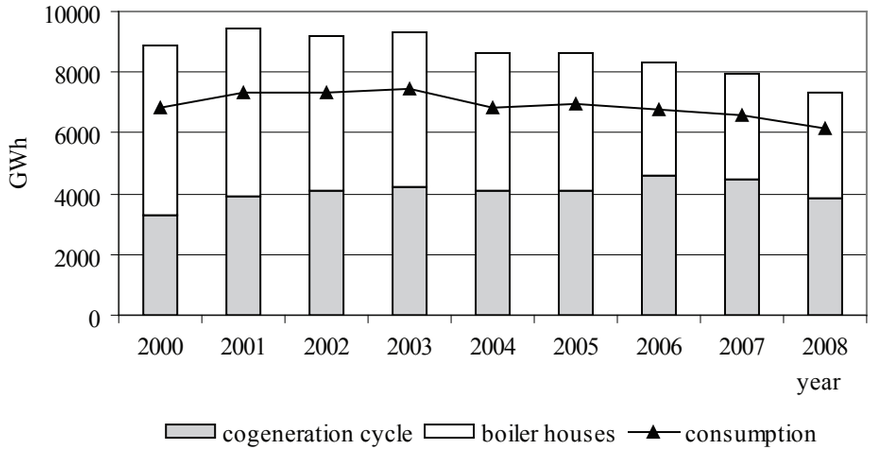

Figure 1. Produced heat in boiler houses in Latvia and cogeneration cycle and heat to the final consumer trend (GWh), 2000-2008.

Source: Created by the authors, based on Elektroenerģijas ražošana, imports …, 2010

district heating comparison with Finland, where the cost of heat to the final consumer is on average 45.6 EUR MW h^{-1} (calculated 32 LVL MW h^{-1}). In Latvia such heat rate in 2009 was only in 5% of the companies forming part of Latvian District Heating association (Vīgants, 2010).

On the other hand, the Latvian District Heating association indicates that a large part of the heating companies have already fulfilled all the prerequisites for increasing the energy efficiency requirements (at current energy type). New energy efficiency opportunities from heat business standpoint are possible only by changing the heat sources and switching to the production of the cogeneration cycle which requires substantial investment (Ratniece-Kadeģe, 2009).

2. Effects of realised amount of heat on profit

Both the Latvian District Heating association enterprises and Farmers' parliament in their studies point to the positive usage experience of the Scandinavian fluidised-bed boilers, since their efficiency is even drawn up to 80-85%; moreover, it allows the use of all forms of biomass and its blends (Vīgants, 2010; Atjaunojamie energoresursi Latvijā…, 2008).

Based on the above mentioned, for the mathematical statistical calculation the Latvian heat company is chosen where such a boiler for heat production is used. Table 1 represents data from the chosen Latvian district heating company's economic activity in an eight year period.

As shown by Latvian District Heating association enterprises, additional profit increase can be realised via the amount of heat only at low temperatures when the heat consumption is increasing (on the condition that the rate of thermal energy covers the cost of production) (Siltumapgāde Latvijā, 2009).

For the proof or rejection of that argument, the mathematical statistical method is used - Spearman's rank correlation coefficient.

The estimated coefficient (r_s = 0.29) indicates that there is a weak positive correlation between the amount of heat energy and the profit (see Formula 1.). However, using the SPSS computer program, calculated correlation coefficient of reliability test p-value (0.493) is greater than 0.05; therefore, the probability of P 0.95 shows that the relationship between the realised amount of heat and profit does not exist (maximum likelihood, which can be assumed that such a correlation exists, however is 0.507). Calculations show that the increase in company's operating revenue can not be directly linked with the consumption of heat provided. Therefore, it can be argued that the profit growth, based on heat consumption, can be ensured with temperature lowering.

In assessing the situation in more detail from the district heating company's point of view, it is possible to argue that the correlation between the amount of consumed heat and profit is not only decreasing temperature and increasing heat consumption. Heat volume and profit are the unifying factors for the transmission losses. Rate of thermal energy includes heat transmission losses; however, increasing the amount of heat, decreases the percentage of losses (physical losses do not change) because they are

Table 1

Realised energy and profit of heating enterprise "xxx", 2002 – 2009 (Calculations of Spearman's rang correlation)

Year	Realised heat, MWh (X)	Profit, LVL (Y)	Rx	Ry	$(Rx - Ry)^2$
2002	56110	-132368	6	6	0
2003	56065	+93884	7	2	25
2004	55865	-127841	8	5	9
2005	57995	-62349	4	4	0
2006	59593	+87207	2	3	1
2007	57785	-227966	5	8	9
2008	58611	-181300	3	7	16
2009	59664	+168177	1	1	0
				Total	60

Source: Calculations by the authors, based on data from the Latvian district heating enterprise "xxx"

Calculations:

$$r_S = 1 - \frac{6 \cdot 60}{8(8^2 - 1)} = 0.285714 \qquad (1)$$

Where:

r_s - Spearman's rank correlation coefficient
n - number of observations
x - sign of factorial
y - tangible sign of

Source: (Paura and Arhipova, 2002)

calculated as the difference between sold and produced heat. The transmission losses are directly dependent on the heat supply temperature and indirectly dependent on the heat flow - the higher feed temperature, the greater the losses - this can be explained by the loss of heat absorbed by the mines, land etc (Sabiedrisko pakalpojumu tarifu…, 2001).

Based on the fact that the amount of realised heat indirectly affects the profit, but directly affects the heating rate, which has borne the cost of production, the company used structure of primary energy may be correlated with heat production cost restrictive (reducing) factors. The relevant factors are used in energy cost, production technology specific characteristics depending on the required heat load and energy efficiency measures which reduce heat transfer losses. This factor is the variation of the limiting factor of the investment that the company can afford to invest in heat sources and heat systems.

The specific unit of heat consumption (see Fig. 2.) in the company is the approved temperature schedule and the load of heating main (flow) which determines heat supply temperature depending on the environmental temperature and the heat load of building.

In contrast, the temperature schedule assurance is a key energy resource (see Fig. 2.), whose processing heat sources are capable of providing the required heat supply temperature. If the required temperature schedule can be achieved by both natural gas and wood chippings, the next determining factor is the energy price, whichever is of a lower production costs.

Heating and hot water supply to the technological conditions require that the supplied heat at the same time provides the building with heat and hot water. During heating season, the company needs to provide heat, which is sufficient for both hot water heating and heating systems to ensure temperatures. In contrast, during the summer season, providing hot-water heating requires significantly less heat load, which creates the company's need for multiple heat sources with different production capacity.

3. Strategic use of energy principles (future situation)

Due to environmental improvement and primary fossil fuels (natural gas) reserves limitations, heating companies in the future will need to restructure the production of thermal energy, replacing natural gas entirely with renewable energy sources. The strategic setting of energy conversion will be carried out with optimal efficiency and minimal environmental pollution.

Significant is the fact that the substitution of fossil fuel in heating plants (despite the financial opportunities) has to be associated with both the available energy resources and consumer's needs. To specify the future factor cluster of heating enterprise that will influence the strategic use of energy, the cluster has to be divided into three categories (see Fig. 3.) and each category has to be examined separately, according to the processes in the energy sector and the economic situation in the country.

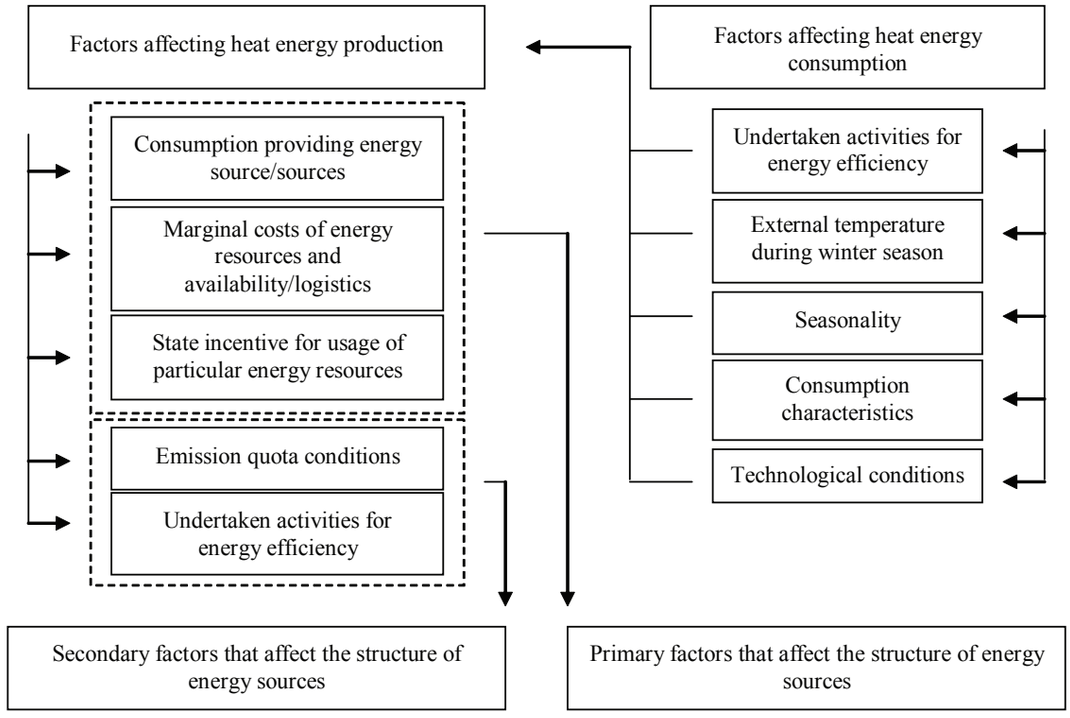

Figure 2. The factors affecting heating enterprises "xxx" structure of used energy.

Source: Created by the authors

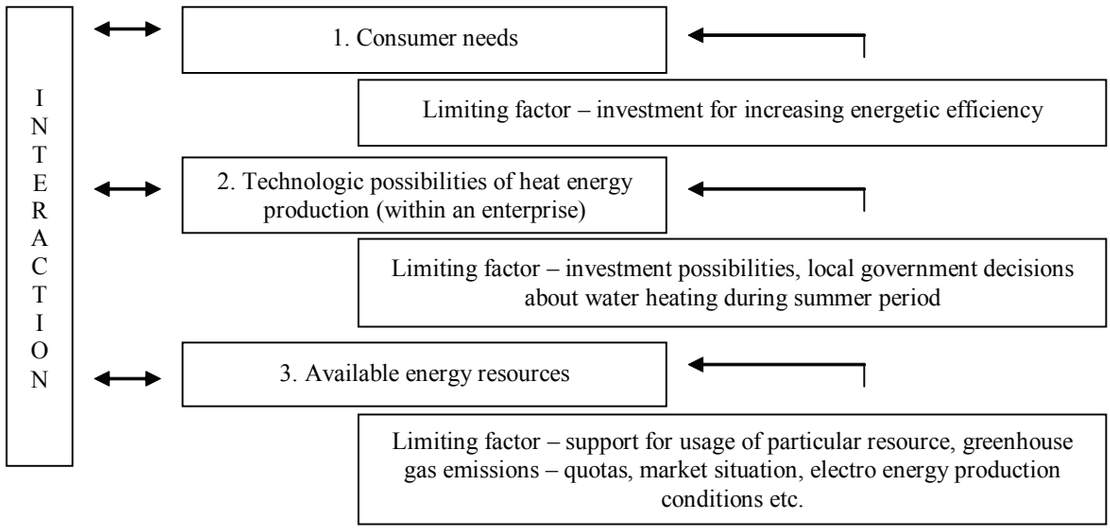

Figure 3. Aggregate factors that will impact the strategic usage of energy resources in heat supply enterprises in future.

Source: Created by the authors

Specifying the group of future factors (see Fig. 3), it is possible to calculate a future outcome.

1. Consumer needs: rate of thermal energy in recent years has risen faster than personal income levels. On average, the population spends 20 - 30% of their income (the poor more) on the heating payments in winter. The situation requires the buildings to reduce energy consumption from an average of 200 to 250 KWh m^{-2} to 150 KWh m^{-2}; thus, thermal energy consumption could be reduced by 20 - 25%, followed by the final heat of charge reduction (the reduction in consumption at the expense of) (Latvijas Republikas Pirmais…, 2008).

On the basis of current discussions on the energy efficiency factor of the importance and economic situation in Latvia, one can conclude that the population with such funds is not present. Consequently, it can be predicted that consumer heat demand needs will not change significantly in the coming years (3 to 5 year period). The total energy in the context of district heating companies will be the key to ensuring that the difference between the thermal energy available to the consumer price and the price of electricity is greater than 15 - 20%. If the electricity becomes cheaper than heat, mass-residents might start using electricity for hot water heating and heat provision (Akermanis, 2008).

Latvia will not be able to provide internally-based power capacity, import of electricity or basic power generation (including cogeneration promotion) in high electricity price (support for electricity produced from renewable sources).

2. Technologic possibilities: online heat tariff components can be comprehensively divided into three groups: heat production, distribution and marketing expenses. Fuel costs for heating tariff accounts for 60 - 70% depending on the energy resource used. In case if a rate of thermal energy does not cover the cost of heating and heating company has no spare cash, it is possible to vary only the remaining 30% of the factors affecting heat tariff (staff salaries, repair costs and electricity costs) to cover energy costs (Akermanis, 2008).

Moreover, at least four months are required to approve a new tariff of heat (if it has not been confirmed in tabular form) (Par sabiedrisko pakalpojumu…, 2001).

Therefore, from a technological point of view, the primary requirement is to reduce energy costs in the overall heat tariff. The condition is also important from the standpoint of debtors, because not in all cases the payment for the heat is settled by building management. Heat distribution cost reduction can be achieved by increasing the energy efficiency in heat transfer tracks. Heating companies attracting outside funds and investing in heat transmission run in the reconstruction, reduce heat tariff (tariff would be included in interest payments on borrowed capital, and reduced heat transfer loss of interest) and accounts receivable. By contrast, funds would be re-earned on average in 20 to 25 year period, so now the company is more efficient to operate the existing transmission heat loss (in any case it will be 10 - 12%) and accounts receivable, rather than get in debt with raising capital for 20 years.

3. Available energy resources: most experts consider that the oil peak will be reached within the next 10 years. The biggest unknown will be linked to the fair determination of the extent of oil reserves. About 10 years after reaching the peak of oil production it is expected to culminate in the extraction of natural gas (Strautiņš, 2008).

In assessing the wood chippings as a renewable energy opportunities for Latvian energy, its production potential is very large (virtually unlimited), and the government's guidelines do not provide additional wood chippings for other energy purposes. Heating traders can plan that the wood chippings cost increases will continue to be gradual (Siltumapgāde Latvijā, 2009).

Conclusions

1. District heating not only has a potential opportunity for the usage of extensive biomass and cogeneration, but also needs new technology which will enable to vary the energy sources.
2. Realised amount of thermal heat indirectly affects the operator's profit, but directly affects the rate of thermal energy, since the structure of primary energy use should be associated with heat production cost restrictive factors.
3. Hypothesis is proven, because:
   - key factor in the energy mix is the temperature schedule and the thermal load-providing resources (larger role of technological, not economic factors);
   - the main strategic principle in the future – district heating enterprises will have to use energy resources with optimal efficiency and minimal environmental pollution.

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IDENTIFICATION AND APPLICATION POSSIBILITIES OF TOURISM SYSTEM MODELS IN REGIONS

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Abstract. Systemic view on tourism as an economic activity is the best way how to characterise an economic nature of this industry. The paper presents the methodology which integrates the system approach and other research methods of social sciences; this methodology forms the basis for identification of social agents and models of tourism system. The methodology is approbated in the survey of providers of rural tourism services in Zemgale planning region. The research results are useful in future application of models for development of tourism whereas the models are useful for other purposes: they can provide additional information necessary for evaluation of tourism influence on economy. They form a basis for detecting participants in tourism clusters in regions and for evaluation of cooperation between social agents of public, nongovernmental and private sectors, and as an instrument in tourism marketing strategies
Key words: tourism, system, social network, cooperation models.

Introduction

Since the role of the tertiary sector in the economy of industrial states is growing, interest about tourism is also increasing. Development of tourism in any particular state is based on natural and manmade resources which form a tourism offer and infrastructure. Development of tourism in Latvia is one of the potentialities of globalization of the economy that should be used more extensively. This can extend potentialities of economic growth of the state as well as promote harmonious regional development. Tourists are mainly interested in the regions where initial offer is improved with additionally developed offer, which in turn can becom an attractive and specific tourism product of a particular region if creation of this product is based on cooperation. Possibilities to promote cooperation are better visible when treatment of tourism industry is based on a systemic approach.

Tourism definitions embrace all the possible forms of tourism phenomenon and their analysis allows concluding that tourism is a complex phenomenon having many dimensions and social agents such as organizations and individuals, which cooperate in realization of all tourism forms.

The object of the paper is to show how to identify cooperation models in tourism by integrating tourism theories and methodological approaches of social sciences and what are application possibilities of tourism system models for development of tourism in regions.

Materials and Methods

The methodology for identification of the models of tourism systems is based on scientific research principles: system, determinism, and unity between theory and practice in the research. Unity of theory and practice becomes apparent as an opportunity to apply theoretical system conditions in investigation of a particular situation. For identifying the tourism system models, a system approach towards tourism industry, social network analysis and standardised interviews as a method of data obtaining was integrated successfully.

System approach in tourism industry. The concept of the system and systemic treatment of different issues is used in all contemporary sciences including natural, technical, arts and social sciences. Also economic theory elaborates logical systems that embrace schemes comprising explanations of economic reality. Instead of giving ready-made opinion, economics provides methods and techniques that allow interpretation of data and developing correct conclusions. A system is a unified entity of interrelated interacting elements having characteristics, which are inherent for any element separately (Līdumnieks, 1994; Тихомиров, 1996). Plurality of systems that are widespread in a society is based on characteristics of material environment as well as expression of conscious human activities (Пудич, 2006). Different notions about systems form an understanding about structural elements of a system which are parts, elements, components. In social sciences for characterizing cooperation and other processes in a system the concept of element is frequently replaced by the concept of *social agent*. Wasserman and Faust define social agents as separate individuals, corporative and collective social units (Wasserman and Faust, 1994). Accordingly to Inverno and Luck, organizations and enterprises are also social agents having relationships that may lead to the particular result in case of successful management and development (Luck, 1995).

System functioning is based on cooperation. Theoretical aspects of cooperation are analysed by Fyall and Garrod. These authors have elaborated their theory by integrating ideas of Himmelman, Crott, Haywood and Murphy, which focus on an expression of cooperation. Cooperation means information exchange that leads towards mutual benefits, common stakeholder activities that are directed towards allocation of resources and meeting common aims (Fyall and Garrod, 2005).

In order to show diversity of tourism, many authors in their works considertourism a heterogeneous activity (Halloway, 1994) viewing it as a system; however, the notion of system is developed by different approaches. One of the approaches emphasizes aspect

of geographical environment of tourism or regional aspect in description of tourism system. The concept of tourism region to characteriz tourism system is used by Gunn, Leiper, Miller, Kabushkin. Tourism regions are viewed similarly like geographic space where cooperation takes place between hospitality enterprises, infrastructure, industry, producers and organizations. The authors use different approaches to characterize social agents. Leiper believes that tourism system consists of five elements: tourists, three geographic regions (tourist generating regions, tourist routes, and tourist destination regions), and producing elements which form tourism industry. Gunn believes that tourism spatially involves three elements: (1) tourist generating regions, which are basis for tourism market, (2) tourist destination regions as a place for entrepreneurship in tourism industry, and (3) transit routes that are emphasized as places which are organized in a way that attracts tourist attention and therefore is a very important element in geographical tourism system (Leiper, 2005).

The second approach in tourism theories is mainly related togeneral characteristics of tourism industry and tourism multiplicative impact on other economic activities. This approach is acknowledged, for example, in writings of Pompl, Halloway, Kabushkin, Kvartalnov, Birzakov. Kvartalnov's main point of view about tourism industry forms a detailed system where cooperation takes place between social agents involved in tourism and representing tourism firms, possible services; interaction between tourism and other economic activities is regulated by demand and offer (Figure 1.).

Kvartalnov also defines tourism economy as a system. Tourism economy represents a system of relationships that have been formed within processes of production, allocation, exchange, consuming in tourism industry (Квартальнов, 2003). Birzakov defines tourism industry as a system that mutually relates enterprises and entrepreneurs providing tourists with all tourism services and goods necessary for tourism processes (Биржаков, 2003). Pompl defines tourism as the system that consists of two subsystems (nuclear systems and a subsystem (Pompl, 1996), which involve different social agents, and external environment of the system:

1) nuclear system - enterprises of rural tourism, tourism agencies, tourists,
2) subsystem – providers of services, suppliers, attractiveness, institutions,
3) external environment of the system – society, economy, politics, and nature.

Accordingly to Kabushkin, the tourism system is formed by two subsystems: the tourism subject and the tourism object. The tourism subject is a traveller or in other words, a participant of tourism process, which seeks opportunities to satisfy his or her needs by purchasing tourism services. The tourism object includes all tourism services that can become a destination for the tourism subject during a trip. Kabushkin also distinguishes external environment of tourism region: economy, nature, politics, and society (Кабушкин, 2001).

Detailed mechanism of how tourism system develops can be explained on the basis of theoretical conceptions of tourism product. Durovich emphasizes the main traits of contemporary tourism as a system with specific tourism marketing and looks at tourism and tourism product, services and organization of production. The system of tourism industry involves

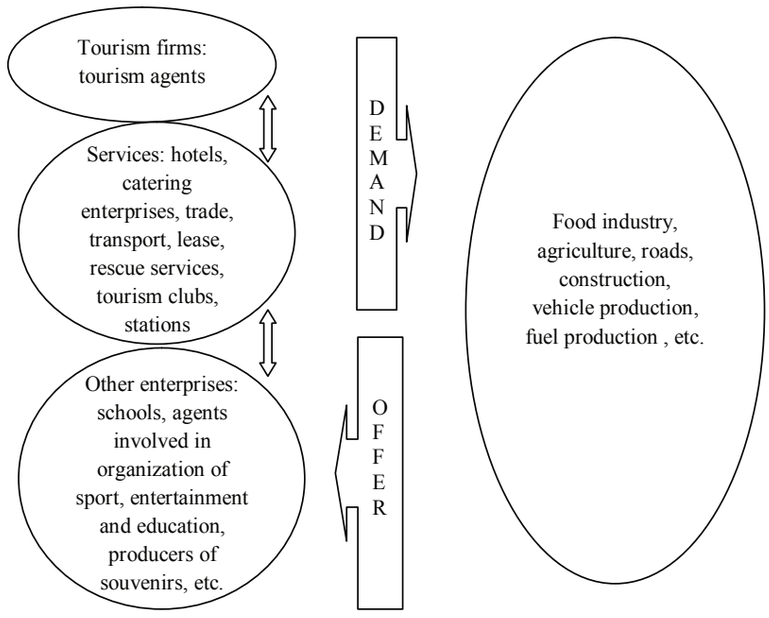

Figure 1. Tourism system.

Source: Developed by the author and based on Кварталнов, 2003

specialized enterprises, organizations and institutions (Дурович, 2008). Also Birzakov shows, which social agents are involved in creation of tourism product. In his writings the author combines both a very traditional way which is related mainly to preparation of special undertakings and objects for tourism purposes, and other tradition that emphasizes the role of social agents, which are related to knowledge, organizational and legal environment, and personnel training system (Биржаков, 2003).

Systemic view on the economic essence of tourism product as well as previously overviewed theoretical models of tourism system allows making a following statement: the process of creation of tourism product is a central activity of the tourism system, which has impact on involvement of other social agents in creation of tourism product. Tourism systems are not created; they develop when tourism product is created during the cooperation between social agents directly or indirectly involved in the industry.

In the narrow sense of the term, creation of tourism product can be viewed in relation with a presence of tourism resources. Interests of travellers and travelling motives are basis for development of systems of tourism regions. When various tourism resources are allocated in a particular territory, this is an opportunity to develop appropriate kinds of tourism with specific tourism products, for example, culture tourism, rural tourism, etc.

Social network method. Social network analysis is distinctive perspective in researches of social and behavioural sciences, because it emphasizes relationships of interacting social agents. This approach investigates social relationships between individuals, organizations or other social agents, which are connected with social ties (Wasserman and Faust, 1996). Social networks are relationship networks within community or outside it between individuals and organizations. Dyadic social relationships (between two actors), triads (three actors and their relationships) and larger social groups (subgroups of wider social network) are investigated most frequently. There are two types of network analysis: ego network analysis and complete network analysis. Both types differ in ways of obtaining data. In complete network analysis the researcher tries to obtain all the relationships among a set of respondents while ego network analysis focuses on interaction network of a single agent. In a case of ego network respondents are chosen randomly from population and the analysis concentrates on quality of individual network (size, diversity, etc.). Social network researchers ground on the assumption that all network structures have an impact on activities of network members (Flap, 2002). Organizations and service providers in tourism industry that are involved in cooperation form particular relationship type – obligations that may involve also various intermediate social agents. Cooperation ensures better information exchange between all social agents involved in mutual relationships, thus promoting especially successful and close cooperation in the tourism industry (Luck, 1995).

Standardized interviews. In order to obtain initial data, sociological research methods are most appropriate. Systemic approach allows using standardized interviews. Survey method is useful for obtaining information on real models of tourism system which are formed in cooperation networks. Sociological research relates theory and reality that has been investigated. Theoretical models of tourism system can be used in elaboration of the questionnaire; they are useful in drawing network maps as well as in development of conceptual cooperation models in particular territory in any kind of tourism or in a context of particular tourism product.

The methodology of tourism system models' identification was approbated in 2007, when pilot research was conducted in Jelgava district (Kaufmane et al., 2008), and in 2008 during the survey which involved service providers of rural tourism in Zemgale planning region. (Kaufmane et al., 2008) Since rural tourism is defined as a kind of tourism which provides accommodation in rural houses (guest houses, B&B, farms, etc.), 110 units providing these facilities were identified both offering accommodation facilities and farm visits. The survey did not focus on museums, palaces, manor houses, catering enterprises, and managers of natural resources unless they provided accommodation facilities. Also the survey excluded providers of tourism services in centres of districts and towns. In total, 75 rural entrepreneurs were involved in the survey. Asample was made of entrepreneurs representing all districts of the region.

Results and Discussion

Data were obtained about 75 providers of rural tourism services in Zemgale planning region; this was realized by integrating system approach, social network analysis and method of sociological research. Ego networks of providers of rural tourism services identify those social agents that play different role in creation of tourism products. In total, 30 social agents were identified in all ego networks. Each ego network represented different number of agents. Two social agent groups were formed of individuals and 28 of social agents embracing organizations, institutions and entrepreneurs. Regularity of cooperation from network to network and interaction occur only if necessary. Social agents are viewed as accumulated resources.

Municipalities, neighbouring rural tourism entrepreneurs, tourism information centres or local offices, banks, mass media, tourism associations, customer services more frequently were mentioned as the fruitful cooperation partners. Infrequent cooperation is realized with catering enterprises, educational and cultural establishments, organizers of undertakings, farms, Rural Support Service, LAD, rural consultation bureau, NGOs, museums and collectors, developers of additional offer, security

companies, advertising agencies, publishers, hotels, sport organizations, craftsmen and producers of souvenirs (Figure 2.).

Systemic view on tourism industry allows identifying the most significant social agents in Latvia's regions, detailed evaluation of strengths and weaknesses of the industry, and it allows to develop conceptual basis for resolution of practical tourism problems in the future. Similar theoretical and empirical studies that would consider context and conditions of Latvia's regions have not been conducted in Latvia and accordingly to the renewed tourism policy of the EU, but they might be useful in promoting understanding about the role of tourism industry.

Structure of really functioning tourism system models comprises wide range of social agents having specific influence on development of tourism products and ensuring an operation of providers of rural tourism services. The research results allow developing conceptual cooperation model of rural tourism, which involves interaction with other sectors offering possibilities to analyse and develop methodologies for investigation of demand of tourism goods and services. Cooperation models of service providers in such kinds of tourism as culture tourism or conference tourism can provide an additional information for evaluation of influence of tourism industry on national economy.

The methodology of identification of tourism system models allows identifying various cooperation aspects (amount of cooperation (Figure 2.), results and cooperation motives) that serve as a basis for detecting of clusters in rural tourism in regions, because cooperation models of rural tourism service providers are one of the forms of economic interaction between incidental transactions where partners are independent *de jure* and geographically concentrated in one region. Diversity of activities and status was found in cooperation; competition, cooperation, and specialization between partners were recognized. In Europe, issues related to clusters have recently attracted considerable attention. Competitive capacity of the state should be directed by bottom-up processes that express as cooperation models of independent kinds of economic activities. Development of clusters would promote competitive capacity and innovations in regions.

Regional cluster is a geographical agglomeration of firms and organizations, which operates in one or more related kinds of economic activities (Enright, 1992). The smallest structural unit of a cluster is a company, a firm, an organization or an institution. In order to identify members of a cluster, it is important to integrate all chain of production, which must also include regional public organizations, associations and local authorities (Boroņenko, 2007). Networks of social agents of rural tourism service providers meet these requirements. Amount of cooperation that is shown in cooperation networks differs; however, all rural tourism service providers in their ego networks evaluate organizations and enterprises very well, as they increase profit, identification, knowledge, new offer and new contacts that are important in creation of tourism products.

The research shows that rural tourism service providers cooperate with enterprises from public, private and nongovernmental sectors. In Latvia, optimization of cooperation between these three sectors is emphasized as one of topicalities in national tourism policy documents of recent years. Previously mentioned methodological approach can be useful in order to clarify the most significant social agents from all sectors in particular regions as well as in particular tourism ways.

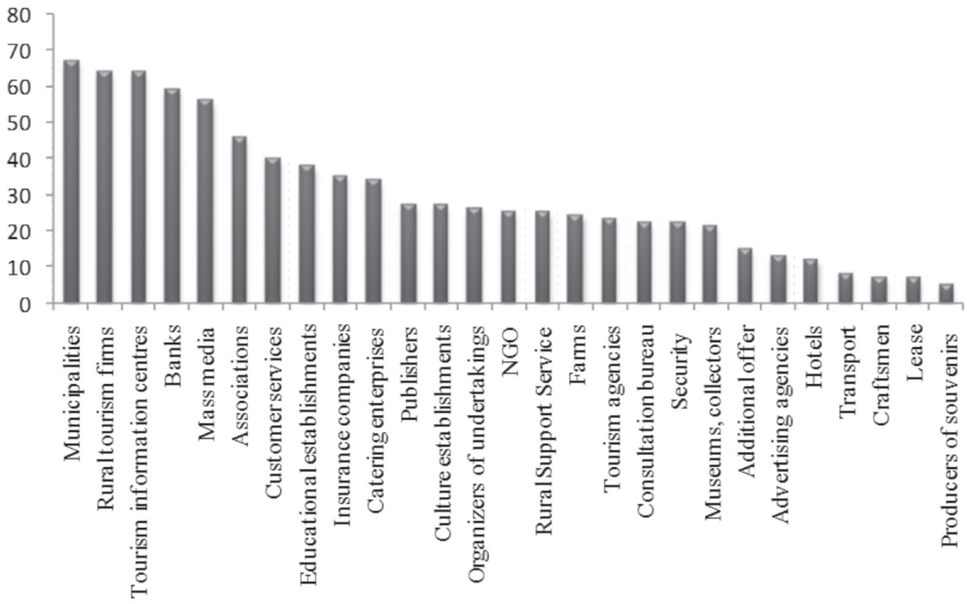

Figure 2. Amount of cooperation with social agents in rural tourism.

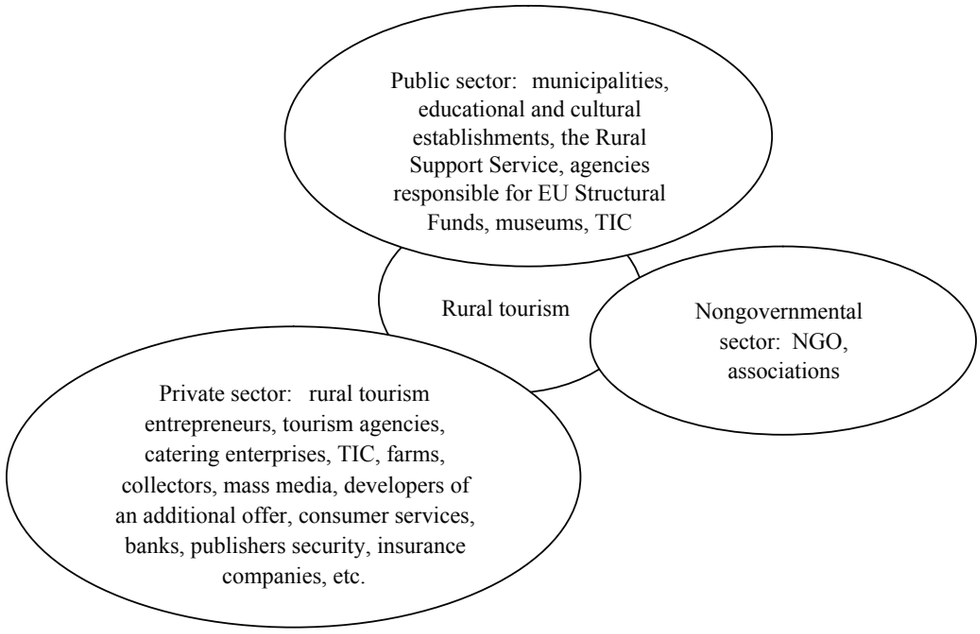

Figure 3. Social agents of public, private and nongovernmental sectors in rural tourism.

The providers of rural tourism services as cooperation partners present mainly agents of private sector; however, cooperation with the public sector (the state institutions) emphasizing local municipal territories as a space for entrepreneurship was presented in 64 cooperation networks (Figure3).

Nongovernmental sector is mainly represented by organizations related to professional interests of rural tourism service providers. The model where particular social agents are identified can improve mutual cooperation (regular information exchange, coordination of activities, realization and financing of common undertakings with economic activities that are related to tourism (transport, culture, environment, rural development etc.)).

Nongovernmental sector comprises significant and growing part in economy in Latvia and worldwide. That is approved also by the research results: all ego networks of tourism firms involved various nongovernmental organizations. Zemgale Tourism Association, Latvian Country Tourism Association "Lauku ceļotājs" and organizations, which are involved in development of tourism products, were mentioned most frequently. The tourism associations were evaluated as significant social agents for information exchange and for attracting of new clients. Thus, they are treated as agents, which ensure tourism firms with additional profit.

One of the options of applying tourism system models is systematization of marketing strategies within a framework of both tourism firms and industry. Cooperation models of rural tourism service providers help in identifying the main addressee of communication (Figure 4.). They also can help for the system of activities which aims to ensure particular interaction between tourism entrepreneurs and addressees of communication. Theoretically, the state institutions are the main addressee of communication. For maintenance of interaction they can apply lobby, participation in national programmes, exhibitions, etc. Municipalities and the state institutions responsible for rural development have been mentioned as significant cooperation agents in their cooperation networks by the rural tourism service providers. Also there are opportunities for interaction, for example, participation in resolution of problems relevant to the particular territory, common activities. It is possible to elaborate a similar system of interactive activities also for other groups of communication addressee.

The objective of the paper was to show conceptual possibilities of application of tourism models as a perspective for activities in future. Explicit contribution of tourism to regional development does not give identification of tourism system models due to absence of statistics explicitly reflecting all cooperative activities. Possibilities of application of tourism models can be expanded by conducting more detailed quantitative and qualitative researches about distinct social agents and their role in a particular tourism system that is under investigation.

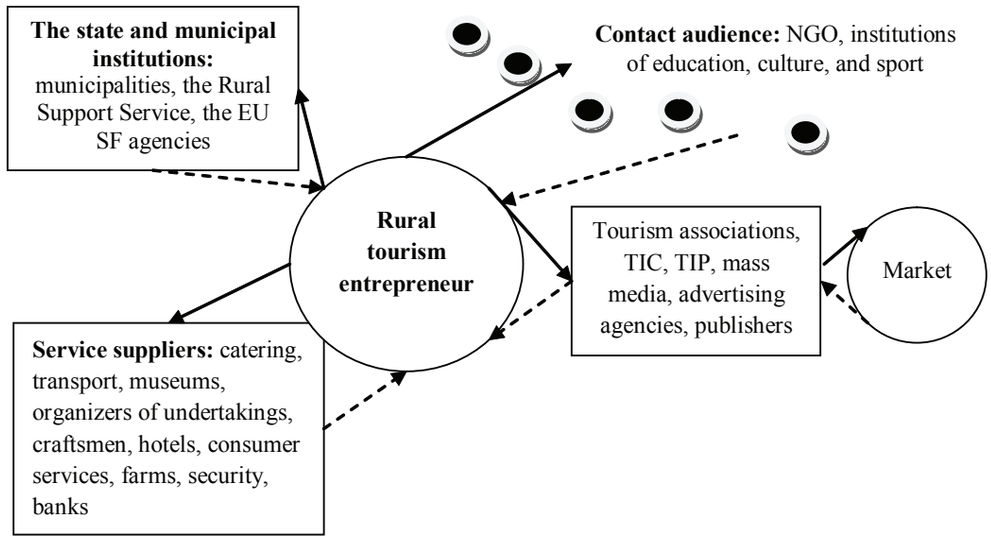

Figure 4. The main addressee of marketing communication of rural tourism enterprises.

Conclusions

Entrepreneurial activities of tourism service providers are closely tied with entrepreneurs of other sectors. Methodology of identification of tourism system models that was approbated in Zemgale planning region opens up new opportunities for investigation of tourism industry at various levels both in relation to particular tourism product and region. This is a way, how to broaden evaluation of economic situation within industry by conducting more comprehensive qualitative researches and specific data, which in turn would promote understanding of society on multiplicative effect of tourism.

Cooperation models embracing particular social agents are useful for identification of tourism clusters, evaluation of marketing communication, and for activation of cooperation between the state and municipalities, nongovernmental and private sectors. Common experience and skills as well as long-term projects are the main aspects of activities directed towards cooperation and optimization. That kind of cooperation is most effective at regional and local levels where interests of the state and private sectors meat directly. Cooperation between the state and private sector is necessary also for development of new tourism products and services that in turn are related to improvement of competitive capacity of the industry and regional sustainability.

Acknowledgements

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COMPETITION LEGISLATION FRAMEWORK OF DAIRY SECTOR INTEGRATION IN THE BALTIC STATES

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Abstract. Appropriate resources, availability of infrastructure, economic significance and food market forecasts determine the rationale for development of the dairy sector in the Baltic states. The sector is faced by significant economic problems, inter alia, production structure fragmentation, lack of investments and low labour productivity. Several sector's problems can be directly or indirectly solved by integration. Competition legal acts setting strict penalties directly and widely apply to integration processes, imposing a high level of legal risks on integrating parties. Thus, competition legislation forms a central framework limiting and guiding integration.

As the subject has not been explored earlier, the author researched the Baltic dairy sector integration options at primary and secondary levels as influenced by the EU and Baltic national competition legislation and its implementation practice. Abstract-logical, monographic and interview methods have been used. The author concludes that law-compliant cross-border integration opportunities for the Baltic dairy sector exist to form larger integrated undertakings with higher market power.

Reference to market shares in the competition legislation in countries with lower aggregate crude milk market sales puts the dairy sector participants at a disadvantage in case of integration processes resulting in smaller absolute size of the allowable integrated undertaking. Integration by agreements, decisions and concerted practices is appropriate for national level arrangements but is with limited applicability in the Baltic states cross-border integration at both levels of the dairy sector. In case of concentration, integration may be used to create cross-border integrated structures increasing concentration at every level of the Baltic dairy sector.

Key words: dairy sector, integration, competition law.

Introduction

The dairy sector, including dairy farming and processing, is an important part of the Latvian economy as in 2006 it used approximately 5.5% of country's total labour units in full time equivalents. The relation of each Baltic state's dairy sector gross value added at factor cost to its GDP at current prices indicates that the dairy sector is the most significant one in Lithuania where it is 2.6-3% of the GDP. Latvia is next with approximately 2%, but in Estonia this sector is relatively smaller – 1.2-1.6% of the GDP. The weight of the dairy sector in structure of the Baltic states' economies decreased in the years 2004-2006 but is still significant (Ozolins and Veveris, 2009). Appropriate natural resources, availability of existing infrastructure, and long-term world food market forecasts will determine the rationale for retention and development of the dairy sector in the Baltic states (Ozolins, 2009). Revealed comparative advantage analysis shows that Latvian indicators in the group of dairy and dairy products have become positive since 2004 and are growing rapidly (Saboniene, 2009).

However, the sector in Latvia faces significant economic problems, inter alia, fragmented milk production and processing, milk processing is dominated by mass products such as milk, cultured products, cheese and butter, the price of which cannot be influenced by the producers (Leimane et al., 2006). Research carried out in other EU countries evidences that larger processing units are needed to shift the emphasis on to more value added products and adequate investment in research and development, e.g. in Ireland (Briscoe and Ward, 2006). The Competition Council of Latvia has concluded that there is an unequal distribution of market power between milk processing companies and retail companies which are able to influence supply price, because they sell most or a significant proportion of the producers' products (Konkurences padomes…, 2007). Major Lithuanian dairy sector problems are the prevalence of small-scale farms in milk production and low productivity due to out-dated technologies (Zemeckis et al., 2009). Lack of investments and low labour productivity are identified as major weaknesses of the Estonian dairy sector (Sepp and Ohvril, 2009).

The major identified Baltic dairy sector problems can directly (such as fragmented primary or secondary production) or indirectly (such as low productivity) be solved by integration. For the purposes of this paper the author uses a broad integration definition developed by another author: a process of economic, legal collaboration and hierarchy of enterprises with a determined degree of connection, which shows to what degree the integrated enterprises lose or retain their own economic or legal independence enforcing achievement of concrete objectives, both the achievement of common objectives and achievement of the objectives of every collaboration partner (Zvirbule-Bērziņa, 2003). Empirical research carried out in Hungarian dairy sector produced a significant and positive relationship between amount of milk sold by the processing companies and their market power (Szabó and Popovics, 2009). The determinants influencing specific form and degree of integration are exploitation of economies of scale, technological interdependencies and uncertainty, life-cycle considerations, preventing double-marginalisation and transaction

cost reduction (Kedaitiene and Hockmann, 2002). Other researchers point out that any of the Baltic countries is too small for the implementation of a large project, and their markets are too small as well. Therefore, realistic economic or technological advancement in various economic spheres must take place in all Baltic countries simultaneously (Melnikas, 2008). The different co-ordination mechanisms strengthen the position of farmers and some effects might go beyond the industry and concern the whole society, such as decreased demand for subsidies through stabilised prices and supply, or lower food prices through more effective marketing (Popovics, 2008).

Although various forms of integration, including cross-border, may solve several major dairy sector problems, it can also produce significant harmful side effects such as elimination of competition in respect of a substantial part of the market or creation of undertakings in dominant position. In view of need to carefully balance the potential benefits arising from agreements between undertakings, decisions by associations of undertakings and concerted practices and their possible harmful influence, and possible benefits, the EU has adopted various legal anti-trust and merger control instruments. At national level the EU member countries have adopted legal instruments and set up institutions to ensure free competition in respect to the national markets or activities whose size is below control limits set in EU-level legal instruments. Competition laws are being actively enforced in the Baltic states and penalties may reach up to 10 percent of net turnover of an undertaking and, depending on country, up to three years imprisonment with or without confiscation of property.

Literature research by the author did not yield other authors' work on possible Baltic dairy sector cross-border integration in the framework of national and the EU competition legal instruments. In view of the importance of integration for the development of Baltic states dairy sector and legal risks associated with integration, it is useful to fill in this gap. Results may be useful for integrating parties, agricultural and rural development support policy planning and for further research on optimal structures of the Baltic states dairy sector.

The aim of this paper is to evaluate Baltic dairy sector integration options at primary and secondary levels as influenced by the EU and national competition regulations and their implementation practice. The following tasks had been set to reach the aim:

1) Analysis and evaluation of EU competition legal acts in respect to the Baltic dairy sector integration;

2) Analysis and evaluation of national competition legal acts and their implementation cases in Latvia, Lithuania and Estonia in the dairy sector;

3) Identification of appropriate options of integrated undertakings in view of competition legislation.

The hypothesis of the paper is that there are cross-border integration opportunities for the Baltic dairy sector to form larger integrated undertakings which are legal in view of competition legislation.

Due to the format of the paper and need to focus on the legislation with highest impact on cross-border integration other legal acts such as co-operation laws, legislation governing EU structural funds support eligibility, laws regulating forms of business, those directly regulating primary and secondary levels of the dairy sector and agriculture on the whole are not analysed. The author evaluated other types of legal acts in the above-mentioned other areas and came to a conclusion that competition legislation is significantly more important.

Materials and Methods

Materials from the Official Journal of the European Union, Latvijas Vēstnesis, Riigi Teataja, Competition councils of Latvia, Estonia and Lithuania, Ministries of Agriculture of Latvia, Estonia and Lithuania as well as other authors' research (Kedaitiene and Hockmann, 2002; Melnikas, 2008; Popovics, 2008 and others) were used in order to complete the research tasks of this paper. Representatives of competition councils and Ministries of Agriculture of the Baltic states were contacted to clarify issues in relation to competition legal instruments implementation precedents in the respective dairy sectors at national level. Abstract-logical, monographic and interview methods were used.

All references to Article 31, 81 and 82 of the Treaty establishing the European Community (the Treaty) in the existing legal instruments referred to in this paper should be understood as references to the current articles 39, 101 and 102 of the Treaty on the Functioning of the European Union (as renamed by the Treaty of Lisbon, which entered into force on 1st December 2009). Results and discussion section are structured by competition law areas.

Results and Discussion

Agreements, decisions and concerted practices preventing, restricting or distorting competition

Article 101 of the Treaty on the Functioning of the European Union (TFEU) prohibits as incompatible with the internal market all agreements between undertakings, decisions by associations of undertakings and concerted practices which may affect trade between the EU member states and which have as their object or effect the prevention, restriction or distortion of competition within the internal market (Consolidated version…, 2008). However, these provisions may be declared inapplicable in the case of agreements, decisions and concerted practices which contribute to improving the production or distribution of goods or to promoting technical or economic progress, while allowing consumers a fair share of the resulting benefit, and which does not impose on the undertakings concerned restrictions which are not indispensable to the attainment of these objectives and does not afford such undertakings the possibility of

eliminating competition in respect of a substantial part of the products in question.

Council Regulation (EC) No 1184/2006 provides that the article 81 of the Treaty shall not apply to such of the agreements, decisions and practices which relate to production of, or trade in, the products listed in Annex I to the Treaty which are integral part of a national market organisation or are necessary for attainment of the objectives set out in Article 33 of the Treaty (Council Regulation (EC) No 1184…, 2006). In particular, it shall not apply to agreements, decisions and practices of farmers, farmers' associations, or associations of such associations belonging to a single EU member state which concern the production or sale of agricultural products or the use of joint facilities for the storage, treatment or processing of agricultural products, and under which there is no obligation to charge identical prices, unless the Commission finds that competition is thereby excluded or that the objectives of Article 33 of the Treaty are jeopardised.

Analysis of the provisions of the Council Regulation (EC) No 1184/2006 allows to conclude that although certain exemptions apply to the dairy sector, in practice these are limited and provisions of the Article 81 of the Treaty mostly do apply to the sector. The Council Regulation (EC) No 1234/2007 which establishes a single common market organisation determines milk market organisation (Council regulation No 1234…, 2007), therefore, national market organisations as a part of justification for exemptions lose importance. The Article 33 of the Treaty sets objectives of the Common agricultural policy, and it may be difficult to justify that certain restrictive practices in dairy sector at national level are necessary to fill in a gap that has not been provided for at the EU level. Further, the exemption may not be applied to agreements, decisions and practices involving parties from more than one EU member state which does not allow to apply it in case of cross-border integration in the Baltic states. The exemption may not be applied in case of organisations which involve not only the farmers or their associations, but also other market participants such as milk processing companies.

In order to create equal competition conditions, the Council Regulation (EC) No 1/2003 determines the relationship between national laws and Community competition law (Council Regulation (EC) No 1…, 2003). The application of national competition law may not lead to the prohibition of agreements, decisions by associations of undertakings or concerted practices which may affect trade between the EU member states but which do not restrict competition within the meaning of the Article 81(1) of the Treaty. The EU member states should not be precluded from adopting and applying on their territory stricter national laws which prohibit or sanction unilateral conduct engaged in by undertakings.

The provisions of Section 11 of the Latvian Competition Law on prohibited agreements are close in meaning to those contained in the Article 81 of the Treaty, apart from specifying prohibited actions in auctions and activities which may force another market participant to leave the market or make it difficult to enter (Konkurences likums…, 2001). Latvian Cabinet Regulation No 797 includes exemption of vertical agreements referred to in Section 11 of the Latvian Competition Law in case market share of each party to the agreement in the specific market does not exceed 10% (Noteikumi par atsevišķu…, 2008). Specific horizontal agreements which do not significantly affect competition and therefore are exempt from Section 11 of the Latvian Competition Law have been defined in the Cabinet regulation No 798 (Noteikumi par atsevišķu horizontālo…, 2008). Among the covered by the block exemption are horizontal agreements on joint procurement of goods, sales or distribution and advertising, if the aggregate market share of directly and indirectly involved parties in the specific market does not exceed 15%. Unilateral and reciprocal specialisation and joint production agreements are exempted in case the market share of the parties does not exceed 20%.

Estonian Competition Act sets similar prohibition on agreements, concerted practices and decisions by associations of undertakings which restrict competition to that of the Article 81(1) of the Treaty (Konkurentsiseadus…, 2001). The Act specifies that prohibitions, except those not allowing price and trade conditions fixing, do not apply to agreements and practices of agricultural producers or to decisions by associations of agricultural producers, which concern the production or sale of agricultural products or the use of joint facilities, unless competition is substantially restricted by such agreements, practices or decisions. In cases of pre-defined practices and decisions of minor importance the Act regulates that prohibition to exchange information which restricts competition, adding unrelated supplementary obligations as a precondition of entry into agreement and agreeing on dissimilar conditions to equivalent agreements do not apply. The cases of minor importance are vertical agreements with combined market share not exceeding 15%, horizontal agreements and combined agreements with 10%, respectively. Estonian Government of Republic Regulation No 196 sets block exemption to agreements, consorted practices or decisions regarding terms of specialisation and research and development activities (Vabariigi Valitsuse 18. juuni 2002 määrus nr 196… 2002). The exemption does not apply to parties in dominating position, specialisation agreements with aggregate market share of participants exceeding 20% and research and development agreements with the aggregate market share exceeding 25% in the specific market.

Republic of Lithuania Law on Competition Article 5 prohibits all agreements, concerted practices and decisions (Republic…, 1999); its legal content does not significantly differ from the formulation used in the Treaty. The Lithuanian Competition Council in its Resolution No 1S-172 defines agreements of minor importance that are not considered infringing the law on competition (Resolution…, 2004). Agreements of

minor importance are horizontal and mixed agreements between undertakings with aggregate market share not exceeding 10% and vertical agreements with individual market shares not exceeding 15%.

Competition Council of Latvia has passed one decision on a notified agreement in the dairy sector. It exempted the holding company Rīgas piena kombināts and Valio Ltd. for 5 years allowing formation of a joint venture to cooperate in production and distribution (Konkurences padomes lēmums Nr. 49…, 2002). The decision was based on a conclusion that the agreement will significantly promote entrance of Valio into Latvian market and will not give an opportunity to eliminate competition in a considerable part of the specific market. Competition Council of Estonia has not passed any decisions on prohibited or notified agreements in the dairy sector. Lithuanian Competition Council has passed a resolution on a prohibited agreement in milk purchase and processing, imposing fines upon the involved undertakings totalling LTL 2.2 million (Competition Council of the Republic of Lithuania Press Release 2008-02-28…, 2008). Undertakings of the agreement, Lithuanian Milk Producers' association Pieno centras, AB Kelmės pieninė, UAB Kelmės pieno centras, UAB Marijampolės pieno konservai, UAB Modest, AB Pieno žvaigždės, AB Rokiškio sūris and AB Vilkyškių pieninė exchanged information about the quantities of raw milk purchased, quantities of individual milk products produced and marketed. Lithuanian Competition Council established that the exchange of information affected behaviour of competitors in the markets which eventually affected the final prices and caused restriction of competition.

Existing legal framework is facilitative to agreements, decisions and concerted practices by dairy farmers and their organisations unless the arrangement involves participants from more than one EU member state and involves participants which do not produce agricultural products or their associations. In case of integration agreements involving parties from more than one country the favourable conditions applicable to dairy farmers set forth in the Council Regulation (EC) No 1184/2006 do not apply and general competition legislation must be observed. However, the general legislation is highly limiting in relation to horizontal and vertical agreements, especially on horizontal agreements allowing only agreements in which aggregate market share of involved parties is up to 10-20%, depending on the country. A cross-border dairy primary sector agreement involving maximum 40% aggregate market share in the Baltic states would be less attractive than the 40% possible in case of a single-country arrangement because of restrictions contained in the competition legislation. The allowed agreements, decisions and concerted practices at secondary level of the dairy sector are subject to a number of conditions and may be possible between relatively small market participants and therefore are limited to small-scale applicability in partial integration processes (Table 1).

Dominating position and concentrations

Article 102 of the TFEU prohibits any abuse by one or more undertakings of a dominant position within the internal market or in a substantial part of it so far as it may affect trade between the EU member states (Consolidated version…, 2008). The Council Regulation (EC) No 1184/2006 does not set any exemptions regarding application of the Article 82 that may be referred to in the dairy sector (Council Regulation (EC) No 1184…, 2006). According to the EC Merger Regulation all Community dimension concentrations have to be reported to the Commission (Council regulation (EC) No 139…, 2004). For a concentration to have a Community dimension the combined aggregate worldwide turnover of all the undertakings concerned must exceed EUR 2500 million. A concentration which would significantly impede effective competition, in the Common market or in a substantial part of it, in particular as a result of the creation or strengthening of a dominant position, shall be declared incompatible with the Common market after evaluation by the Commission. The conditions to qualify as a Community dimension concentration are high and therefore unlikely to be applied in the Baltic states dairy sector.

Latvian Competition Law provides that market participants who have decided to merge submit a merger notification to the Competition Council if the combined turnover of the participants in the merger for the previous financial year in the territory of Latvia has exceeded LVL 25 million or their aggregate market share in the specific market exceeds 40% (Konkurences likums…, 2001). The reporting threshold turnover is approximately 4.1 times higher than in Lithuania and 5.6 times higher than in Estonia. The merger does not have to be reported in case the turnover in the previous financial year of one of the two parties merging does not exceed LVL 1.5 million. The Cabinet Regulation No 800 specifies that while examining a merger it is especially taken into account whether market participants carry out significant economic activity in the same or connected markets and whether the coordination of competitor action will cause a possibility to significantly decrease competition (Kārtība, kādā…, 2008).

For the purposes of the Estonian Competition Act an undertaking or several undertakings are in a dominating position if they are operating in the same market whose position enables it/them to operate in the market to an appreciable extent independently of competitors, suppliers and buyers (Konkurentsiseadus…, 2001). Dominant position is presumed if an undertaking or undertakings account for at least 40% of the turnover in the market. A concentration must be reported to the Estonian Competition Board if the aggregate turnover during previous year in Estonia of the parties to the concentration exceeded EEK 100 million and the aggregate turnover in Estonia of each of at least two parties to the concentration exceeded EEK 30 million.

Table 1

Baltic Dairy Integration Options Evaluation in Competition Legislation Framework

Integration territory/Dairy sector level	Single country	Multiple countries
Integration by agreements, decisions and concerted practices		
Primary	***	*
Secondary	*	*
Integration by concentration		
Primary	***	***
Secondary	*** for Latvia and Estonia * for Lithuania	***

Legend: level of appropriateness: * - low; ** - medium; *** - high
Sources: authors' analysis

According to the Lithuanian Law on Competition an undertaking with the market share of not less than 40% is considered to enjoy a dominant position within the relevant market (Republic…, 1999). Each of a group of three or a smaller number of undertakings with the largest shares of the relevant market, jointly holding 70% or more of the relevant market shall be considered to enjoy a dominant position. The intended concentration must be notified to the Competition Council and its permission shall be required where combined aggregate income of the undertakings concerned is more than LTL 30 million for the financial year preceding concentration and the aggregate income of each of at least two undertakings concerned is more than LTL 5 million for the financial year preceding concentration.

In the period from 2002 until 2009 competition councils of Latvia, Estonia and Lithuania had passed, respectively, 1, 2 and 4 decisions or resolutions on dairy sector concentrations. Latvian Competition Council allowed one concentration that increased concentration level in curds cheese and yoghurt market as the aggregate market share of merger parties did not exceed 20% and dominating position would not arise and competition would not be significantly decreased (Konkurences padomes lēmums Nr. 179…, 2007). Estonian Competition Council allowed 2 concentrations in the dairy sector secondary level. In its analysis the Estonian Competition Council has come to a conclusion that in case a processing company would offer worse conditions to a crude milk supplier, the supplier would turn to a competing company in Estonia, Latvia or Lithuania (Annual…, 2007). In a similar way, it came to a conclusion that a single Estonian milk processor cannot act independently as it competes with Estonian, Latvian and Lithuanian dairy processing companies via the large retail chains that buy and resell dairy products across the Baltic states.

The Competition legislation framework does not provide exemptions that may be applied to the dairy sector primary level concentration type integration. Concentrations may not exceed 40% market share, otherwise a dominating position is created as defined in the national competition legislation of the Baltic states. A concentration involving participants from all Baltic states is possible, with a maximum market share of 40% in each country in product sales. The size of concentration may be increased, in case products exceeding the 40% threshold are sold outside the respective country's specific market or outside the Baltic states in case of hypothetical all Baltic states integration undertaking. The limiting factor of concentration is market shares for crude milk supply and purchase markets both at primary and secondary level which is a local resource. In relation to crude milk a Baltic-states-wide market exists. Share of raw milk intake in dairy processing may indicate a domineering position. Milk intake in 2007 by Lithuania top 4 dairy processing companies was over 90%, of which AB Rokiškio sūris purchased 39, 5%, by Latvian top 4, 61%, of which Rīgas piena kombināts group purchased 24%, by Estonian top 5, 68%, respectively (Van Berkum, 2009). Opportunities for further concentration in compliance with competition legal acts at the secondary level of the dairy sector exist in Latvia and Estonia at the national level. Opportunities for cross-border integration involving concentrations exist also for the respective level market participants in Lithuania as well as in other Baltic states (Table 1).

Terminologically and institutionally the EU and national competition legislation sets a common framework for integration activities which is increasingly homogenous across the EU. What differs is the context of their application. Most important contextual difference arises from the references to the market shares which limit intra-country growth in such small countries as the Baltic states in comparison with neighbouring countries, e.g. Poland. Existence of a single Baltic-wide crude milk and milk products market renders the reference to a single-country market in the national legislation questionable due to its overly limiting nature in favour of application of aggregate market share in the specific three-state market.

Conclusions

1. The legal sanctions set by the EU and national competition legal acts are stringent as monetary penalties may reach up to 10% of an undertaking's previous financial year turnover and national laws in Latvia and Estonia qualify certain competition infringements as criminal offence with penalty of up to 3 years imprisonment in Estonia. Competition authorities at the EU and Baltic states levels have been set up and actively enforce competition legislation, inter alia, in the dairy sector. Competition legal acts directly and widely apply to integration processes and as such integration is associated with a high level of legal risk.
2. Competition case law of the Baltic states acknowledges existence of a single Baltic states market for crude milk, liquid milk products and curd cheese products. Competition authority decisions have been made on basis of market shares in the national markets though as specified in legal acts.
3. Reference to market shares in competition legislation in countries with smaller crude milk markets puts dairy sector participants at a disadvantage in case of integration processes by agreements, decisions and concerted practices and concentrations. Smaller absolute size of integration arrangements are allowed in smaller countries in view of reference to the crude milk specific market.
4. Integration in form of agreements, decisions and concerted practices at dairy sector primary level allows to form a considerable size of integrating undertaking in terms of market share, up to 40%, in respective country. Similar cross-border integration at the primary level does not allow exemptions for agricultural products set in competition legislation and therefore is inferior to a one-member-state arrangement.
5. Integration in the form of agreements, decisions and concerted practices at dairy sector secondary level is subject to significant restrictions of the type of activity and size of integration. Although opportunities for such integration exist, they may not be used to create large integrated structures with considerable market power.
6. High or full integration is allowed by the competition legal acts in case of concentration. No exemptions apply in relation to agricultural products in competition legislation concentration regulations. A concentration of up to 40% in each country's specific product market is allowed and cross-border integrated structures may be created, with higher market power both at the primary and secondary levels of the dairy sector. It proves the paper hypothesis and draws attention to future opportunities that would allow to form larger stabilising market structures facilitative to sustainable Baltic-wide development of the dairy sector.

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EVALUATION OF RESOURCE PRICE PREFERENCES AND RESOURCE UTILIZATION EFFICIENCY IN DAIRY SECTOR

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Abstract. The paper deals with the evaluation of resource price preferences and resource utilization efficiency in Latvian dairy sector that shows Latvian relative competitive position both in terms of producing competitive products for the market, as well as ensuring competitive salaries and a general rise in living standard for the employees. The evaluation is carried out through analyzing price levels of the main production resources and the utilization efficiency of these resources, based on the comparison with other EU countries. The efficiency indicators in Latvian primary milk production sector are considerably lower and despite resource price preferences the cost level per production value in Latvia is higher than in other countries. The analyzed resource utilization efficiency is low in Latvia also at the processing industry level, though the current price level of the main production resources helps to ensure competitive positions of Latvian dairy products. But considering large differences in compensation levels for labour force between Latvia and other EU countries, without increase in productivity, the situation is not sustainable in long-term.
Key words: dairy sector, resource prices, resource utilization efficiency, the value added, competitiveness.

Introduction

Dairy sector is one of the main agri-food sectors in Latvia, accounting for almost ¼ of the total agricultural goods output and 20% of the total output in food industry (EAA, 2010; CSB of Latvia, 2010).

Compared to other European Union (EU) countries, Latvian primary milk production and processing sectors are characterized by low value added per employee, but the value added forms the basis for the compensation/income of the production factors. Generally the value added refers to the total return earned by the team of workers, capital providers and the government, and it shows the total amount of money available for reinvestment and retained earnings (Riahi-Belkaoui, 1992).

The value added or the additional value created by the production factors is determined by price (also product subsidies), production volume and intermediate consumption of goods and services used in the production process. Considering that output prices are generally determined by the development on the markets, producers have more limited possibilities to influence product prices (especially for base or commodity products), compared to the level of production costs.

The analysis carried out by the author has shown that the development of the value added has been mainly determined by the changes in prices in recent years. Resource prices have increased considerably in Latvia since 2003, though it was compensated by the rise in milk prices. But generally it would not be reasonable to count on milk price above the levels observed in the period before milk price surge in 2007 (at the same time, the risk of price volatility has increased), contrary to resource prices that still have growth potential in Latvia. Under these circumstances the resource utilization efficiency right now becomes crucial to ensure sustainability of the sector that includes increase in the value added and competitive remuneration for the labour force.

Production costs in Latvian dairy sector have been widely studied (e.g, Bratka and Praulinš, 2009; Latvietis and Priekulis, 2006; Miglavs et al., 2006); however, the studies have mainly focused on the primary milk production level, the analysis has been scarce at the dairy processing industry level. The author also wanted to combine the analysis of differences in resource prices with the analysis of resource utilization efficiency.

The objective of the paper is to evaluate resource price preferences and resource utilization efficiency in Latvian dairy sector. In order to reach the objective, the following tasks were set – 1) to determine the main production costs in dairy sector both at the primary and processing level; 2) to compare the main resource price levels between Latvia and other EU countries; 3) to calculate efficiency indicators and evaluate resource utilization efficiency in dairy sector in Latvia, compared to other EU countries.

The object of the study is primary milk production sector (represented by the average dairy farm) and dairy processing industry in Latvia and other EU countries, and the subject – resource prices and efficiency.

Materials and Methods

Analysis of the efficiency at the primary production level has been carried out using FADN (Farm Data Accountancy Network) data on dairy specialization farms. The EU average corresponds to the average level observed in the countries covered by FADN database (EU-27 countries, except Cyprus). To make evaluation and comparison among countries, 6 leading EU milk producing countries that produce more than 2/3 of the total milk in the EU (Germany, France, the United Kingdom (UK), Poland, the Netherlands and Italy) and 3 Baltic States were selected. The latest available comparative data cover the year 2007.

For making analysis at the processing industry level, Eurostat data on manufacture of dairy products were used. The Eurostat does not provide EU average figures and due to the lack of data for some countries, the average indicators could not be calculated either.

Table 1

Cost structure of dairy farms in Latvia and other EU countries in 2006-2008

	Latvia			EU-average	
	2006	**2007**	**2008**	**2006**	**2007**
Intermediate consumption	**77.5%**	**75.9%**	**73.9%**	**69.2%**	**70.7%**
Livestock specific costs	42.8%	40.9%	38.7%	34.4%	36.7%
- feed	37.7%	36.2%	34,1%	27.5%	30.0%
Farming overheads	2.0%	26.8%	27.4%	27.4%	26.6%
- machinery and building current costs	7.2%	7.6%	6.8%	7.5%	7.3%
- energy	12.1%	12.0%	13.0%	6.4%	6.3%
- contract work	2.3%	2.1%	2.2%	5.9%	5.8%
Depreciation	**12.5%**	**14.1%**	**15.1%**	**17.0%**	**15.8%**
Factor costs	**10.0%**	**9.9%**	**10.9%**	**13.8%**	**13.5%**
- wages paid	7.1%	6.7%	7.3%	4.4%	4.4%
- rent paid	0.6%	0.4%	0.5%	4.7%	4.4%
- interest paid	2.2%	2.9%	3.2%	4.6%	4.8%
TOTAL INPUTS	**100%**	**100%**	**100%**	**100%**	**100%**

Source: FADN, 2010

The latest available comparative data also cover the year 2007.

The main sources for price data include Eurostat, DG Agri as well as calculated data from FADN. Generally the data for the year 2009 were used or in case of lack of such data – the latest available year.

In the context of this paper, the value added is assumed to be the gross value added, i.e., production value at producer prices less intermediate consumption. Production efficiency is considered to be the ability to balance production costs with the revenue in the most rational way. The resource utilization efficiency is perceived to be input productivity in yielding output.

Methods of statistical analysis and logically constructive analysis were employed in data analysis.

Results and Discussion

The share of intermediate consumption in the total production value of dairy specialization farms was 72.9% in Latvia in 2007, compared to 58.9% in the EU on average. The level of intermediate consumption is important in determining the gross value added - the remaining part of revenues gained from the market that forms the basis for the compensation/income of the production factors.

The main intermediate cost position is feed that comprises almost half of the total intermediate consumption (46.2% in Latvia, 42.4% in the EU on average). Energy costs are the second most important intermediate consumption cost position in Latvia, accounting for 17.6% of the total intermediate costs. The share of energy costs is lower in other EU countries mainly due to higher share of costs of contract works that is largely associated with lower relative labour input.

Considering the costs associated with maintenance of machinery and buildings, as well as fixed capital consumption, important expenditures of the dairy farms are associated with capital items.

Although the value added is the source of income of production factors, the actual level of factor costs is important in determining the overall cost level and return on farm produce and consequently the competitiveness of the farm both on the product market and also labour market. Wages forms the most part of factor costs in Latvia. In other EU countries factor costs are split almost evenly between wages, rent and interest paid.

However, paid labour constitutes a small part of the total labour input of dairy farms due to large family labour contribution that gives rise to opportunity costs. If costs of all labour input are considered, feed costs along with labour costs are the main costs positions of dairy farms in Latvia (Bratka and Prauliņš, 2009).

The analysis based on the interviews with dairy processors carried out by LSIAE in 2006, showed that the most important production cost item is purchase of raw milk material, accounting for about 70% of the total production costs. Other main costs positions include materials and services (about 19%), compensation for labour force (about 5%), energy (about 3%) and depreciation (about 2%) (Miglavs et al., 2006).

The analysis carried out by the author on marketing margins in dairy supply chain revealed that the share of farm gate price in liquid milk ex-farm price during 2004-2009 comprised 52%, the respective share for cheese is 62%.

Available information on intermediate costs in dairy processing enterprises reveals that these costs account for 81.3% of the production value in Latvia and 84.6% in the EU on average (Eurostat, 2009). Personnel costs account for 10.9% of the total intermediate and personnel costs in Latvia and 9.4% in other EU countries.

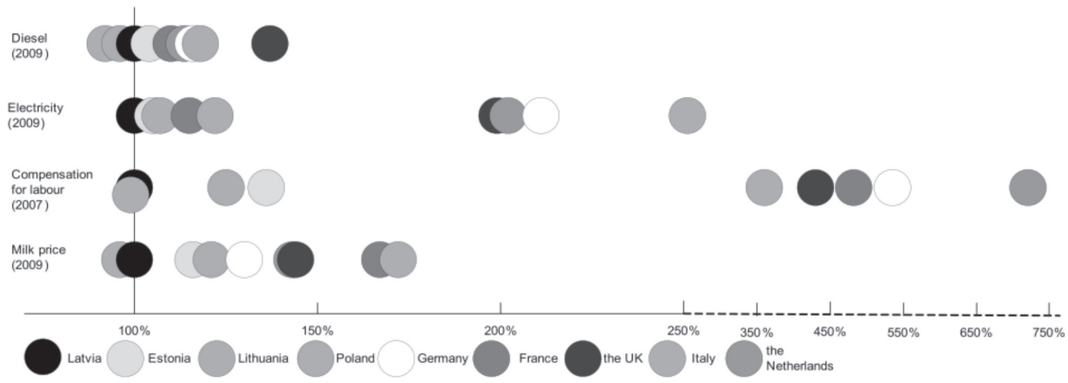

Figure 1. Comparison of the prices of the main production resources in Latvian primary milk production sector, compared to other EU countries.

Source: calculations by the author based on DG Agri, 2010; FADN, 2010; DG Energy, 2010

Considering the available information on production cost structure in dairy sector, the main cost items that determine the actual cost price of dairy products and the profit margin, and consequently the competitiveness of the sector include animal feed, compensation for employees, energy, depreciation and maintenance of machinery and buildings, as well as the interest associated to the purchase of capital items, rents and the value of purchased land, the value at which raw milk is available for processing industry, as well as other dairy product ingredients and materials.

The cost level per product item is determined both by the prices at which resources necessary for production are available for a producer and also by the resource utilization efficiency. Consequently, the resource prices show the potential competitiveness, but the actual competitiveness is achieved by the knowledge, managerial abilities, technologies and techniques by which the resources are turned into marketable product. At the same time it has to be acknowledged that productivity is closely connected with higher compensation levels for production factors that is logical considering that the same production factor creates more value added.

To compare feed price levels between Latvia and other analyzed countries, the data availability aspect has determined that feed barley prices were used. The comparison of the average prices in 2009 shows that feed prices were about 30% higher in Italy, 20% higher in the Netherlands, and almost 10% higher in France, as well as in the United Kingdom and Germany than in Latvia (see Figure 1). As France and Germany are the largest cereal and also barley producers in the EU, the average EU price is generally determined by the prices in these countries. Prices in Estonia were 4% higher than in Latvia, but the price level in Lithuania and Poland was below Latvian price level (accordingly by 7% and 3%). Although, the general trend in recent years has been that Latvia has one of the lowest prices in the EU that are below price level in Lithuania and Poland.

The available data for electricity prices (with excise tax, but without VAT) in 2009 reveal that Latvia has the lowest price level among the countries compared (see Figure 2). The prices in compared *old* Member States (except France) are from almost twice to more than two times higher than those in Latvia. Electricity prices in Poland are 22% higher than in Latvia, in neighbouring Estonia and Lithuania the price level was also slightly higher. The difference between prices of diesel is not so pronounced, with prices (with excise tax, but without VAT) ranging from 4% higher level in Estonia to 37% in the UK, and lower price level in Lithuania and Poland. However, if diesel prices excluding taxes and duties are compared, the price level in Latvia and other *new* Member States are even to 8% higher than in the *old* Member States (except Italy). This has to been taken into account considering that in some countries farmers can apply for excise tax compensation.

According to the latest available FADN data on labour compensation, the average wages paid per AWU (annual work unit – 1,840 hours within a year) by dairy farms in Latvia in 2007 were more than 6 times below the level observed in the UK and the Netherlands, and about 5 times less than in Germany, Italy and France. Also in Estonia persons employed by the dairy farms received twice as much as in Latvia. The compensation level in Latvia and Lithuania were almost on the same level, with 5% higher wages in Poland. The average level in the EU was 3.5 times above the level observed in Latvia.

The average monthly labour costs in Latvian dairy industry were lagging behind some other countries even more than on dairy farms (see Figure 2). If the monthly minimum wages in the second half of 2009 between countries are analyzed, employees in the Netherlands and France are guaranteed to receive 5 times more than the level observed in Latvia; however, minimum wages were lower in Lithuania and Poland (by 13% and 6% respectively).

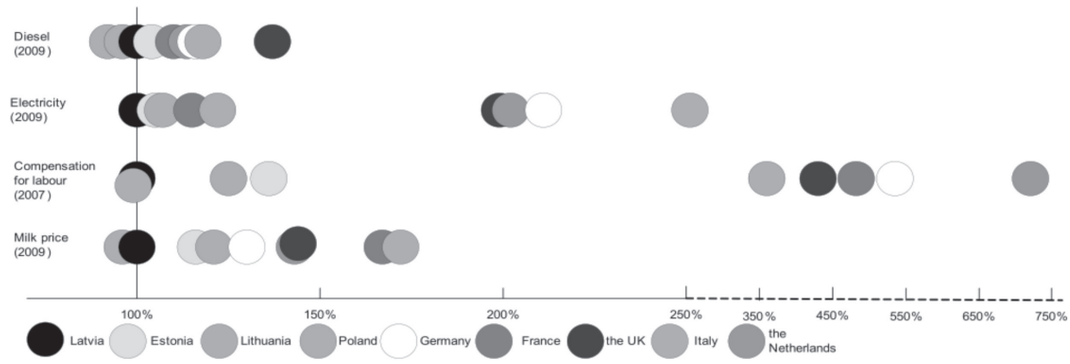

Figure 2. Comparison of the prices of the main production resources in Latvian milk processing sector, compared to other EU countries.

Source: calculations by the author based on DG Agri, 2010; Eurostat, 2010; DG Energy, 2010

The information on the prices of land and rents is scarce; however, from the available sources it can be concluded that the price level in *old* Member States is considerably higher than in Latvia. For instance, in the Netherlands that is characterized by very intensive land use, agricultural land costs about 30,000 EUR/ha.

During the year 2009, the average raw milk purchase price in Latvia was among the lowest in the EU, except Lithuania where farmers received even less. The highest milk price among the compared countries could be observed in Italy (by 72% higher than in Latvia), followed by France (+67%), the UK and the Netherlands (both +44%). The difference between Latvia and Poland was also 21% in favour of the latter. It has to be marked that Latvian raw milk prices have been the second lowest during all the EU membership period, with the price gap between Latvia and other EU-25 countries decreasing till 2006, and widening again afterwards. In 2007, the difference between Latvia and the EU average level was 21%.

No comparative data are available on capital items and also materials used in milk processing, but, considering that Latvia is importing these items, the prices should generally be at the EU level. Though, the prices could be higher in Latvia due to the fact that it is small market that increases transport costs per imported item. Nevertheless, higher costs of capital are distributed in a couple of years. It is known that cattle prices are considerably lower in Latvia.

It can be concluded from the resource price comparison that generally Latvia has resource price preference that gives preconditions for a lower cost level and consequently higher production efficiency.

The calculation results show that efficiency indicators in Latvian primary milk production sector are considerably lower (see Figure 3) and despite resource price preferences the cost level per production value in Latvia is higher than in other countries. It can be argued that Latvia has one of the lowest farm-gate price of milk; therefore, indicators based on costs per output value are increased in Latvia due to low milk price. Nevertheless, it shows the poorer ability to balance costs with the revenue and generally milk price is associated both with quality of milk supply and also farmers' bargaining power. The large differences compared to other countries and also generally better efficiency indicators in Lithuania (the country with the lowest milk price), confirm that Latvia has low resource utilization efficiency.

Referring to the calculation results at the main production costs level, the total feed costs per produced animal output in analyzed farms are EUR 0.30 in the EU on average; in Latvia, however, the cost level reaches EUR 0.55. The highest efficiency level can be observed in France and the Netherlands (EUR 0.20), that is almost 3 times better indicator than in Latvia. The ratio of feed costs and obtained animal output is also good in Poland; it is better in Lithuania as well and also slightly better in Estonia than in Latvia.

Energy efficiency is also the lowest in Latvia among the analyzed countries in relation to the obtained output. The energy costs per production value are EUR 0.12 in Latvia, compared to EUR 0.05 in the EU on average, EUR 0.06 in Poland, EUR 0.07 in Lithuania and EUR 0.08 in Estonia. The differences between the cost level in Latvia and other countries exceed the differences that could be explained by various price levels, consequently indicating on low energy utilization efficiency in Latvia. There is a tendency that southern countries have generally lower energy costs (e.g., Italy despite high prices); nevertheless, Estonia that is situated further north than Latvia achieves better results.

Differences in labour productivity of dairy farms between the analyzed countries are even more pronounced than the differences in compensation levels. Although the average output per labour force input (AWU) in the EU is 3.7 times Latvian level, in the Netherlands, labour productivity exceeds Latvian indicator almost 11 times, but in the UK – 9.4 times. Considering the very high productivity, compared to the average level, it seems logical that employees in the Netherlands and the UK are rewarded with the

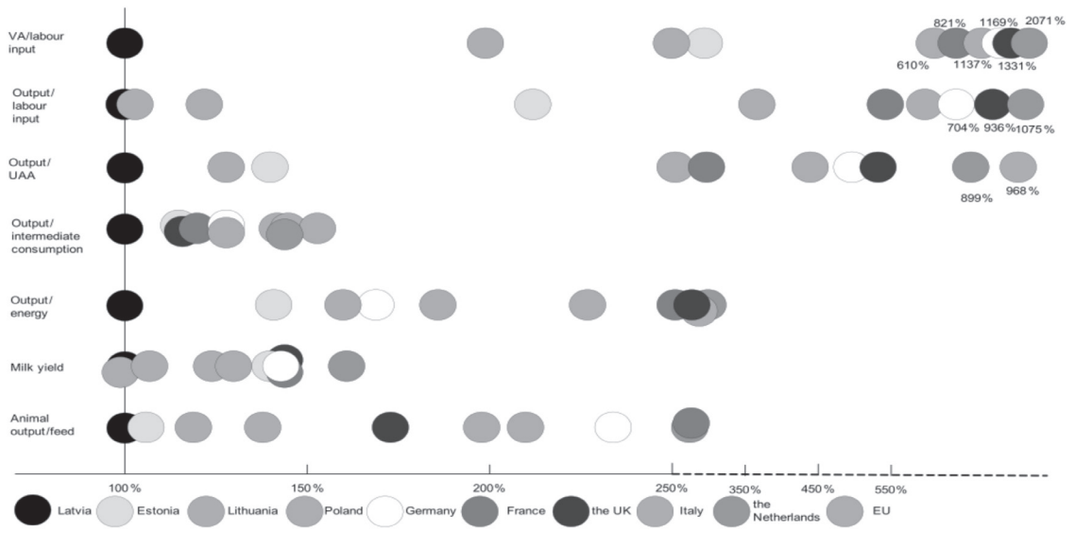

Figure 3. Efficiency indicators in Latvian primary milk production sector, compared to other EU countries.

Source: calculations by the author based on FADN, 2010; ADC, 2010

highest salaries among the analyzed countries. Labour productivity in Estonia is also 2.1 time higher than in Latvia, Poland excels by 22%, but in Lithuania it is almost at the same level as in Latvia.

When the gross value added (at producer prices) per AWU of dairy farms is analyzed, Latvia lags the efficiency of other countries very considerably – the EU average indicator exceeds Latvian level 6.1 times, but the Dutch productivity is almost 21 times than in Latvia (see Figure 3). Due to higher efficiency of intermediate consumption, Estonia, Poland and Lithuania have also considerably higher value added per employee.

There is also small production value per UAA in Latvia, compared to other countries (especially, the Netherlands). Considering the availability of land resources in Latvia, the low land utilization intensity currently is not a direct threat to future competitiveness of the sector, and it can have also some environmental benefits. At the same time, higher production value per UAA would compensate potential rise in land prices.

Latvian dairy farms are not in a good competitive position in terms of the intermediate consumption per production value. The indicator exceeds the average EU level by almost 30%, but the difference with Lithuania and especially Poland is more explicit, indicating that these countries have been able to use the lower resource price preference to some extent.

The position is also not good when the total input costs are considered - Latvia has by about 20% higher total costs per production value than in the EU on average; furthermore, they are almost at the same level as the total output value meaning that there is no place left for profit margin. It has also to be mentioned that in 2007, which is used for the comparison, milk prices were exceptionally high; in 2008 the total input already exceeded production value. Therefore, rising production costs can be only compensated by higher resource utilization efficiency, because the other option – increase in milk prices – should not be reasonable to count on as generally milk prices depend on the situation in dairy markets and even in this situation processing industry has higher bargaining power in setting prices, but in other cases rise in milk prices would cause problems for processing industry due to limited possibilities to absorb it and, therefore, is unlikely.

Latvia has comparatively high depreciation level per production value, compared to the EU level. The total interest paid has also increased in Latvia in recent years reaching the level of most of the *old* Member States, but the labour productivity as described before is far behind the EU average level that indicates on problems in providing reasonable ration between borrowed money and output. When looking at endowment of dairy farms with capital, Latvia has the lowest level of fixed capital among the compared countries. But the previous analysis shows that generally capital and labour are substituted which is a precondition for rise in productivity.

Although production efficiency in other EU countries is higher, generally the average EU dairy farm cannot generate from the market enough value added to fully cover all factor costs – both actually paid and opportunity costs (for family labour) - and those which are determined by the necessity to compete with other sectors of the economy. If only family labour force is considered as the only opportunity costs, then all costs from the market are compensated in all observed countries, except Germany, Estonia, France and Latvia. The costs in these countries are fully covered only by the contribution of subsidies. And despite lower support level per UAA, Latvia has the highest subsidies per production value that used

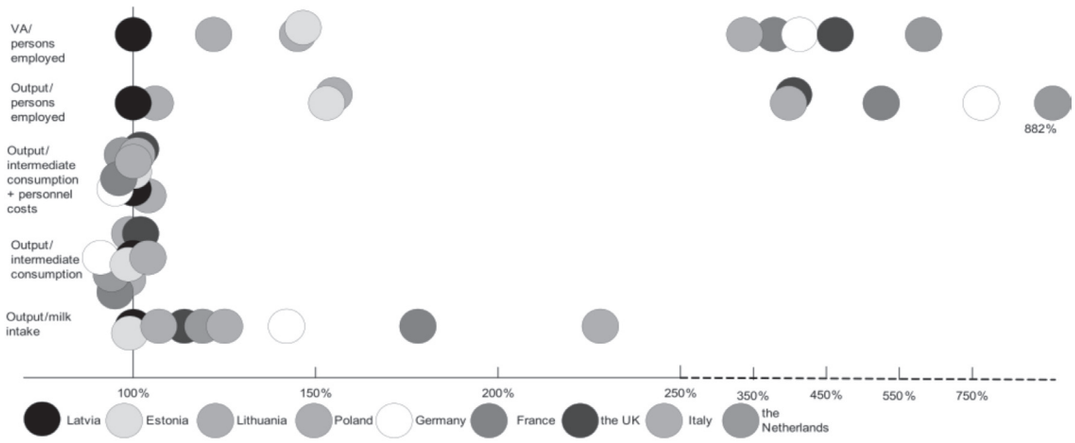

Figure 4. Efficiency indicators in Latvian milk processing sector, compared to other EU countries.

Source: calculations by the author based on Eurostat, 2010

to correct total input costs ensures that Latvia has the overall costs at the EU average level.

The analyzed resource utilization efficiency is low in Latvia also at the processing industry level, though the current price level of the main production resources helps to ensure competitive positions of Latvian dairy products. But considering large differences in compensation levels for labour force between Latvia and other EU countries, the current situation is not sustainable in long-term.

When looking at milk utilization efficiency, the comparison shows that other countries can add higher value to raw milk than Latvia. The gap between Latvia and other countries is more pronounced if the total collected milk in the country is considered, because none of the analyzed countries has such a high export of raw milk that does not make any contribution to the local processing sector. The corrected (by foreign trade data) milk intake volumes indicate that the leaders among the compared countries in producing value-added products are Italy and France (see Figure 4). These countries have the highest milk price that facilitates creation of higher value added at the primary milk production level, and it generally should be related to the possibilities to obtain higher value from the market which is demonstrated by the higher production value per milk volume. Besides, the calculated ration of milk purchase and production value confirm that despite higher milk purchase costs the processing sector in these countries add higher value to milk. The lowest created additional value among the analyzed *old* Member States could be observed in the UK, where the majority of raw milk goes into the production of liquid milk (DairyCo, 2009), and cheese accounts for comparatively smaller share in the total production than in other countries (IFCN, 2008). The *new* Member States demonstrate comparatively low productivity; the data on processing profile (IFCN, 2008) and calculated indicator show that these countries could be described as producers of base products.

The results of the comparison of labour productivity in dairy industry reveal that Latvia has lower efficiency than other countries. In terms of the production value per person employed, only Lithuania has comparative level, in other countries it is from 1.5 times (Estonia, Poland) to even 8.8 times (the Netherlands) of Latvian level. In Germany the indicator is 7.6 times that of Latvian level.

Contrary to the situation at the primary level, the differences between Latvia and other countries in gross value added per employed person are generally smaller than shown by the previous indicator (except Lithuania and the UK) suggesting that generally there is better ratio between intermediate consumption and production value in Latvia, though the differences with most of the countries are still considerable.

Latvian dairy processing sector has comparatively good overall costs level of intermediate consumption (represented by the total purchase of goods and services) per production value; only Lithuania and the UK has slightly better indicator. Based on the available data, the positions of Latvia is also good when intermediate costs together with personnel costs are calculated per production value; the situation is slightly better in Lithuania, the UK and Poland, as well as at the same level in Estonia and Italy. However, it has to be reminded that it is achieved at lower prices of some of the main production resources. If it is assumed that just salaries rise by 50% (the difference with the EU average level is considerably higher) or just milk purchase price rise by 15%, Latvia already starts to lose its competitive positions. But generally Latvian processing industry already has to compete with other countries in terms of labour force, a lot of people have used the possibility to go for work in countries with higher salaries, farmers also want a better price for their milk and are looking for other options that include export of raw milk to Lithuania. With the present production structure, organization and efficiency Latvian processing industry cannot ensure higher milk purchase prices and competitive

salaries that would contribute to the increase of the living standard of the employees. Without increase in the resource utilization efficiency any global rise in prices of the production resources will be more felt by Latvian industry as it means higher transmission of costs per produced unit. Since 2007 with the latest comparative data for dairy industry available, the average salaries in food processing have increased by almost 20%, but the milk average purchase price has decreased by 30%. Although prices of milk dropped in all EU countries, the decline in Latvia was among the sharpest, and the author assumes that it was already the indicator of weakening competitive position.

Although there are no available comparative data on costs associated with consumption of fixed capital, it has been suggested that production capacity in Latvia considerably exceeds the current production volumes increasing the fixed costs per produced unit (Miglavs, 2006) that further weakens Latvian competitive positions.

Conclusions

1. The main cost items in dairy sector include animal feed, compensation for employees, energy, depreciation and maintenance of machinery and buildings, as well as the interest associated with the purchase of capital items, rents and the value of purchased land, the value at which raw milk is available for processing industry, as well as other dairy product ingredients and materials.
2. Latvia has considerable price preference in compensation for labour force and land; the price level in Latvia is generally lower for energy and should be also for feed. Latvian processing industry also buys milk at comparatively low prices.
3. The efficiency indicators in Latvian primary milk production sector are considerably lower, with the largest difference in labour productivity (output is 3.7 times lower than in the EU on average), and despite resource price preferences the cost level per production value in Latvia is higher than in other countries (intermediate consumption is 28% above the EU average level).
4. The total inputs on Latvian dairy farms are at the same level as production value or even exceed it, leaving no place for profit margin.
5. Although production efficiency in other EU countries is higher, generally the average EU dairy farm cannot generate from the market enough value added to fully cover all factor costs – both actually paid and opportunity costs (for family labour) - and those that are determined by the necessity to compete with other sectors of the economy.
6. The analyzed resource utilization efficiency is low in Latvia also at the processing industry level, though the current price level of the main production resources helps to ensure competitive positions of Latvian dairy products.
7. There is low labour productivity in Latvian milk processing sector (for example, output is 7.6 times lower than in Germany); Latvian dairy industry also adds comparatively small value to the purchased raw milk and can be described as a producer of base products.
8. Considering the large differences in compensation levels for labour force between Latvia and other EU countries (3.5 times lower in primary production than in the EU on average, and, for example, 5.4 times below the indicator in the German processing sector), the current competitive position that is achieved mainly by lower resource prices and not high resource utilization efficiency is not sustainable.

To maintain the competitive position of Latvian dairy sector, the increase in resource utilization efficiency should be achieved. The increase in the share of high value added products would also ensure higher production efficiency in the sector. It is also important that the whole sector increases its bargaining power that would help to attract more value from the market, but on the condition that the efficiency distribution of the value among the players of the sector are ensured.

Acknowledgements

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INNOVATIVE COMPOSITION POULTRY PRODUCTS PRODUCTION

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Abstract. The production of innovative composition (high omega group fatty acids and antioxidants-carotenoids) broiler chicken meat and egg opportunities in Latvia was assessed. After feeding the poultry with feed enriched with fatty acids and antioxidants, broiler meat and eggs of innovative composition containing a higher amount of omega-3 (in meat by 1.7%, in eggs by 2.7%), omega-6 (in meat by 3.9%, in eggs by 3.2%) and carotenoids (0.44 mg kg^{-1} in meat and in eggs by 6.9 mg kg^{-1}) when compared with the content of commercial products are obtained. Nutrition costs of innovative composition-based broiler chicken meat production are LVL 20 higher and nutrition costs of egg production are LVL 1.49 higher per 1000 units of output than in the standard version of the poultry feeding-stuff. The poultry farming production of an innovative composition, however, is economically profitable due to the higher rates of poultry productivity. In the case of an innovative composition-based yield the potential profit at the currently equal cost realisation of poultry meat and eggs is higher when calculating 293.47 LVL per 1000 broiler chickens and 5.52 LVL per 1000 eggs in comparison with commercial production.
Key words: poultry, meat, egg, innovative composition.

Introduction

One of the poultry farming industry goals in Latvia is to obtain production that would integrate into the united European Common Market and compete with poultry production producers from other countries by means of their quality and costs. The highest competitiveness in the world market in the current situation is ensured mainly by innovative composition-based poultry meat and eggs of a high quality, ensured for consumers` health and safety. Innovative food-stuff, especially the functional food, contains biologically active substances, which favourably influence the vital human body functions, reduce risk factors of different diseases and promote health preservation (Zariņš and Neimane, 2002; Hasler, 2002).

It shall be noted that the world population and people in Latvia mostly suffer from cardiovascular diseases (WHO, 2003). The shortage of omega group fatty acids (linolenic acid and linoleic acid) and antioxidants (carotenoids) in everyday food products is one of the cardiovascular diseases risk factors. The ingestion of omega group fatty acids and antioxidants with nutrients enables metabolism of cholesterol in the human body, and averts risk factors causing cardiovascular, tumour, rheumatic, and other diseases (Aro, 2000; Connor, 2002; Kris-Etherton et al., 2004; Roberfroid, 2002). Therefore, one of the development directions in the poultry production industry is to ensure poultry and egg production, enriched with omega group fatty acids to improve the health of the population against various diseases (Pisulewski et al., 2005).

Fatty acids in the human body are, to a greater or lesser degree, exposed in oxidation processes. Free radicals, neutralised by antioxidants: carotenoids, selenium, vitamin E etc., originate due to the oxidation process of fatty acids. Hence, producing fatty acid-rich products, the content of antioxidants, especially carotenoids shall be increased (Pappas et al., 2005). It shall be specified that studies are being carried out on the production of innovative composition broiler chicken meat. Researchers in Estonia have studied possibilities on increasing omega-6 and omega-3 fatty acids in broiler chicken and quail meat and fat (Hämmal et al., 2000; Tikk, 2002).

In 1997, Leskanich C.O. and Noble R.C. already ascertained, and in later years several scientists (Wenk et al., 2000; Gonzales-Esguera and Leeson, 2001) confirmed that omega group fatty acids can be increased in the avian muscle tissues and eggs when feeding poultry with omega group fatty acids-rich feed-stuff.

The yield of innovative composition poultry products is based on avian feed composition enrichment with fatty acids-contained feeding stuff. Various poultry companies include vegetable oils (linseed, rapeseed oil) as well as fish oil, kelp, synthetic substances, etc. in the avian feed list of ingredients (Bou et al., 2004). For fatty acids stabilisation the carotenoid, especially β-carotenoid, vitamin E, vitamin C, selenium and other antioxidants are used (Pappas, 2005). Avian feed nutrition costs are increased by addition of these oils and antioxidants to a poultry feed. This accordingly means that the poultry products of innovative composition - meat and egg production require higher expenditures, thus, resulting in higher realisation prices than in commercial production of a conventional composition. Product prices of innovative poultry products in the Great Britain vary substantially; they are analogous to poultry product prices obtained in biological agriculture production process, which is typically twice higher than conventional prices. The differences in prices are determined by the costs for additional feeding stuffs, included in the avian nutrition (Michelle, 2000). The first trials to produce avian eggs of an innovative composition containing high omega group fatty acids content have been launched in Latvia. “Balticovo” JSC produces “eggs that strengthen the heart” while broiler chicken meat of an innovative composition is not being produced. Therefore, a production of innovative broiler chicken meat and egg products requires an economic and

scientific assessment. In this aspect, zootechnical and economic interdisciplinary study was carried out.

The research hypothesis: Production costs of innovative composition broiler chicken meat and egg exceeds production costs of commercial composition poultry. The research aim: to assess economic aspects for production of innovative broiler chicken meat and eggs. The following tasks are defined to achieve the set aim:

1. To clarify the quality of available feeding stuff in Latvia and costs of avian feeding for the production of innovative composition meat.
2. To assess quality of innovative composition broiler chicken meat and eggs as well as production profitability.
3. To explore the general preconditions for production of innovative composition broiler chicken meat and eggs in Latvia.

Materials and Methods

The studies were carried out at the Research Institute of Biotechnology and Veterinary Medicine "Sigra", the Latvia University of Agriculture. The author of the study group examined practical poultry nutrition, statistical and economic data processing and evaluation. Trial with cross ROSS 308 broiler chickens of a high productivity, grown in Latvia, at the age of 0 to 42 days old, and cross Lohman Brown laying hens at the age of 22-42 weeks old was carried out, the period of research: 2008-2009.

In order to obtain broiler chicken meat and eggs of an innovative composition, poultry was fed with nutrition enriched with fatty acid-containing feeding stuff: flaxseed and rapeseed oils in combination with conventionally used oils in poultry feeding: soya bean and sunflower oils. The studies were carried out at the Research Institute of Biotechnology and Veterinary Medicine "Sigra", the Latvia University of Agriculture, by the group of scientists with the participation of the author and in accordance with the scheme shown in the Table 1.

The following poultry productivity key figures were calculated during the trial period – live-weight, feed to gain, number of eggs, preservation, etc. The content of linolenic acid (omega-3 group fatty acid) and linoleic acid (omega-6 fatty acid) were analysed in flaxseed and rapeseed oils produced in Latvia by "Iecavnieks" and in soya and sunflower oils import purchased for the trial.

Fatty acid content of omega group was determined in broiler chicken muscle tissue in the age of their realisation, i.e. in 42 days of age, and in chicken eggs in the 3rd and 4th month of laying, i.e. in the 30 and 34 weeks of age. Fatty acids have been analysed with gas chromatograph and mass selective detector device Hewlett Packard. Generally approved research methodology of economic science was applied for data assessment.

Results and Discussion

Quality and costs of applied feeding-stuff for innovative poultry products production in Latvia

One of the most important conditions in production of an innovative broiler chicken meat and layer egg which contains an increased level of omega group fatty acids and antioxidants is the quality of feeding stuff used in avian feed according to omega group fatty acids content. Omega group fatty acids are found mostly in such feeding stuffs as flaxseed, rapeseed and soya bean oils. Rapeseed and flaxseed oil in Latvia is produced from locally grown canola and flax. Oil production amount and quality is sufficient to be used in poultry feeding mixtures and to develop the production of broiler chicken meat and layer eggs in Latvia, which contains increased amount of omega group fatty acids – antioxidants. The largest omega-3 fatty acid content was observed in flaxseed oil constituting 55%, which exceeds the respective figures in rapeseed oil and soya bean oil for 6-7 times. The largest omega-6 amount is observed in soya bean oil which constitutes up to 54%, if calculated in per cent of the total lipid amount. It is 3-4 times higher than in rapeseed oil and flaxseed oil. One kilogram of flaxseed oil contained most omega-3 and omega-6 fatty acids, namely, 666 g kg^{-1}, while the least amount was detected in rapeseed oil, so the difference is 2 times. One kilogram of flaxseed oil contained 539 g of omega-3 and 127 g of omega-6 fatty acids. According

Table 1

Trial Scheme for Production of Innovative Composition Poultry Meat and Eggs

Group	Feeding programme	
	Broiler chicken n=50	Laying hen n=40
1st control*	Basic feed + 4% soya bean oil (Basic feed + 4% soya bean oil (food content of commercial mass production)	Basic feed + 2% soya bean oil (Basic feed + 2% soya bean oil (food content of commercial mass production)
2nd trial **	Basic feed + 1% flaxseed oil + 1% rapeseed oil + 2% soya bean oil + 0.15% complex antioxidant additive	Basic feed + 1% flaxseed oil + 1% sunflower oil +0.15% complex antioxidant additive

* broiler chicken meat and laying hens of commercial mass production are obtained from the 1st group poultry
** broiler chicken meat and laying hens of innovative composition are obtained from the 2nd group poultry
Source: according to the unpublished data of the Research Institute "Sigra"

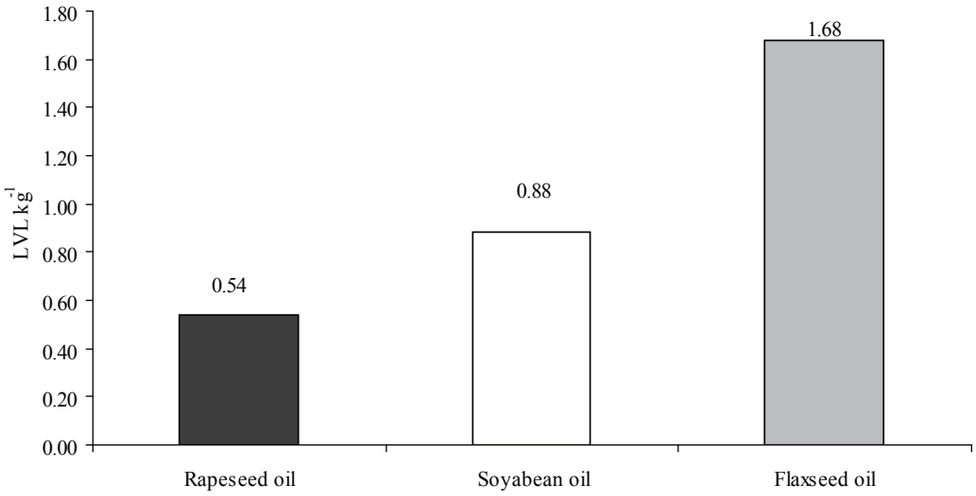

Figure 1. Vegetable oil sales prices of "Iecavnieks" Ltd. and "Rīgas kombinētās lopbarības rūpnīca" Ltd. from December 1, 2009, LVL kg^{-1}.

Source: made by the author according to the producers' sales prices

to the total content of omega-3 and omega-6 fatty acids, flaxseed oil was the most valuable feeding stuff, though it was also the most expensive one (Figure 1). The total content of omega-6 and omega-3 fatty acids in flaxseed oil is 666 g kg^{-1} and its price equals to 1.68 LVL kg^{-1}. Out of the two analysed fatty acids in the composition of innovative products exactly omega-3 fatty acid has a special physiological significance in a human body. The majority of conventional food products contains insufficient amount of omega-3. Hence the content of omega-3 in the used feeding stuff is of great importance, and the larger the content of omega-3 in the used feeding stuff, the greater the possibility that the obtained innovative product contains larger content of fatty acids. The prices of vegetable oils supplied by "Iecavnieks" Ltd. and "Rīgas kombinētās lopbarības rūpnīca" Ltd. valid from December 1, 2009 is shown in Figure 1.

The quality of innovative broiler chicken meat and eggs, the production benefits

In production of innovative broiler chicken meat, broilers are fed with a nutrition mix that contains flaxseed oil in combination with rapeseed and soya bean oils and antioxidants - carotenoids-containing additives.

After feeding the broiler chickens with fatty acids and antioxidants enriched feed, omega-3 fatty acid content in the muscle tissue increased by 1.7%, omega-6 fatty acid content - by 3.9%, carotenoid amount - by 0. 44 mg kg^{-1} in comparison with conventional mass-produced poultry products, see Table 2.

In order to obtain innovative layer eggs containing increased content of omega-3 and omega-6 fatty acids and antioxidant carotenoids when compared with conventional composition eggs, flaxseed oil was used in combination with sunflower oil and carotenoids-contained additive in feed nutrition mix to hens. The nutrition food of this composition makes it possible to increase the amount of omega-3 fatty acids in egg yolk by 2.7% , omega-6 fatty acids by 3.2%, carotenoid content by 6.9 mg kg^{-1} but reduce the cholesterol level by 7.8 mg% when compared with conventionally produced egg composition, see Table 3.

Table 2

Quality of an Innovative Composition Cross ROSS 308 Broiler Chicken Meat

Composition indicators	Conventional composition-based food fed to broilers	Food enriched in fatty acids and antioxidants fed to broilers	+ against feeding of a conventional composition
∑ fatty acids, % of total lipids: Σ omega-3 (ω-3) Σ omega-6 (ω-6)	 6.9 25.1	 8.6 29.0	 +1.7 +3.9
∑ total carotenoids, mg kg^{-1} (antioxidant)	0.42	0.86	+0.44

Source: according to the unpublished data of the Research Institute "Sigra"

Table 3

Quality of an Innovative Composition Cross Lohmann Brown Layer Eggs

Composition indicators	Conventional composition-based food fed to layers	Food enriched in fatty acids and antioxidants fed to layers	+ against feeding of a conventional composition
Fatty acids, % of total lipids: Σ omega-3 (ω-3) Σ omega-6 (ω-6)	 3.4 15.8	 6.1 19.0	 +2.7 +3.2
Total carotenoids, mg kg^{-1}	16.5	23.4	+6.9

Source: according to the unpublished data of the Research Institute "Sigra"

The use of rapeseed and flaxseed oils grown in Latvia as well as antioxidant additives in poultry feed composition made it possible to obtain food of a higher-quality: broiler chicken meat and layer eggs with high content of fatty acids and carotenoids.

To obtain innovative broiler chicken meat and eggs, the price for poultry nutrition feeding is approx. 2.0-4.2% higher than the price for feeding of conventional composition. Feeding enriched in fatty acids increased the poultry productivity by approx. 2.5-4.7%.

According to the trial data, feeding broilers with feed enriched with fatty acids resulted in 195.92 kg more of the carcass weight of innovative composition broilers (calculating per 1000 broilers) than the carcass weight of broilers fed with conventional composition feed (Group 1). Feed consumption costs for broilers at poultry farms draw up of ~ 73% -76% of the total costs. In trial the expenses of commercial business per 1000 breeding broilers were 1485.00 LVL, but expenses enriched with fatty acids and antioxidants were 1505.00 LVL, i.e., LVL 20 higher than in a standard variant. Income from sales of innovative poultry amounted to LVL 293.47 more (calculated per 1000 broilers) than from the 1st group (both broiler meat groups have the equal sales). These financial results have been obtained due to the higher indicators of poultry preservation, and mainly due to the fact that live-weight of the broilers fed with nutrition enriched with fatty acids and antioxidants were relatively higher than in the control variant. It shall be noted that the broiler meat of trial groups had the highest omega-3 fatty acid content and the optimum ω-6: ω-3 fatty acid ratio, the broiler meat of this group had a top quality and the highest broiler live-weight in the age of 42 days. Consequently, even at the same broiler sales prices healthier products of a higher value have been obtained, and total revenue for producer might be for approx. 15% higher than in the standard broiler chicken feeding.

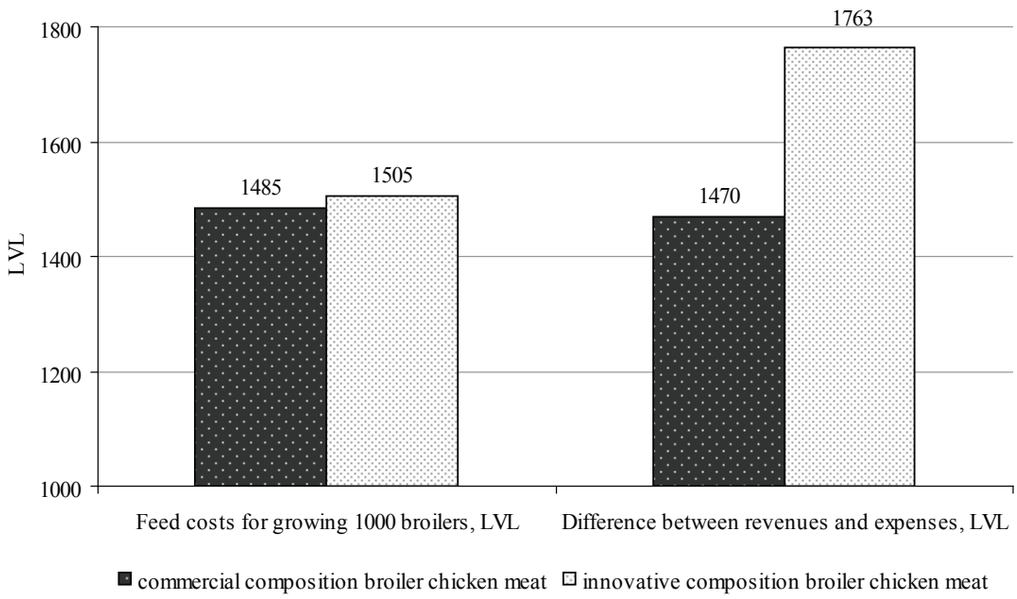

Figure 2. Economical efficiency of innovative broiler chicken meat production (calculating per 1000 broilers) in comparison with conventionally produced broiler chicken meat, LVL.

Source: made by the authors according to the unpublished data of the Research Institute "Sigra"

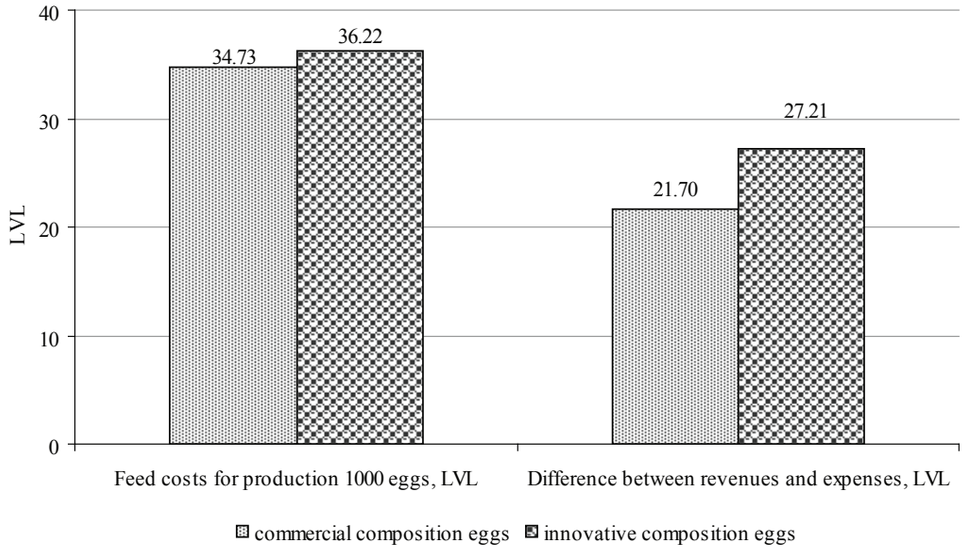

Figure 3. Economical efficiency of innovative hens` egg production (calculating per 1000 eggs) in comparison with conventionally produced hens` eggs (in the period of laying from 22-24 weeks old).

Source: made by the authors according to the unpublished data of the Research Institute "Sigra"

Accordingly, it is economically profitable to produce and sell eggs of an innovative composition. To obtain 1000 eggs of conventional composition under trial conditions, 135.15 kg of feeding was consumed with costs of LVL 34.73. While production of innovative composition eggs accounted for 138.76 kg of feed, the costs were LVL 36.22. In comparison with the control group of 1000 egg production, feed consumption was higher for about LVL 3.61, and food consumption costs respectively were about 1.48 LVL higher than in the conventional composition egg production. The price of innovative composition egg could be LVL 0.007 per egg, or 10.3% higher than of an egg of conventional composition. The raised sales price of innovative eggs covers the increased costs of feeding consumption and made it possible to obtain additional revenues of LVL 5, 52 from 1000 egg sales, or revenue of innovative composition egg sales was increased by 25.3% at other constant factors of production.

As a result, an innovative composition broiler chicken meat and layer egg production allows the company to increase revenues and provide consumers with the healthy foods that are necessary in everyday food products.

Preconditions for production of innovative composition broiler chicken meat and eggs in Latvia

According to the study data, Latvia has all the possibilities to develop production of innovative composition broiler chicken meat and eggs. The existing poultry companies have highly advanced production technologies that comply with the standard requirements of the European Union. Produced amount of poultry production provides the consumer demand for eggs and meat. In 2008, 23.1 thousand tonnes of poultry meat were produced, and 601.7 million eggs (according to LR CSP (Central Statistical Bureau of Republic of Latvia) data).

Only cross poultry of high productivity is grown for poultry meat and eggs: Hibro-G, Ross 308, Kob (Cobb) cross poultry for broiler meat production; Lohmann Brown, Hisex Brown, ISA Brown etc. layer crosses for egg production.

In Latvia, the biggest poultry producers are "Lielzeltiņi" Ltd. and "Putnu fabrika Ķekava" JSC. Latvian consumers have increased the demand for poultry meat. Poultry meat production costs are lower than pork and beef costs. Poultry is produced in a shorter period of time when compared with pork and beef, due to the fact that poultry has more intensive metabolism and precocity. Currently there are 14 hen egg-production companies with their own sorting and packaging workshops operating in Latvia. "Madona" JSC, "Daugavpils putni" Ltd., "Co priedes" Ltd. and "Balticovo" JSC are the largest egg production companies. In order to increase the poultry business competitiveness and export, it is recommended to produce poultry meat and eggs of an innovative composition. It is recommended for poultry producers to organise an image recognition of innovative composition poultry produced in Latvia by specifying their quality, beneficial effects on consumer health and safety, and product traceability from a producer to a consumer.

Conclusions

1. The research hypothesis - excess of production costs of innovative composition broiler chicken meat over production costs of commercial composition broiler chicken meat has been proved, as the feed

costs for production of innovative composition broiler chicken meat are LVL 20 higher and egg production costs of feed consumption per 1000 production units are 1.49 LVL higher than in a standard feeding variant.
2. Broiler meat and chicken eggs of an innovative composition containing an increased amount of omega-3 (in meat by 1.7%, in eggs by 2.7%), omega-6 (in meat by 3.9%, in eggs by 3.2%) and carotenoids (in meat 0.44mg kg^{-1}, in eggs by 6.9 mg kg^{-1}) when compared with the content of commercial production composition is obtained by feeding poultry with fatty acids and antioxidants enriched feed.
3. Economic calculations on the possible economic profitability of broiler chicken meat production carried out during the experiment, led to the conclusion that based on higher avian productivity indicators, also the potential profit at presently equal poultry and egg sales price is higher in case of innovative composition broiler chicken meat production when calculated per 1000 broilers - by LVL 293.47 and calculated per 1000 chicken eggs - by LVL 5.52.
4. For innovative poultry meat and egg production the poultry company has no need to change production technology and rearing avian cross.
5. To launch innovative broiler chicken meat and egg production, which contains increased content of omega-3 and omega-6 fatty acids and antioxidant carotenoids, it is necessary to promote the research data in poultry companies in Latvia.
6. In the same way consumers educating about the positive role of innovative broiler chicken and egg usage in food should also be provided.

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BIOECONOMIC ASPECTS OF DEER FARMING IN LATVIA

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Abstract. Carcass quality in deer and purchasing prices in comparison with beef carcass quality and purchasing prices were assessed in the research from the bio-economic aspect. Specific gravity of muscle tissue in deer carcass in comparison with specific gravity of cattle carcass component was 13.2% higher and specific gravity of bone tissue was 2.8% higher, but adipose tissue was 16% less. Venison quality was higher than beef quality. In venison when compared with beef a cholesterol level (45.2 mg %) was 31.8 mg % lower, but crude protein content was 2.9% higher (23.4%). Meat quality index was 26.0, which is 8.9 higher than in beef. These indicators characterise venison as a healthy product of higher quality for consumer food in comparison with beef. Purchasing price (LVL 4.21 per kg) of venison carcass in 2009 was 1.6 times higher in comparison with beef carcass purchasing price. Research results lead to the conclusion that deer farming products on the market can be positioned as a high-quality, nutrient-rich food with higher sales price than one of beef.
Key words: deer farming, venison, meat quality, purchase price.

Introduction

One of the most perspective, potentially capable of export and rapidly growing non-conventional livestock farming industry is wild animals raising including breeding of deer in captivity. 70 farms were engaged in deer breeding in 2009. Latvian Wild Animal Breeders Association (SDAA) united 37 members, and in 2009, within its frame there were 26 fully developed deer gardens with a total fencing area of 8000 ha and 7500 different breeds of wild animals. Basically the red deer (*Cervus elaphus*) - 66% had been bred at farms, and few fallow deer *(Dama dama*) - 12%. There are approximately 30 fully established wildlife gardens running separately from the framework of association in which red deer, fallow deer, wild boars and other wild animals are reared. Other 10-15 wildlife gardens are currently under way (SDAA, 2009). Wild animals breeding in captivity makes it possible to supplement the market with food products of different animal assortment.

Conditions for animal keeping in deer gardens bear resemblance to wild conditions. Deer at farms live in the open air for a whole year; they are kept in small herds, fenced areas or enclosures. According to Animal Protection Law by the Republic of Latvia, the section 13, wild animals, including deer that are kept in enclosed areas for the acquisition of products of animal origin or for the purposes of species selection shall also be considered to be animals kept for farming purposes (Animal Protection Law, 1999).

Deer raising farms in Latvia specialize in three main areas - breed animal raising, meat production and animal raising for hunting trophy purposes. Not infrequently, the farms go for the fourth area of activity - agrotourism, which successfully combines the above-mentioned areas of activities (SDAA, 2009; Paeglītis et al., 2006). The main source of income in deer-breeding is a meat production (Paeglītis et al., 2006; Tuckwell, 2003; Fletcher, 1989). In 2008, SDAA members implemented a total sale of breed red deer amounting to LVL 333 701.64 and exported 8.6 tons of meat production (Agriculture and Rural Areas of Latvia, 2009), and within the framework of cooperative "BG Exsport" (SDAA) 100 breed animals - approximately 11 tons of venison were exported in 2009. Most part of farms are now engaged in herd increasing, so only 10-15% of the total amount of animals kept in deer gardens are being implemented for meat realisation. In some works by individual authors it is mentioned that the most profitable income in deer raising farms is brought by trophy hunting (Holst, 2002), consequently the development of this area shall also be viewed as a perspective in Latvia. One of the increasing factors for competitiveness in cattle breeding production in the aspect of economic globalisation is a high-quality production. A quality concept in food production is defined as the quality set of the product based on the property ability to satisfy consumer needs while the production quality is assessed as one of the basic elements of the economic development in competitive production (Mihejeva, 1999). Deer meat quality has an essential role in deer breeding bio-economy determining its` market niche and product prices. The studies show that most part of consumers associate price level with a product quality, the production price to some extent is perceived as a fixed social status symbol (Upīte, 2000).

So far, venison usage in food in Latvia has not been sufficiently popular, since pork and beef has been used as the main meat production. Venison consumption is prevented by both insufficient knowledge on its` quality and a lack of market recognition. So far, farm-raised venison in Latvia could be purchased only in certain shops. Venison products sold in supermarkets are mainly imported frozen meat from New Zealand.

It shall be stressed that consumer knowledge about venison as a high quality product is quite poor. Under conditions of Latvia, no significant research in the deer breeding industry has been done; therefore, bio-economic in-depth studies are required that will position the deer breeding products on the market as a high-quality, nutrient-rich food.

Consequently, the following **research object** has been defined – bio-economic indicator analysis of venison production. The research **hypothesis:** Venison

quality and purchase prices of carcass are relatively higher than in beef quality and its` purchase prices. The research **aim** was to assess the qualitative and quantitative indicators of venison raised in captive and the purchase prices in comparison with the respective beef indicators.

Tasks of the set aim:

1. To clarify specific gravity of deer carcass components;
2. To study venison quality of deer kept in captive;
3. To assess the purchase prices of venison and beef carcasses.

Materials and Methods

Both qualitative and quantitative indicators of captive bred red deer (*Cervus elaphus*) by agricultural holding "Saulstari-1" from age of 16 to 18 months old (n_1=6) were carried out for studies performance purposes. The obtained data were compared with the 1st grade cross LBxHE (Latvian brown x Hereford) beef qualitative and quantitative indicators (n_2=7) raised in biological farming system in agricultural holding „Kalna Bērziņi". Age of cattle: 15 - 18 months.

Venison and beef quality was assessed according to the dry matter, crude protein and fats, cholesterol and crude ash content in muscle tissue. Biochemical analysis was carried out by the Research Laboratory of Biochemistry and Microbiology of the Research Institute of Biotechnology and Veterinary Medicine "Sigra" of Latvia University of Agriculture, according to ISO standard method (LATAK reg. № LATAK-T-038-06-99-A). Specific gravity of deer and cattle carcass components was assessed according to the actual abattoir data.

According to the study data, meat quality index was calculated as follows: crude protein ratio in muscle tissue (%) against the crude fat amount in muscle tissue (%). Energy value of meat was calculated according to formula applied in nutrition science: [dry matter % - (fat% + ash %)] x 4.1 + (fat% x 9.3) (Zariņš and Neimane, 2002).

The information by Latvian Wild Animal Breeders Association (SDAA, 2009) was used for data assessment, as well as venison and beef purchase prices published by the Agricultural market promotion centre (LTVC, 2009).

Appropriate qualitative and quantitative economic research techniques - monographic descriptive, grouping and comparing data, methods of analysis and synthesis were applied for handling of research data, and a non-parametric method (Mann-Whitney U test) was applied for data comparison. Two independent variables – count of deer (n_1=6) and count of cattle (n_2=7) were compared at the essentiality level α=0.05.

Results and Discussion

There are widespread endeavours in the world to produce food-stuffs characterised by specified quality. The investigations carried out to determine market strategy influence on production profitability indicate that high correlation between corresponding products quality and enterprise profitability exists (Miller, 1993). The primary production of animal husbandry is connected with living organisms that in large extent influences economic effectiveness of the whole production. The quantitative and qualitative indices of obtained products are directly dependent from such factors as animals' species, breed, climate and welfare conditions, and physiological processes in organism, which directly or indirectly influence product quality.

The quality of deer and cattle carcasses is basically determined by ratio of muscle tissue, connective tissue, adipose tissue and bone tissue amount and nutritional value indexes. According to literature data, the meat of the highest quality is obtained from young stock deer usually slaughtered at the age of 14-16 months, their carcass weight at this age amounts approx. to 60 kg (Vigh-Larsen, 1987). The age of slaughtered deer assessed in the trial ranged from 16 - 18 months and their carcass weight ranged from 63.0 to 69.1 kg, an average was of 66.0 kg (Table 1). Specific gravity of components in carcass of the 1st grade cross LBxHE (Latvian brown x Hereford) beef (15-18 months of age) was comparatively assessed; their average carcass weight was 240.0 kg, which corresponds to a cross standard carcass weight.

Table 1

An average component mass and specific gravity of deer and cattle carcasses

Species	Average carcass weight	Muscle tissue mass		Bone tissue mass		Adipose tissue mass		Correlation mass of bone tissue and muscle tissue
	kg	kg	%	kg	%	kg	%	
Red deer (*cervus elaphus*)	66.0	47.7	72.2	13.7	20.8	4.6	7.0	3.5
Cattle (LBxHE)	240.0	141.6	59.0	43.2	18.0	55.2	23.0	3.3

Source: made by the author according to the Research Institute "Sigra", 2009

As it is seen from Table 1, in organic farms cattle carcasses the specific weight of high value beef (muscle tissue) was essentially (α=0.05) less, but increased average value (fat tissue) specific weight in comparison with corresponding deer meat carcasses components. Specific gravity of muscle tissue (lean meat) in red deer (*Cervus elaphus*) carcasses was approximately 72.2%, i.e., 13.2% more than the specific gravity of lean meat in beef carcass (Table 1). Whereas a specific gravity of adipose tissue mass in red deer carcass was 7%, i.e. approx. of 16% less than the specific gravity of adipose tissue in beef carcass. Bone tissue mass in red deer carcass drew up 20.8%, i.e. 2.8% more than a specific gravity of bone tissue mass in beef carcass. Correlation mass of muscle tissue and bone tissue in deer and cattle carcass did not differ significantly (α=0.05, n_1=6, n_2=7), and it was respectively 3.5 and 3.3. The research data on a specific gravity of deer carcass components are similar to the research data mentioned in literature by other authors (Paeglītis et al., 2006; Vigh-Larsen, 1987). Overall assessment shows that according to the specific gravity of muscle tissue and bone tissue mass, red deer carcass quality was higher than beef carcass quality.

The qualitative indicators for venison are one of the factors that make it possible to take a certain market niche as a product of superior quality. The row of meat quality indices was evaluated in this aspect that determines products dietetics value and consumers state of health.

The mass of deer muscle tissue contained approx. 24.3% of dry matter, 23.4 % - crude protein, 0.9% - crude fat and 45.2 mg kg^{-1} cholesterol. Venison in comparison with beef contains more of dry matter (about 1.2%), crude protein (2.9%) and crude ash (0.5%) (α=0.05, n_1=6, n_2=7) (Table 2).

Cholesterol level in diet influences its content in blood to part of people, that can be considered as cardiovascular diseases risk factor and promotes arteriosclerotic changes in organism. Constantly increased cholesterol level taken up with diet can unfavourably influence human health.

A special notice shall be taken to the fact that a cholesterol level (by 31.8 mg kg^{-1}) and total fat amount (by 0.3%) are less than in beef (α=0.05, n_1=6, n_2=7). The results of investigation testify, that deer meat is healthier for a consumer than beef.

Meat quality is essentially characterised by amino acid tryptophan and oxiproline amount ratio. The amount of amino acid tryptophan in meat determines the richness and quality of protein. The higher level of tryptophan amount defines higher quality of meat. The amount of amino acid oxiproline characterises the fibroidity and the leatherity of meat. So the meat quality is lower. Amino acid tryptophan and oxiproline amount ratio were analysed for characteristics of meat nutritional value (Мысик and Белова, 1986).The amino acid ratio in venison was 3.1, which is about 0.8 lower when compared with the ratio of amino acids in beef (3.9). The level of amino acid oxiproline was elevated, the meat was more stringy. The amount of tryptophan was of equal level both in venison and beef; therefore, tryptophan and oxiproline amount ratio were lower in venison, compared with beef. Such a slightly lower ratio of tryptophan and oxiproline in meat does not reduce nutritional value in venison (Table 3).

Nutritional value of meat is also characterised by the meat quality index. The higher is meat quality index, the higher is meat quality. The meat quality index of venison was 26.0, i.e. 8.9 higher than the beef quality index (17.1) (Table 3). Thus, venison quality was higher than the beef quality when assessed according to meat quality index.

Energy value in venison was 99.4 kcal per 100 g^{-1}, the energy value in beef was 96.9 kcal per 100 g^{-1}.

Table 2

Comparison of venison and beef quality indicators

Species	Dry matter,%	Crude protein,%	Crude fat, %	Crude ashes, %	Cholesterol, mg kg^{-1}
Venison (*Cervus elaphus*)	24.3	23.4	0.9	1.2	45.2
Beef (LBxHE)	23.1	20.5	1.2	0.7	77.0
+/- to venison	1.2	2.9	-0.3	0.5	-31.8

Source: made by the author according to the Research Institute "Sigra", 2009

Table 3

Tryptophan and oxiproline ratio, meat quality index and energy value of venison and beef

Species	Tryptophan and oxiproline ratio	Meat quality index	Energy value of meat, kcal $100g^{-1}$
Venison (*Cervus elaphus*)	3.1	26.0	99.4
Beef (LBxHE)	3.9	17.1	96.9
+/- to venison	-0.8	8.9	2.5

Source: made by the author according to the Research Institute "Sigra", 2009

Table 4

The purchase prices of beef and venison carcasses in 2006 – 2009 in Latvia LVL kg^{-1}

Indexes	2006	2007	2008	2009*	Mean in period
Venison, LVL	2.45	2.90	3.15	4.21	3.18
Beef, LVL	1.22	1.27	1.56	1.64	1.42
+/- to venison, LVL	1.23	1.63	1.59	2.57	1.76
% to venison	101.6	128.5	101.4	156.7	122.07

Source: made by the author according to SDAA, personal communication, 2010, LTVC, 2009; *provisional results

The energy value in venison estimated in the research was practically equivalent to the energy value in the beef, the differences are not significant (α=0.05, n_1=6, n_2=7). Correspondingly to chemical composition properties deer meat production has higher diet value in comparison with analysed beef meat during the investigations.

As it is known, product quality, consumers' satisfaction and enterprise profitability are mutually closely connected factors. Higher quality indices create higher consumer satisfaction by giving possibility to sell products by significantly higher prices (Kotlers, 2006). It is possible to sell by significantly higher prices only products of the highest quality.

The purchase prices of venison and beef carcass in Latvia were comparatively assessed in the period from 2006 – 2009. The research ascertained that during this period the average price of a deer carcass ranged from LVL 2.45 to 4.21 per kg (Table 4).

The average purchase price of venison carcass in 2006 was LVL 2.45 per kg, namely it was LVL 1.23 per kg higher than the purchase price of beef carcass. It was observed that in the period between 2006 – 2009 the venison carcass purchase prices increased rapidly. In comparison with the year of 2006, the purchase price increase was: in 2007 - by 18%, in 2008 - 29% and in 2009 - 72%. Purchase price of venison in 2009 mounted to LVL 4.21 per kg exceeding beef purchase price by 1.6 times or by 2.57 LVL kg^{-1}

During the period 2006 – 2009 the purchase price of the beef carcass has also been increased. In comparison with the year 2006, the purchase price increase was: in 2007 - by 4%, in 2008 - 28% and in 2009 - 34%. In 2009 the purchase price of beef mounted to LVL 1.64 per kg.

Over the analysed period, a venison carcass price was about 1.2 times higher than that of beef. In 2009, the average purchase price of venison carcass exceeded the beef carcass purchase price by 1.6 times or 156.7%. It is related to a high quality of venison and unsaturated market niche with unconventional assortment of meat production in Latvia.

Conclusions

1. Deer carcass quality and purchase prices in comparison with beef carcass quality and purchase prices have been considered.
2. High value meat (muscle tissue) specific weight was essentially higher (by 13.2) in clear carcass in comparison with cattle carcass components specific weight and less average value meat (fat tissue) specific weight (by 16%).
3. Deer meat quality is higher than that of beef. Cholesterol level in deer meat was lower than in beef 31.8 mg % and 45.2 mg % correspondingly, but by 2.9% higher total protein content that composes 23.4%.
4. Deer meat quality index (26.0) is by 8.9 higher than that of beef.
5. It can be concluded, that deer meat higher quality is precondition for comparatively higher market price determination. Deer carcasses purchase prices are higher than beef carcasses purchase prices. Deer carcasses purchase price was 4.21 LVL kg^{-1} or by 156.7% higher than beef carcass purchase price in the year 2009.

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HISTORICAL DEVELOPMENT OF BLOOD DONOR MOVEMENT AND ITS ECONOMICAL IMPACT IN LATVIA AND WORLDWIDE

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Abstracts. Health care has an important role in regional economic and politic development because human life and health is the only criterion and prerequisite for any other value. If for any reason human loses more than 20% of his blood, he is not able to join in economic actions and is under a risk of dying. That is why economic development loses human resources. In case of losing blood, human life can be saved only by donor blood, since synthetic blood replacements have not been discovered yet.
In this paper, historical development of blood donor movement as an aspect of economic development has been researched. Experiments, failures and scientific discoveries in blood transmission history have also influenced world economic history. Based on historical literature in Latvia and eye witness stories, historical development of blood donor movement in Latvia as well as its role in health care as a part of economics is studied in this paper.
Key words: Blood transmission, blood donor movement history.

Introduction

Ancient Greek philosopher Xenophon (430 - 355 B.C.) was the first that named science how to manage a household economics, but ancient Greek philosopher Aristotle (384 - 322 B.C.) added to Xenophon's ideas cognition about economics with an idea that economics is human actions with natural desire to meet their needs. Though, for people to be able to work both physically and mentally, there is a necessity to be healthy. Researchers Stores, Noren and Shindell in 1982 offered a definition that health is a condition which can be described by anatomic integrity and feeling of welfare, ability to form family, meet social obligations, possibility to cope with physical, biological and social stress, freedom from risk to get ill or die prematurely. In 1990, Rockefeller fund financed a project in which scientists Rubinstein and Lane defined health as 'ability to do work'. This definition of health is connected with the idea of Aristotle: economic work, ability to do work, to fulfil social obligations.

Human health can't be imagined without blood. Blood is liquid connective tissue (erythrocytes, thrombocytes, leucocytes), which together with lymph and tissue liquid forms inner environment of human body, which is responsible for organism functioning. Adult has 4 - 6 litres of blood that is approximately 6 - 8% of body weight (Aberberga - Augškalne, 2002). If for any reason human loses more than 20% of his blood, he is not able to participate in economic functions and is under the risk of dying. So, also economic development loses human resources. In case of loosing blood, human life can be saved only by blood donors, because nowadays synthetic blood substitutes have not been discovered yet.

Materials and Methods

Hypothesis: Historical development of blood donor movement has also influenced economic processes in Latvia and in the world.

The aim of this research is to examine historical development of blood donor movement in the world and Latvia describing its importance and analysing its influence on health care as a part of economic development.

Tasks for reaching this aim:

Based on literature of history of the world, examine blood donor movement development in world and its influence on economic historical events;

Based on literature about history of Latvia and eye witness stories, to study historical development of blood transmission movement and its role in health care development in Latvia.

Methods used in this research: analysis and synthesis, monographic method, logic – construction method, time series analysis, analysis of documents and expert interview – State Blood Donor Centre (further in text – SBDC) Donor selection head of department, doctor Irena Danilane and SBDC director, doctor Gita Ņemceva.

Results and Discussion

1. Historical development of blood donor movement in the world

The 15th century in Europe is the century of great geographic discoveries which had important influence on economic development in the whole world. During this time Atlantic and Indian oceans were studied; navigation gained more important role. In West Europe the number of people rapidly increased. Also church tried to take important role in economic processes of developed cities. Riga in those times was financial and trade metropolis, important decisions on financial questions (for example, excise tax invention) were made by Pope Innocent VIII. This pope is also associated with a beginning of blood transmission. In 1492 chronicler Stefano Infessura described blood transmission to Pope, who after a stroke was in coma. S. Infessura wrote that blood from three boys was transmitted to dying Pope. In those times blood transmission was done through mouth because blood circulation and intravenous blood transmission methods were not discovered yet. Pope and donors died.

World economic development in later centuries was a prerequisite for further discoveries in blood transmission history. By developing and emerging Hansa city union and alongside it also economic development of Germany boomed as well as other sciences in Germany. In 1615, German scientist Andreass Libaviuss first time in history used blood transmission technique, based on which after serious experiments on animals, in 1628 English doctor, anatomist and physician William Harvey proved that blood circulated in unified, closed system, and he also described function of the heart. As economics of England and different sciences developed fast, also further achievements in blood transmission were made by English scientists and researchers. From discoveries mentioned, one -discovery made by J. B. Denys is a special one. After successful lamb blood transmission to human there was no success with following experiments and J. B. Denys sent a letter to the king of France, in which he described his experiment in blood transmission. This is the first known written record about a set of symptoms which is now known as haemolytic transfusion reaction. But as a result of this description, J. B. Denys was blamed for murder. Later he was justified, but French court together with British parliament banned blood transmission. This restriction was in effect for 150 years (Klein and Anstee, 2005). Though in Europe experiments were stopped, tests to transmit blood continued in the USA where in 1795 a doctor Philip Syng Physick demonstrated first blood transmission for a human, but there are no details about the result of this. When in 1818 in England restriction for experiments with blood transmission was cancelled, J. Blundell did the first successful blood transmission. From 1825 till 1830 this doctor documented 10 more blood transmissions from which 5 were successful.

While in England and most of Europe in 19th century economics was developing and also different other sciences prospered, for the USA territorial expansion was a priority. As a result of conquests and trade, the territory of the USA increased twice in the 19th century. Though economic development during this time in the USA was slower than in Europe, by increasing number of people and necessity for health care services, experiments with blood transmission were carried out. From 1873 till 1880 American therapists documented the usage of goat and cow milk in transmissions for humans. In 1884 due to unfavourable results, milk as 'blood substitute' was substituted by physiological solution, which for some manipulations is used also nowadays.

One of the main discoveries in blood transmission history is considered Austrian doctor's Karl Landsteiner discovery of the first three human blood groups – A, B and O that was made in 1901. Karl Landsteiner is thought to be the most important scientist in blood transmission because he participated in discovery of Rhesus factor and its incompatibility, and he also worked out blood compatibility system and so unsuccessful blood transmissions (when body doesn't accept blood) happened more rarely. In 1902, A. Decastrello and A. Sturli discovered also the fourth blood type – AB.

Based on important discovery about human blood groups, blood transmission history in next years developed very fast. Next discoveries developed not only transfusiology but also other sectors of medicine. For example, when in 1908 French surgeon A. Carrel tried to prevent blood clotting with a surgical suture joining an artery in a donor to a vein in the recipient, the starting point for organ transplanting was marked. For this invention, in 1912 A. Carrel received Nobel prize (Starr, 2002).

Many discoveries from the 20th century are also used nowadays. For example, anticoagulant, natrium citrate are used both for a donor and recipient, during blood transfusion, manipulations, which were first documented by R. Lewisohn in Harward in 1915 in New York Mt. Sinai hospital. Similar it is with discovery by E. Cohn, biological chemistry professor of Harward Medicine School, that with cold ethanol it is possible to separate blood plasma and other blood components. We should particularly mention C. Walter and W. P. Murphy for discoveries in 1950 that let us substitute glass bottles for blood collection with plastic bags. With this discovery blood collection and transmission became both more comfortable and safer.

Discoveries in blood transmission history have significantly influenced many states' histories in general. For example, R. Lewisohn invented blood transporting containers that let British O. Robertson make first blood 'warehouse' during the First World War, but in 1941 in Philadelphia surgeon I. Ravdin, reduced shock for those injured during Pearl Harbour attack (Jesse, 2002).

Alongside the rapid economic development in 20th century in the USA, there was also important development in blood transmission in the USA. In 1937 in Illinois, Chicago Cook County therapeutical hospital director B. Fantus founded the first Blood bank in the USA, in the next five years such blood banks were opened all over the country. In 1947, American Blood Bank Association made changes in donating blood that allowed blood donation also outside the premises of blood bank. In the period of three years after this decision blood collection system in the USA grew up to 1500 hospital banks, 46 micro district blood centres and 31 American Red Cross regional blood centres.

2. Historical development of blood donor movement in the territory of Latvia

During the 19th century and beginning of 20th century till the First World War fate of Latvia was dictated by tczarist Russia and provincial assemblies made by mainly German, large property owners. After bondage was removed and other agrarian and urban reforms in 70s and 80s of 19th century, people from rural regions started to migrate to cities, as well as

the number of inhabitants increased. Among Latvians increased number of educated people, and different sciences started to develop. This is a time period when history of blood transmission in Latvia started in which Russian achievements and development in blood transmission occupied an important place. First blood transmission in the territory of Latvia was registered in July 28, 1871 when German doctor Karl Reiers for the first time did intra-arterial blood transmission to a soldier sick with cholera. This trial was done prior K. Landsteiner had discovered blood types, and it was not successful. There is not much information about blood transmission in the territory of Latvia at the end of 19th century and in the first half of 20th century.

In 1940, after being joined to the Soviet Union (hereinafter SU), health care in Latvia was reorganised according to the SU system, and in March 18, 1941, Republic Blood Transmission Station (hereinafter RBTS) was founded. It was subordinated to Health protection nation commissariat. RBTS had 28 employees led by Pauls Stradins, who before official establishment of blood service visited Moscow Blood Transmission Institute to receive advice on work and consultations as well as deliver lectures on blood transmission. Till the year 1960, RBTS was located in Riga, Pilsonu Street 13.

It did not matter that political and economic situation in the territory of Latvia was hard, and in the spring of 1941 there was crisis in economics, RBTS planned its economic development. In June 7, 1941, a meeting gathering leaders from Latvian Soviet Social Republic (hereinafter LSSR) was held to inform them about RBTS work and instruct them about importance and techniques of transmission of preserved blood. This event was attended by 39 doctors from different LSSR regions and 14 doctors from hospitals in Riga. By planning regional system development of RBTS, it was decided that in every hospital with 35 beds, there should be a blood donation room. To increase knowledge of these doctors about blood transmission, there were 7 papers presented in this meeting: Blood transmission and its role; Donors and organization of their work; Blood stabilizers and blood transmission indications; Blood removal demonstration in operating room; Group identification; Donor hematologic testing; Blood substitutes. This meeting took an important place in the history of blood transmission in Latvia because it was calculated for the first time in history of the blood donor's movement that there would be a necessity of 2000 donors in Latvia. This number was calculated by comparing number of people in Latvia and Russia, and based on donor number calculations per one inhabitant in Russia. At the end of the meeting it was decided to hold the next meeting after several weeks but, the Second World War started on June 22, 1941. Due to the war, RBTS stopped its work on November 1, 1941. Blood service station with one doctor and one laboratory assistant continued their work till February 1, 1945.

During the war from 1941 till 1942 in Borovicos, Leningrad district, Volhova front line doctor Abram Trilisskis worked as a chief of 1371 Evako blood transmission station. In 1942, the infirmary was renamed the third mobile blood transmission station which was led by A. Trilisskis till the end of the war. At the end of 1944 this institution was dislocated and employees dismissed. In February 1, 1945, work of RBTS was regained. A. Trilisskis, the second blood service doctor, worked in this post for 28 years. Simultaneously with RBTS, blood transmission offices in Riga and the largest city hospitals were opened. In 1947, blood was transmitted in 11 district hospitals.

Admission of blood donors for determined compensation, amount of which has not been mentioned in historical data, began. According to the author's calculations, in which changes in the number of donations of charge Latvian blood donors from the year 1945 to year 1959 were compared, the largest number of charge blood donors' blood donations was in the year 1959. It means that activity of blood donors donating blood for reward grew every year. The base year for this calculation is the year 1945, which means that the number of charge blood donations is compared to the year 1945. Comparing figures on such basis the author concluded that in all years, comparing to the base year, the number of blood donations has been superior. Chain indicators in calculus showed the number of blood donations that has grown or decreased compared to the previous period. The greatest absolute growth in number of blood donations was in the year 1947 – 875. The biggest growth rate in % compared to the previous year was in 1946, when the number of blood donations increased by 72%. But the smallest number of blood donations was in 1952, only - 12% compared to the previous year. The author calculated that in the year 1949 the absolute significance of 1% increase in absolute figures of blood donations is the greatest – 28.4.

Though economically Latvia in the second half of 20th century was separated from other world, scientists from the SU worked and developed different methods, also connected to medicine. In 1948, A. Trilisskis with his colleagues, started research and translation work to provide specialised literature in transfusiology for doctors in Latvia and dry plasma was started to be produced. After Latvia was joined to the SU, it developed rapidly. As one of the main events in Latvia blood transmission history was no compensation blood donor movement that began in 1957, when 124 Proletarian district company workers donated blood without compensation for the first time. During next twenty years no compensation donor plan was fulfilled and even over – fulfilled.

Data in Table 1. show increase in the number of gratuitous blood donors during the period of time starting from the year 1957, when gratuitous blood donation movement began, till the year 1968.

Table 1

Changes in the number of gratuitous Latvian blood donors in Latvia, 1957 – 1968

Year	Number of blood donors	Absolute increase		Growth rate (%)		Increase rate (%)		1% increase in absolute figures $tm_{(1\%)}$
		Annual $\Delta m_{(ķ)}$	Compared to base year $\Delta m_{(b)}$	Annual $Tm_{(ķ)}$	Compared to base year $Tm_{(b)}$	Annual $\Delta m_{(ķ)}$	Compared to base year $\Delta m_{(b)}$	
1957	124	-	-	100	100	-	-	-
1958	298	174	174	240	240	140	140	1.2
1959	1141	843	1017	383	920	283	820	3
1960	4577	3436	4453	401	3691	301	3591	11.4
1961	1184	- 3393	1060	26	955	- 74	855	45.8
1962	5760	4576	5636	486	4645	386	4545	11.8
1963	8200	2440	8076	142	6613	42	6513	58
1964	12276	4076	12152	150	9900	50	9800	81.5
1965	19753	7477	19629	161	15930	61	15830	122.6
1966	26460	6707	26336	134	21339	34	21239	197.3
1967	31794	5334	31670	120	25640	20	25540	266.7
1968	37941	6147	37817	119	30597	19	30497	323.5

Source: computed by the author according to the State Blood Donor Centre data

Comparing figures on such a basis the author concluded that in all years, compared to the base year, the number of blood donors has been superior. Chain indicators in calculus showed the growth or decrease in the number of blood donors compared to the previous period. The greatest absolute growth in the number of blood donations was in the year 1965 – 7477. The biggest growth rate in % compared to the previous year was in 1962, when the number of blood donors increased by 386%. But the smallest number of blood donors was in 1961, only – 74% compared to the previous year. This can be explained by the political situation in Latvian history. The author calculated (see Table 1) that in the year 1968 the absolute significance of 1% increase in absolute figures of blood donations was the greatest – 323.5.

When Latvia was a part of the SU, economics experienced a central planning system which was based on five year plans split in one year plans, which was compulsory to fulfil. The SU plans in Latvia included rapid industrial development. That included also blood transmission. In 1962, RBTS started trips to regions. In this year blood was donated in 40 districts. From all prepared blood, 40% was mainly from trips to districts from donors without compensation. There was a specialised bus where donors could donate blood. In districts socialistic competitions were organised to involve people in donor movement. For each institution there was a plan confirmed by Red Cross District Committee, its fulfilment was monitored by the executive committee and main doctors of the district. Motivation to join blood donor movement were benefits for donors: vacations in the summer time, free trips to resorts in Latvia, trips abroad; first in line for installing telephones and receiving flats, ordering press and deficit goods (Gaile,1986).

One of the most important measures that describe people supply with donor blood is donor blood ml per one inhabitant (Figure 1.). As we can see in the graph, the peak of donor movement popularity in Latvia was in 1982. Though in that time to prepare blood components other technologies were used, that was the time when hospitals were not in lack of blood components for blood transmission. In all territory of the SU there was one preservative for storing blood, and blood was useful for blood transmission for 21 days. But in Latvia where number of donors per 1000 inhabitants was the largest in the SU – 53.2, there was a decision not to transmit blood if it is older than 10 days. Specialists from all the Soviet republics came to Latvia for experience exchange.

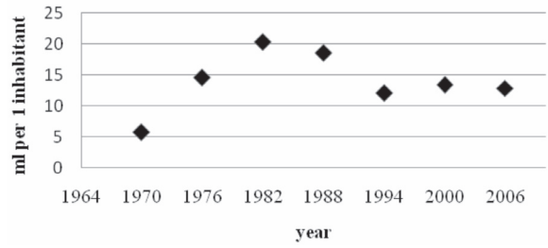

Figure 1. Number of blood donors, ml per 1 inhabitant from 1970 till 2006.

Source: Author's construction based on data from State Blood Donor Centre

Latvia Blood Donor Service regional system development was influenced by the process of blood component collection and preparation process which in the second half of 20th century was complicated and took much time. Until mid 80s of 20th century systems which took blood were not hermetically closed, that is why before blood donations donors were dressed in special clothes. Work in RBTS and blood collection departments established in hospitals (hereinafter BCDs) was like a conveyer – while one donor was undressing, the other was already prepared for blood donation. Donor blood was put in large glass bottles, later – in ampoules which were hermetically closed with gum pile and aluminium clips. After blood was tested, and it was possible to separate levelled plasma, work was done in sterile cabins. Plasma was used for making preparation but erythrocytes were put under strict centrifugation to be able to collect extra ml of plasma. In this separation process erythrocytes were traumatized, haemolysed and that is why utilised in huge amounts. In 1967, the plasmaferesis method that allowed to decrease tons of utilised erythrocytes was used. In the same year RBTS registered first 19 plasma donors. Blood was collected in glass bottles. 300 ml plasma was taken from one donor.

Around 1970 requirements for blood preparation changed and instead of cabins, wide, easily to clean rooms were used. In trips to regions many local medical workers helped. For example, work in Bauska health centre was carried out in the assembly hall where blood was donated by 16 donors at a time. Team worked for two days during which blood was donated by more than 500 donors. There were practically no refusals to donate blood. One donor gave around 200 ml and 50 ml blood.

In 1970, RBTS started to test each blood portion for B hepatitis antigen; in 1985, databasis for refuse started to work, but in 1987 test for human immunodeficiency virus (further in text - HIV) antibodies was started.

From 1971 till 1994 blood bank worked in RBTS. There were kept around 2000 units of rare group blood. After 1994 all storage in RBTS blood bank compiled, was destroyed due to the fact that before 1994 blood was not tested for C hepatitis, and these blood samples were not allowed to be used in transmission.

From 1972 till 1993, RBTS was led by doctor Aleksandrs Bikovs, who paid special attention to people involvement in donor movement. By the lead of A. Bikovs in 1983, RBTS that was located in Riga, Selpils street 6, built a new administrative building where most of the laboratories that are still working nowadays were located.

After Latvia gained independence on May 4, 1990, reforms changed central planning to market economy. Latvia was hit by economic crisis. Only starting from 1993 when economics in Latvia stabilised health sector reorganisation started, as a result of which on August 1, 1993, name of RBTS changed to SBDC, which now is subordinated to Latvia Ministry of Health, methodologically leading Latvia Blood Donor Service. Alongside with the change of the name, a new director doctor Gita Nemceva was designated. With her active participation Latvia Transfusiology association was founded in 1993. Since 1993 unseparated blood is not used for transmission anymore, just components. Every blood dose is carefully tested for C, B hepatitis, HIV antibodies and syphilis. Since March 1993, blood is prepared only in plastic package and a standard dose is taken from a donor – 450 ml and 40 ml for testing.

Until January 1, 2007, Latvia Blood Donor Service regional system consisted of SBDS, its branches in Rezekne and 18 BCDs all over Latvia. Following SBDC conception 'Blood service work and structure optimisation conception 2006 – 2010' introduction in January 1, 2007 and because of Latvia Ministry of Health started health sector reorganisation in 2009 with an aim to save finance, at the moment of March 8, 2010, Latvia Blood Donor Service regional system includes the following institutions: SBDC with a branch in Rezekne, 9 hospital BCDs and 35 hospital blood banks in all regions of Latvia. When making a decision on optimisation of the structure of Latvian Blood Donor Service and elaborating the SBDC's 'The Conception for Optimisation the Performance and Structure of the Blood Donor Service of the Republic of Latvia 2006 – 2010', the following several factors were analysed as a precondition for finding optimal locations of blood service units in the country: population density, locations of medical institutions in the country, availability of information technologies in accordance with the possibilities provided by the National Program's project 'Establishment of a Single Information System for the State Blood Service', and establishment of BCDs in geographically advantageous locations in Latvian regions. The indicator characterising the performance of BCDs – the number of blood donations and donors who donated their blood in a particular BCD was not analysed as one of the key factors. For example, changes in the number of blood donors in 2006 as compared to 2001, % BCD who was excluded from BCDs since 1 January 2007: Madona BCD was 0.97, Saldus BCD 42.57, Tukums BCD, 10.88, Cesis BCD 9.75, but in institutions included in Latvian Blood Donor Service's regional system at the same time were: Jelgava BCD – 8.03, Ventspils BCD – 31.07, Valmiera BCD – 41.95, Jakabpils BCD – 24. 66. According to this data, one can conclude that as a result of optimisation the structure of the Latvian Blood Donor Service's regional system, several equivalent institutions were excluded from preparing blood components: Madona hospital BCD Ltd, Cēsu regional hospital BCD Ltd, and Ogre regional hospital BCD Ltd. (Mistre and Zvaigzne, 2009).

Table 2

Changes in the number of blood donors in Latvia 2004 – 2009

Year	Number of blood donors	Absolute increase		Growth rate (%)		Increase rate (%)		1% increase in absolute figures $tm_{(1\%)}$
		Annual $\Delta m_{(ķ)}$	Compared to base year $\Delta m_{(b)}$	Annual $Tm_{(ķ)}$	Compared to base year $Tm_{(b)}$	Annual $\Delta m_{(ķ)}$	Compared to base year $\Delta m_{(b)}$	
2004	33690	-	-	100	100	-	-	-
2005	34466	776	776	102	102	2	2	388
2006	36095	1629	2405	105	107	5	7	325.8
2007	38348	2253	4658	106	114	6	14	375.5
2008	44619	6271	10929	116	132	16	32	391.9
2009	38986	- 5633	5296	87	116	- 13	16	433.3

Source: computed by the author according to the State Blood Donor Centre data

Data in Table No. 2. show the increase in the number of blood donors during the period of time starting from the year 2004 till the year 2009. Comparing figures on such basis, the author concluded that in all years, compared to base year, the number of blood donors has been superior. Chain indicators in calculus showed increase or decrease in the number of blood donors compared to the previous period. The greatest absolute growth in number of blood donors was in the year 2008 – 6271. In the same year the growth rate in % was the biggest compared to the previous year 16%. But the smallest number of blood donations was in 2005, only 2% compared to the previous year. The author calculated (see Table 2) that in the year 2009 the absolute significance of 1% increase in absolute figures of blood donations is the greatest – 433.3.

In September 13, 2007, SBDC purchased specialised bus. This is the only bus in the Baltic countries that is suitable for comfortable and safe blood donation in it.

Conclusions

1. Scientific discoveries in the history of blood transmission which saved human lives have influenced also the history of the world economics.
2. As one of the most important researchers of blood transmission is thought to be Austrian doctor Karl Landsteiner who in 1901 discovered the first three human blood groups – A, B and O. In 1940, K. Landsteiner together with P. Levine and R. E. Stetson discovered Rhesus factor and its incompatibility; as a result, failures in blood transmission occurred more rarely.
3. After Latvia was made to join the Soviet Union, a centralised plan in economics was introduced in Latvia, its five year plan also referred to health care and donor movement organisation in the territory of Latvia.
4. In the second half of 20th century, no compensation donor movement with socialistic competitions among employees from different enterprises and institutions started. Though voluntary blood donation was propagated in the territory of Latvia, it became a necessity for people to be able to receive different deficit goods.
5. In 1982, the largest donor blood amount ml per one inhabitant – 20.3 was registered in the territory of Latvia. That shows high blood donor activity and full hospital supply with blood and blood components.
6. Starting from 1993 when economic situation in Latvia stabilised, in the blood and blood component preparation process important criteria that had an impact on quality and safety: additional tests, modernization of technologies and premises, introduction of quality management system for the whole process of preparing blood and blood components were introduced.
7. By implementing Latvia Ministry of Healthy structure reorganisation plan, Latvia Blood Donor Service regional system structure after January 1, 2007 has experienced important structural changes: BCDs number decreased from 18 to 9. The aim of these changes was to increase technical support for blood and blood component preparation institutions, and as a result medical service quality in Latvia.

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ANALYSIS OF LAND FRAGMENTATION IN RURAL AREAS

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Abstract. Implementing the land reform, territories of farms were quite often formed of several – up to 20 – land plots, frequently with disadvantageous borders.
With reorganization of production of the farms, rural development and activities of land market, importance and tasks of rational territory organization will grow. Besides, it can be forecasted that, as a result of land rent and further buy-sell and other transactions, many new farmland properties and land uses are going to appear which might not correspond to the requirements of rational territory organization. It indicates that importance of land consolidation, e.i., enterprises for elimination of land fragmentation and other deficiencies of territorial arrangement, is going to increase further.
Key words: size of farmland, land fragmentation, land consolidation.

Introduction

Agricultural land use is being performed within concrete farms, and area of the farm and mutual arrangement of the land plots under management are of great importance for the result of work in these farms besides work, materials, resources and land fertility. As the result of the land reform and expansion of land market in the rural areas, farms with fragmented land arrangement are often formed. This means that areas of the farmlands are compound of several – often up to 20 – land plots which are separated by lands of other farms. This arrangement of the farmlands impedes effective management, increases expenses of transport works in general and on unproductive plots of land.

Land fragmentation, especially, that of farmlands, is very typical and widespread in the post-communism states. It is one of the results of the quick modifications in legislation of land entitling.

Fragmentation of farmlands is present also in many Western countries. One of the most efficient means for elimination or diminishing of land fragmentation is land consolidation that is a totality of enterprises implemented by individual persons or legal entities, moved by state or municipality for public weal to optimize land use. Land consolidation is of a great vital importance in agricultural development. It can promote forming of competitive agricultural production structure, giving opportunities for farmers to make their farms less in number of land plots but larger by area and of better shape, and to enlarge total individual area of their land properties.

Land fragmentation and land consolidation issue has always been and still is an object of interests and a research subject both for researchers (Butāne and Lasteniece, 1999; Lankelis, 2002; Maasikamäe, 2002; Jankava, 2003; Xorzjan, 2005) and land use planners. To evaluate the land fragmentation, a system of indicators is essential by which it could be possible both to compare level of this feature in different states and their regions and to clear its influence on production results of the farms. Many authors use average area of the farmland properties and average index of the land cadastre units (land plots), the number of the land plots etc. as the most common characterizing indicators of land fragmentation.

Although land consolidation is of both economical and ecological efficiency, it is still an expensive enterprise; the question always can arise – will the investments justify? Therefore, the situation should be evaluated compulsory, real level of the land fragmentation of the farmland areas has to be studied.

The situation analysis encouraged selection of the theme and the hypothesis was set that there are too many small and fragmented farms in the rural areas of Latvia which is not characteristic to favourable land use and its efficient management.

These considerations and conditions determined **the aim of the work** – to analyse areas of farmlands in rural regions of Latvia by their used areas and territorial arrangement.

Tasks to reach the aim are as follows:
- To analyse acreage of the farms by the number of the farms and land area;
- To perform analyses of land property fragmetation.

Materials and Methods

Within the research, data on economically active farms in Latvia were generalized from the Central Statistical Bureau of the Republic of Latvia. They are described as farms that are producing agricultural production independently from amount of the production and its way of use or keeping land in good agricultural and environment conditions.

The data are processed indicating percentage of each value group both by the number of the properties and the area; the generalized data are shown in the group intervals: till 0.9; from 1.0-2.4; 2.5-4.9; 5.0-9.9; 10.0-19.9; 20.0-49.9; 50.0-99.9; 100.0-199.9; 200.0-499.9 and ≥ 500.0 by their agriculturally usable land.

According to the studies, all the farms in Latvia were subdivided conditionally into 4 groups (Butāne and Lasteniece, 1999): very small farms till 1.0 ha, small farms from 1.0 – 19.9 ha, medium size ones 20.0 – 49.9 ha and the large farms that exceed 50.0 ha.

Analyzing data from Information System of the State Cadastre of Property of the State Land Service of the Republic of Latvia, grouping of Latvian farmland properties was carried out by the number of the land plots where land properties are explained as all the

real estate which title is consolidated in the Land Register.

The study is based on monographic, analyses and synthesis, deduction and induction, investigation of the statistical data and graphical methods.

Results and Discussion

Land use opportunities, requirements and problems are changing with the development of the state economics and welfare level of the people. Wherewith, the largest part of the economical problems is not related to common land existence but rather with its concrete use. Human economical, cultural and social activities have a single aim – to satisfy their diverse requirements, to secure existence and reproduction opportunities. They can change because the same land plot can be used to meet different needs (Rivža, 2004).

Land quality, climate conditions, location of the land plot and level of the infrastructure are the basic factors influencing land use manner, intensity, its adjustment to definite agricultural activities. In Latvia, the weighted average value of land quality is 38 balls (Zemes politikas pamatnostādnes..., 2008), that, taking into consideration Latvian climate conditions, is considered to be the minimum fertility level regarding agriculturally usable land to be able to provide commercially viable agriculture.

In Latvia, non-effective land use and residue are to be considered as problems, but, in the other states, lack of agriculturally usable land is being discussed. Regarding this, issue of rational, efficient land use becomes topical. It depends on farms sizes by their land areas, composition and territorial arrangement. Territorial arrangement of the farms is substantially influenced by the number of land plots and their mutual arrangement that can be named by notion "land fragmentation".

Characterizing the land fragmentation, the average farm size by land area can be used as one of its descriptive indicators. From the economical point of view, this is not the most objective descriptive indicator of the farms size, although it is widely used in statistics and the branch literature. Land area is one of the basic indicators in land registration, as well as in property registration and consolidation documents (Jankava and Palabinska, 1999). This can be explained by the fact that, in comparison to other descriptive indicators of the farm size, it is the most stable and the most precisely determined.

The reason for a wide use of this indicator is not only the fact that land area is mainly constant indicator but also the feature that land is the main production means in the agriculture, and all the production organization, amount of the essential capital investments and mechanics, construction of residential and production buildings, melioration, roads management and other enterprises depend on the land area of the farm usage. Besides that, land area substantially influences also the amount of the production (Лоцмер, 1979).

In the research, Latvian economically active farms by their agriculturally usable lands were analysed. It can be observed in the Table 1, that there are totally 111 532 farms in Latvia and their common area compounds 1746.8 th. ha, that is 15.7 ha per farm on average. But the most percentage of their number (76.3%) and area (33.3%) are the small farms.

More expanded classification of the farms by their agriculturally usable land area can be observed in the Figure 1. Farm groups with agriculturally usable land in the intervals between 2.5 and 4.9 ha; 5.0 and 9.9 ha are divided comparatively evenly and are the most by number (67.4%), but their covered area is comparatively small - 31.8% of the total area of agriculturally usable land. The most percentage – 24.1% of the total number of the farms – is compound by the farms of the interval group 5.0-9.9 ha. The largest area of the agriculturally usable land covered by all the farms is occupied by the farms with individual area from 10.0 to 49.9 ha. Generally in Latvia, just 4.6% of the total number of the farms are the ones with acreage over 50 ha, but their totally covered area is considerable (48.1%).

Table 1

Classification of Latvian Farms by their Area of Agriculturally Usable Land in 2007

Agriculturally usable land intervals, ha	Number of farms	Agriculturally usable land area, th. ha	%		Total area of agriculturally usable land per farm in average, ha
			of number	of area	
Very small farms (up to 0.9 ha)	10607	4.5	9.5	0.3	0.4
Small farms (1.0-19.9 ha)	85092	582.1	76.3	33.3	6.8
Medium size farms (20.0-49.9 ha)	10753	319.3	9.6	18.3	29.7
Large farms (>50 ha)	5080	840.9	4.6	48.1	165.5
In total:	111532	1746.8	100	100	15.7

Source**:** calculations done by the author according to the Central Statistical Bureau

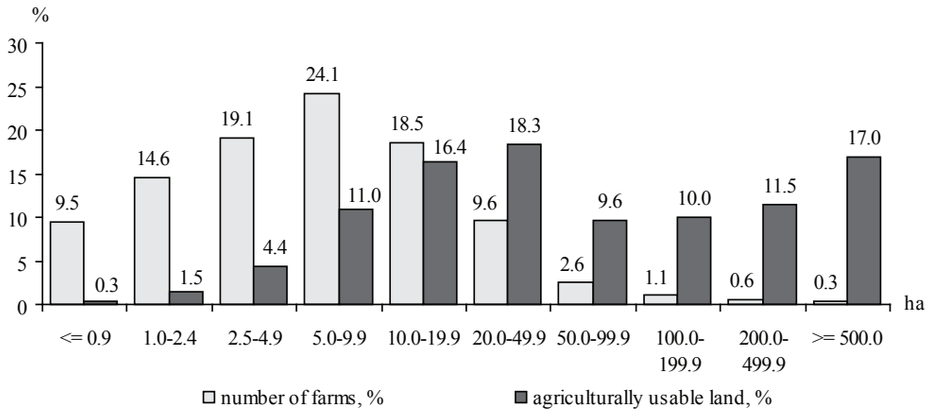

Figure 1. Number of Farms and their Used Agriculturally Usable Land in Latvia in 2007, %.
Source**:** calculations done by the author according to the Central Statistical Bureau

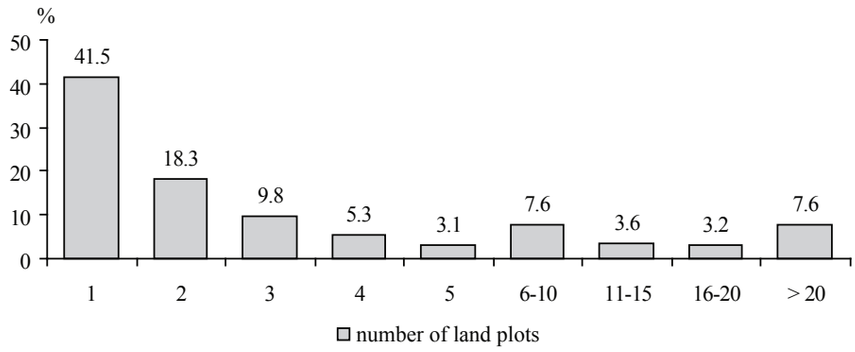

Figure 2. Division of Regional Farms of Latvia by the Number of their Land Plots in 2006, %.
Source**:** calculations done by the author according to the State Land Service

The results of the research indicate that there are comparatively many small land properties, although medium size and large farms by their covered area are dominant in Latvia.

Analyzing the data of Information System of the State Cadastre of Property of the State Land Service (Platonova, 2008) on land properties by their number of land plots, it is possible to state that less than a half (41%) of them are located on a single land plot but more than one third (36%) are compound of two to 5 land plots, besides 8% of the land properties are fragmented of 20 and more land plots (Figure 2).

Evaluating the situation by the regions, it is obvious that the most percentage is compound by Latvian regional farms (Figure 2) whith properties arranged on a sole land plot. Most of them are located in Kurzeme (44.8%) and Vidzeme (43.8%) regions. Farms with one splitting plot compound almost equal percentage in all the regions of Latvia. There is higher percentage (32%) of farms consisting of 3-5 and 6-10 land plots in Latgale region. In Zemgale region, there is the most percentage of farms with 20 and more land plots each.

Table 2

Classification of Agricultural Land Properties in Latvia by their Compound Land Plots in 2006

Regions of Latvia	Number of rural land properties by their compound land plots, %						Total number of the land properties
	1 plot	2 plots	3-5 plots	6-10 plots	11-20 plots	over 20	
Zemgale	41.2	17.7	18.1	7.1	5.1	10.8	44077
Kurzeme	44.8	18.2	16.3	7.6	8.4	4.7	54010
Vidzeme	43.8	18.5	16.4	5.6	7.8	7.9	88961
Latgale	35.6	16.8	20.8	10.9	6.3	9.6	82220

Source**:** calculations done by the author according to the State Land Service

These data expose fragmentation of the areas of the farms. It can be explained by insufficient qualification of land committees and land surveyors, by will of legal land owners and their heirs to gain back the lands within the previous borders of the former properties, by deficiently based research and legal elaborations on economical, social and ecological importance of rational territory organization, and by general requirement to finish the land reform in shorter terms that is often implemented at the expense of quality of the works.

To form a compact rational farm where lands with houses and buildings are owned by a sole physical person, legal entity, or by several persons as entirety, it is essential to implement consolidation of farms. The consolidation is not a forfeit of the land but its joining in a common object for better use and management (Zuševics, 1994). In the seminar "Improved Lands Management in the Way to the EU", A. Miglavs has pointed out that land consolidation has a very important role in agricultural development that can be used as a tool of high efficiency for rural development, providing land users with new opportunities to improve the situation. The land consolidation can promote development of preparatory works of competitive agricultural production, providing opportunity to the farmers to make farms with less separated land plots that are larger and of better position, as well as to enlarge their properties.

Of course, taking into consideration the current situation in the state, implementing of the land consolidation enterprises is not a cheap event for each land owner; therefore, the state should support financially and legally planned elimination of the land fragmentation, regulation of borders and other processes related to the changes of the borders of the properties, as well as title joining between the land and houses and buildings situated on it (Zemes politikas pamatnostādnes..., 2008). Thus, united and compact property would be formed creating beneficial conditions for its efficient use, as well as solving other issues related to the moving of property borders.

Conclusions

1. In Latvia, the most part (76%) of the total number of the farms, in classification by their agriculturally usable lands, are designed as small farms with total individual acreage up to 20 ha, but their total coverage compounds just one third of all the agricultural lands.
2. Although number of medium size and comparatively larger farms is small (14%) in Latvia, their covered area is considerable (66%).
3. Irrespective of large areas of agriculturally usable lands all over the territory of Latvia, properties of farmlands are generally small and fragmented that is not characteristic to beneficial land use and its efficient management.
4. Areas of agricultural land properties are very differential in Latvia and its regions that is leading necessarily to fall in number of the farms and enlarging of the areas.
5. One of the methods for diminishing land fragmentation could be the land consolidation, but more substantial studies have to be performed to investigate its necessity and implementation.

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HOUSEHOLD AND RAINWATER SEWAGE SYSTEM SEPARATION POSSIBILITY IN RIGA

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Abstract. The aim of this research is to study the separation possibilities of household and rainwater sewage collectors in Riga. The performance of sewage pumping stations on the right and left banks of the Daugava River during the dry periods and those of rainfall is analyzed as well as the yearly costs of electric energy are given. This paper analyses the costs that would rise with re-building of the central regional co-system into the separated one.
The locations are shown where the rainwater collectors are connected to the household sewage collectors likewise the recommendations are given for the separation of these collectors.
Key words: Sewage co-system, pumping stations, re-pumping and regulation of wastewater.

Introduction

The data of investigations carried out testify that the rainfalls in Riga become more intensive and the networks of co-system sewage are not able to drain away the whole surface water from the squares and streets having hard covering (Ziemelnieks and Tilgalis, 2008). The number of parking places, pavements and roads in Riga with impermeable hard covering increases (Ziemelnieks and Tilgalis, 2009). The problems caused by rainwater become more and more actual in the town territories. Ltd. "Rigas Udens" increasingly begins to feel the presence of rainwater as well as those of melting snow in the sewage system after the extension of sewage networks (Ziemelnieks et al., 2008). During the last years there is a necessity to open Voleri crash outlet more often in the period of rainfalls, thus, protecting the wastewater purification installations (NAI) from overloading and in order to overpump the accumulated wastewater. The situation becomes worse when the rainwater sewage collectors are connected to the household sewage network, creating an additional load to the sewage system and pumping stations during rain. Overpumping and purification of rainwater create additional costs of electric energy.

Materials and Methods

This paper employs the data (year 2001) of Ltd. "Rigas Udens" registration program of computerized sewage pumping stations "Swedmeter scada system report V4.0" and "ABS Aquaview" about the performance of pumping stations on the Daugava right bank during crash regime and during dry periods.

The existing available information from Ltd. "Rigas Udens", Ltd. "Aqua-Brambis" as well as scientific investigations carried out by the department of architecture and building of Latvia University of Agriculture are used for the data obtaining.

The publicly available information and illustrations of Latvian Environment, Geology and Meteorology Centre about the floods in Riga during rain in the last years are used (Latvijas Vides, Ģeoloģijas un Meteoroloģijas Aģentūra, 2007). Visual investigation and photo documentation of sewage network performance during rain were carried out in 2009. Together with SIA "Rigas Udens" the information about the connections of rain sewage piping with the household sewage systems was collected based on the observations of the sewage network service.

Results and Discussion

The Riga household and rainwater sewage networks were built at the end of the 19th century. At present they are complicated and imperfect. The total length of the household sewage networks today exceed 900 km, the piping diameters are 150-2500 mm (Tilgalis et al., 2005). The number of co-system pumping stations at present is 54. The total length of rainwater sewage networks is about 180 km with 13 rainwater pumping stations. In the old and central part of Riga a co-system sewage system has been built, and the household, production and rain waters are collected in a common net. In other parts of Riga a partly separated sewage system has been built where the rainwater is separated from the other wastewaters. In many places the rainwater collectors are connected with the household sewage network, causing problems during the periods of rain because unforeseen large rainwater discharge flows reach the net impeding the normal performance of both the sewage network and the purification installations. In Riga centre it is not possible to rebuild the historically constructed sewage co-system as a separated system both technically and economically (see Figure 1).

In the town there are several locations where the household wastewater pipe connections to the rainwater sewage system can be found. For example, in Teika district, Palmu street the existing Sirius rainwater collector having Ø 1400 mm is connected to Ropazu street co-system collector having Ø 300-500 mm and the length about 0.8 km (in the span from VEF culture palace to Palmu street) which drains away the wastewater from the block houses and some production objects (Tilgalis et al., 2006).

There is a large number of separate rainwater sewage piping spans having Ø 200-400 mm connected to the household sewage system (Siļķe et al., 2006). A part of these spans is connected to the household sewage with the agreement of Ltd. "Rigas Udens", in order to improve the performance of the household

sewage collectors because of an essential decrease of the household wastewater in the city.

The largest part of rainwater in the household sewage is created by the co-system sewage system without the rain overflows. It is in Petersala, Town pastures of Maskava district, Kliversala, Tornakalns, Ilguciems and Bolderaja. During rain rainwater from them flows into the household sewage (Riga City Council, 2005). Particularly, a large rainwater flow is created by the co-system sewage in Ganibu dambis. There are institutions and production units with water impermeable surfaces almost 100% of the territory. Ltd. "Rigas Udens" considers the extension of rainwater collector to Ø1200 mm from Duntes street pumping station to the hollow under the railway viaduct in the crossing of Ganibu dambis and Bukultu street. They reflect on building the rain collector Ø600-1200 mm in the whole length of Ganibu dambis.

The co-system sewage increases every year, and after considering the situation some conclusions can be drawn:

1. A part of the household wastewater system in Riga centre is not separated from the rainwater system and problems spring up during the periods of rain and snow melting when the sewage flow increases to the main sewage pumping stations.
2. The main - the 15th pumping station on the right bank of the river Daugava in the direction to the sewage purification installation (plants) is able to pump 3.2 $m^3 s^{-1}$, if the Voleri crash station is opened and sewage flows into the Daugava. If the flow exceeds 3.2 $m^3 s^{-1}$ the water level in the tunnel collector and the collector connected with it rises and through the covers of the sewage wells flows out in the lower places of the territories. It is observed that the flow can reach 5-5.5 $m^3 s^{-1}$. During the rainfalls, the 15th pumping station is not able to carry away all the rainwater sewage. Such a situation reoccurs several times a year.
3. The maximum productiveness of the pumping stations is larger than the maximum capacity of the sewage purification plants. The pumping of the sewage amount exceeding NAI maximum capacity is not permissible because the normal performance may be disordered for a long time.
4. NAI "Daugavgriva" maximum capacity is 5.2 $m^3 s^{-1}$, but the optimal capacity - 3.9 $m^3 s^{-1}$. During dry periods NAI are not loaded enough, the average flow during the dry periods was 1.9 $m^3 s^{-1}$ in 2003.
5. During the last years the presence of rainwater and other foreign waters in the sewage system has increased and has reached 30% of the total amount of sewage or 14 million $m^3 s^{-1}$ a year. It is observed that during the rain the sewage flow may exceed five times that of a dry period.
6. In the given situation the household sewage without the rainwater may be successfully carried to NAI along 2 penstocks by the main 2 pumping stations.
7. During the rain the capacity of the 2 penstocks is insufficient and in order to secure the sewage pumping during rain, the 3rd penstock must be built from Voleri shifting chamber to NAI, and additional pumps must be installed in the sewage pumping stations.

Summarizing the data of construction of existing system, approximate costs may be calculated when analysis of manageable reconstruction, building and improvement work of sewage system to be carried out with the technologies available at present has been done. The cost results are approximate and in order to get precise values more thorough investigations are to be made including working out the draft projects. The costs are distributed for separate large projects:

The reconstruction of co-system sewage in Riga central part, by re-building it as a separate sewage system LVL 18 mil. It is not possible to carry out this project at present because of complicated technical problems.

Separation of rainwater sewage system from the household sewage system in other Riga districts – LVL 4.2 mil.

Reconstruction of Riga rainwater sewage systems and building of new collectors – LVL 38.1 mil.

Reconstruction of existing stations, building of new pumping stations – LVL 2.8 mil.

Building of a new (3rd) penstock – LVL 2.1 mil.

Building of decentralized rainwater purification plants – LVL 2.5 mil.

Building of sewage regulation reservoir in NAI territory – LVL 1.1 mil.

Developing of automatic management and control system – LVL 1.2 mil.

Thus total approximate costs – LVL 70 mil.

In order to envision accrued financial expenses by getting rainwaters into the co-system, the data analyses was carried out about Ltd. "Rigas Udens" automated pumping station of the Daugava right bank at 2 Ilzenes street or station No.15. The pumping station performance regime registration has been fixed approximately from the year 2000. The exploitation regime of the sewage pumping station is available in the program "Swedmeter scada system report V4.0" in which the year 2007 is demonstrated in greater detail (see Table 1).

The performance regime of the main pumping station depending on the weather conditions has been shown in Table 1. In the periods of dry weather and rain the amount of the sewage pumped and the costs of pumping differ dramatically. The conclusion may be drawn that the resources necessary for the reconstruction are used at present in order to meet the costs of electric energy.

In order to reduce the maximum flow to the main sewage pumping station, Riga city should carry out undertakings mentioned in Table 2. This table shows possible problematic connection places in the division of the sewage network on the river Daugava left and right banks. While investigating the research and publications already carried out, as well as analysing the networks of the town sewage system, the analyses has been done and the recommendations have been given for the undertakings which should be carried

Table 1

Performance regimes and costs of the main pumping station at 2 Ilzenes street depending on the weather conditions

Performance of pumping station depending on weather conditions		Dry weather on workdays	Dry Weather on days off	Short time rainfall	Lasting rainfall or heavy rainfalls	Dry weather on workdays + short time rain	Dry weather on workdays + lasting rain or heavy rainfalls	Dry weather on days off + short time rain	Dry weather on days off + lasting rain or heavy rainfalls
Amounts pumped	$m^3\ 24h^{-1}$, min	61000	51900	67000	94200	6000	15100	33200	42300
	$m^3\ 24h^{-1}$, max	67000	58000	86200	160000	19200	28200	93000	102000
Electric-energy used	kWh(24h), min	6710	5709	7370	10362	660	1661	3652	4653
	kW(24h), max	7370	6380	9482	17600	2112	3102	10230	11220
Costs of electricity used	LVL(24h), min	498.55	424.18	547.59	769.90	49.04	123.41	271.34	345.72
	LVL(24h), max	547.59	474.03	704.51	1307.68	156.92	230.48	760.09	833.65
Costs of electricity used	LVL(month), min	15156.01	12895.03	16646.77	23404.86	1490.76	3751.73	8248.85	10509.82
	LVL(month), max	16646.77	14410.63	21417.18	39753.47	4770.42	7006.55	23106.71	25342.84
Costs of electricity used	LVL(year), min	181971.85	154825.23	199870.72	281012.26	17898.87	45045.49	99040.41	126187.03
	LVL(year), max	199870.72	173022.41	257147.10	477303.20	57276.38	84124.69	277432.49	304280.79

Source: table and data calculation created by the author

out in separate connection places of the rainwater collectors in the co-system. In the table the main connection places of the household and rainwater sewage network are listed in a numbered successive, and they are shown in Riga sewage scheme (see Figure 1).

Table 2

Main connection places of household and rainwater sewage networks and their separation possibilities

No.	Connection places	Undertakings and approximate amounts of works
The river Daugava right bank		
1.	In Sarkandaugava crossing of Lapstu un Ziemelu streets, rain sewage (LK) Ø 400 mm connected sewage (K) Ø 350mm	To eliminate the rain sewage (LK) Ø 400 mm connection sewage (K) Ø 350 mm. LK Ø 400 mm must be connected to the LK Ø 500 mm placed next to it. LK Ø 400 mm ~ 5.0 m must be built.
2.	Sarkandaugava holding company „Kokvilna" at Ganibu dambis No.30 and holding company „Dambis" in Ganibu dambis No. 24a LK connected at K Ø 1200 – 1500 mm in Ganibu dambis	Ganibu dambis region ~3 km from Patversmes street to Sarkandaugava branch is located from Daugava floods by Katrina dambis and Kakuseklis dambis having surface marks +3.5m. Lately, a large number of offices, warehouses and production centres with large roof areas and paved territories have been built there. Rain water from these buildings is overloading the existing networks of co-system and household sewage as well as the installations of the town sewage purification. It is impossible to build rain overfalls since the networks have low marks. By taking into consideration the requirements of Latvia building normatives and Ltd. "Rigas Udens", a rain collector Ø 600 –1200 mm is expected to be built as well as the sewage drainage to the existing rainwater sewage pumping station in Dambis street.

Table 2 continued

No.	Connection places	Undertakings and approximate amounts of works
3.	In Sarkandaugava, crossing of Padedzes and Patversmes streets, rain sewage LK Ø 250 mm connected sewage K Ø 250 mm	The connection LK Ø 250 mm has to be eliminated K Ø 250 mm. LK Ø 250 mm is to be connected to the planned LK Ø 400 mm at Patversmes street L=320m.
4.	In Sarkandaugava, crossing of Duntes and Vitolu streets, rain sewage LK Ø 400 mm and Ø 200 mm connected sewage K Ø 700 mm	LK Ø 400 mm and LK Ø 200 mm connections must be eliminated to K Ø 700 mm. LK Ø 400 mm and LK Ø 200 mm must be connected to existing LK 1.9x1.8 m by building LK Ø 400 mm, L=10 m and Ø 200 mm, L=21 m.
5.	In Petersala, crossing of Mastu and Eksportu streets, rain sewage LK Ø 500 mm connected sewage K Ø 600 mm	To eliminate LK Ø 500 mm connection to K Ø 600 mm. LK Ø 500 mm must be connected to the existing LK Ø 500 mm. LK Ø 500 mm, L=20 m must be built.
6.	In Centre region, crossing of Hospitalu and Sencu streets, rain sewage LK Ø 500 mm connected sewage K 600x600 mm	To eliminate LK Ø 500 mm connection to K 600x600 mm at Hospitalu street. LK Ø 500 mm must be connected to the existing LK Ø 500 mm in Zirnu street. LK Ø 500 mm, L=10 m must be built having the under-drain, under K 600x600 mm.
7.	In Plavnieki Piedrujas streets at Slavu bridge, rain sewage LK Ø 1200 mm connected sewage K Ø 1200 mm	LK Ø 1200 mm connection to K Ø 1200 mm must be eliminated. LK Ø 1200 mm must be connected to LK 1.9X1.8 m, by building LK Ø 1200 mm, L=65 m having under-drain under Ø 1200 mm.
8.	In centre region, crossing of Kr.Valdemara and Eveles streets, rain sewage LK Ø 300 mm connected sewage K Ø 1200 mm.	LK Ø 300 mm connection must be eliminated to K Ø 1200 mm. LK Ø 300 mm must be connected to the planned LK Ø 500 mm Eveles street, L=250 m.
9.	In Maskavas suburb, crossing Lacplesa and Sadovnikova streets, rain sewage LK Ø 500 mm connected to rain overfall	To eliminate LK Ø 500 mm connection to rain overflow. LK Ø 500 mm must be connected to KP 1.9x 1.75m under the rain overfall. Ø 500 mm, L=10 m is to be built.
10.	In Petersala Lugazu street rain sewage LK Ø 400 mm connected sewage K Ø 900 mm	To eliminate LK Ø 400 mm connection to K Ø 900 mm. LK Ø 400 mm must be connected to KP Ø 900 mm under the main collector Ø 1500 mm in Kakuseklis dambis.
The river Daugava left bank		
11.	In Ilguciems, crossing of Slokas and Saulgozu streets, rain sewage LK Ø 250 mm connected sewage K Ø 300 mm	To eliminate LK Ø 250 mm connection to K Ø 300 mm. LK Ø 250 mm must be connected to the planned LK Ø 600 mm Slokas street L=500 m.
12.	In Zasulauks region, crossing Jurkalnes and Irlavas street, rain sewage LK Ø 200 mm connected sewage K Ø 1000 mm	To eliminate LK Ø 200 mm connection to K Ø 1000 mm. LK Ø 200 mm must be connected to LK Ø 700 mm by building LK Ø 200 mm, L=5.0m.
13.	In Agenskalns Pine neighbourhood in Kristaps and Agenskalns streets, rain sewage LK Ø 300 – 200 mm connected to sewage K Ø 300 – 200 mm	To eliminate six LK Ø 200 mm connections to K Ø 200-300 mm in Kristapa street. Six LK Ø 200 mm outlets of the block must be connected to the planned LK Ø 500 mm, L=550 m in Kristapa and Melnsila streets. To eliminate two LK Ø 300 mm connections to K Ø 200-300 mm in Agenskalna street. Two LK Ø 300 mm outlets of the block must be connected to the planned LK Ø 300 mm, L=470 m in Agenskalna and Vilipa streets.

Source: table and data calculation created by the author

Explanation of abbreviations used in the table:
LK – rain sewage system;
K – sewage system;
L – pipe system length.

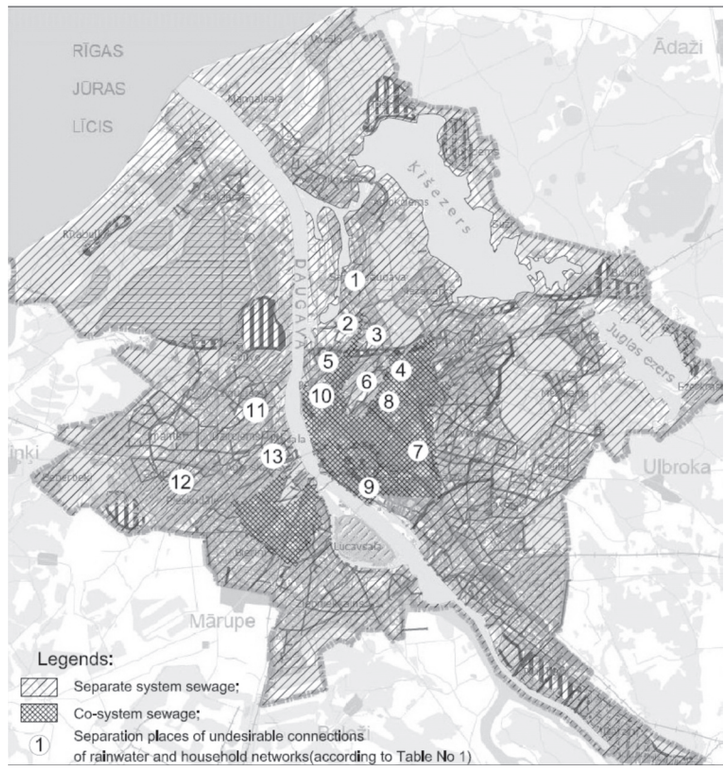

Figure 1. Riga sewage scheme.

The Riga development plan has been used as the basis (Riga City Council, 2005). Numbers show the present town sewage scheme. The numbers on the map show the undesirable connection separation places of the rainwater and household sewage network according to Table 2. The centre region with the co-system sewage has been marked with double expunged area.

Conclusions

Separation of household and rainwater sewage collectors and putting in order the rainwater sewage networks in Riga is technically possible, but today it is limited by the large building costs, about 70 mil. LVL.

Separation of collectors may reduce the unnecessary rainwater pumping (8 km) and purification Ltd. "Rigas Udens" uses ~1.25 mill. LVL a year for.

In the central part of Riga the rebuilding of the sewage co- system in a separated system is not possible both technically and economically at present, possibilities are to be searched in order to reduce the maximum discharge by adjusting, accumulating or infiltrating in the ground.

Performance of the rainwater in flow and the existing rainwater sewage system is to be controlled with the aim to optimise it and reduce the flood possibility. The improvement of the existing rainwater sewage system performance with the infiltration inflow control as well as the sewage network separation and the flow regulation should be carried out.

It is necessary to begin the disconnection, separation of rainwater collectors and roof drain from the co-system sewage and the drainage to the green zone artificially formed zone – rain infiltration cassettes, thus, reducing the flow of rainwater to the sewage system.

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MODELLING OF THE WASTEWATER TREATMENT IN THE FILTERS OF VERTICAL FLOW WITH THE DOLOMITE POWDER MEDIA

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Abstract. The possibilities to use other media instead of the sand in the filters of vertical flow are analysed in the article. The media used has to be inexpensive and its possibilities to clean the wastewater have to surpass that of the sand. The modelling of the wastewater treatment in the vertical flow filters was carried out in 2008 in the Water Research Institute of the Faculty of Water and Land Management of Lithuanian University of Agriculture. Dolomite powder was chosen for the investigation. Two models of 0.2 m^2 filters were made: one was filled with the sand, but the other was filled with the dolomite powder.
It was found that the dolomite filter was less reactive to the primary contamination of the wastewater with the organic pollutants: when their amount rose from 320 to 460 mg O_2 L^{-1} according to the BOD_7 index, the amount of the pollutants in the wastewater cleaned with the dolomite powder filter rose from 1.4 to 3.1 and amount in the wastewater which passed the sand filter rose from 0.5 to 13.9 mg O_2 L^{-1}.
General phosphorus was removed with the efficiency of 99.9% in the dolomite powder filter (and only with the efficiency of 87.0% in the sand filter). Therefore the dolomite powder filter will be removing phosphorus from the wastewater to the allowable contamination level for a much longer period.
General nitrogen was cleaned with the effectiveness of 13.0% in the dolomite powder filter. Therefore, it is necessary to use additional means for its removal from the wastewater in the vertical filters with the output higher than 5 m^3 d^{-1}.
Key words: wastewater cleaning, sand filter, dolomite powder filter, cleaning efficiency.

Introduction

Deep wastewater cleaning is an obligatory condition for the balance of the organic pollutants returning to the natural water reservoirs and their oxidation possibilities. It is well known that the insufficiently cleaned wastewater discharged to the open water reservoirs breaks their ecological balance. In the best case, the regrouping of the biocenosis takes place and the tolerant organisms take over and start prevailing, but in the worst case everything ends up in the total extinction of the aerobic organisms and the spreading processes of putrefaction. Therefore, it is very important to clean the domestic wastewater as well as possible especially when the receiving tank is small, and is not constructed on the flowing principle. At present, the systems used for the wastewater cleaning and their working principles are very different, but one of the most important places is taken by the biological methods. Biological cleaning is first of all destruction of the compounds not characteristic to the natural water and this cleaning is done without reagents. The advantages of this method are as follow: the process is stable, the reaction to the changes in the pollutant concentration and daily fluctuation of debit is small, the process is adjusted to the local conditions, the construction is simple, and the exploitation is not complicated. Recently, the sand-reed filters became very popular in Lithuania and especially vertical ones. In the vertical sand filters the organic quickly decomposing pollutants are easily removed from the wastewater but the biogenic ones are removed with much less success. That is why a new cleaning media is being searched for. The main requirements for the media are as follow: it has to be widely spread in Lithuania, cheap and it's certain qualities have to surpass those of the sand.

According to the data of the laboratory analysis (Rock et al., 1984), the number of the suspended particles and BOD_7 in the domestic wastewater that had been treated by 30 cm layer of peat (the hydraulic load was equal to 8.1 cm d^{-1}) decreased by 95 and 95% respectively.

The peat that is only slightly decomposed (the level of decomposition is equal to 5-15%) and is found in the upland bogs can be used for cleaning of the domestic wastewater (Gasiūnas and Strusevičius, 1997). It was found that the contamination of the wastewater treated with 8 m length peat layer decreased from 131 to 26 mg O_2 L^{-1} according to the BOD_7 (the efficiency of the cleaning process reached 80%). Removal of nitrogen and phosphorus was not that efficient (only about 10-20%).

The method of adsorption is best fitted for the removal of phosphorus from the biologically treated wastewater (Strusevičius and Strusevičiene, 2003). The wastewater was treated with the mineral filters containing metal compounds. When the wastewater was treated with the mineral [filtralit-P (FLP), ceolit (CE) and sulgit (SG)] filters containing 23.0%, 16.1% and 7.9% of gross Ca, Fe and Al oxides respectively the following quantities of phosphorus were removed from the wastewater: 88.5% of phosphorus in the FLP filter, 45.5% in the CE filter and 96.3% in SG filter (Strusevičius and Strusevičiene, 2006).

Other pollutants were also removed from the wastewater that was filtrated through the mineral filters: the quantity of the organic pollutants (according to the BOD) was reduced by 30.8% and up by 72.5%.

The amount of phosphorus compounds (about 90% of which were in the form of ammonium salt) decreased by 93.2% in the CE filter. The quantities of nitrogen removed in the mineral filters were not high and reached only 15-16%.

The amount of the media used in the vertical flow filters is big. Therefore, we chose a local material for our investigation, which was dolomite powder. The dolomite is a mineral belonging to the class of carbonates and is of a sedimentary origin. It is a rock belonging to the carbonate group. The dolomite contains about 20 to 30% of calcium oxide (CaO), 17-22% of magnesium oxide (MgO) and 37-48% of CO_2. The dolomite is found in the North Lithuania in the layers of the Devonian system. It is being extracted in Petrašiūnai, Klovainiai (Pakruojis district) and Skaisgirys (Joniškis district) quarries. From the dolomite extracted in these quarries the chip, dolomite powder and other products are made.

The aim of the research is to identify the possibilities of use the dolomite powder as a media in the vertical flow filters.

Materials and Methods

The modelling of the wastewater treatment in the vertical flow filters was carried out in 2008 in the Water Research Institute of the Faculty of Water and Land Management of Lithuanian University of Agriculture. Two models of the vertical flow filters were made: the first of them was filled with the usual media which was sand and the other was filled with the dolomite powder. Each of the filters took 0.2 m^2 area. On the basis of the experience of other authors (Gasiūnas and Strusevičius, 2004), the filtration path was made 0.8 m in length.

The domestic wastewater coming from Aristava village (Kėdainiai district, Vilainiai Eldership area) which underwent the primary septic treatment was used for the investigation. The same wastewater was poured into the both filters at the same time. The load on the filters was equal to 0.03 m^3 m^{-2}. The research lasted for 2 months. The wastewater was poured into the filters each day. The samples were taken once a week.

The coarse sand with the filtration coefficient of 39.5 m d^{-1} was used for the vertical flow filter. The ratio of the sand particles was d_{60}/d_{10} – 5/6. The dolomite powder with the filtration coefficient of 26.0 m d^{-1} was used for the other filter. The scheme of the experiment is given in Figure 1.

The analyses of the wastewater were conducted in the certified chemical analysis laboratory of the Water Research Institute of Lithuanian University of Agriculture. The unified methods were applied (The unified methods of the wastewater ..., 1994). The following indices were measured: BOD_7, pH, N-NO_2, N-NO_3, N-NH_4, general N, general P, suspended solids.

Mathematical and statistical analysis of test study results was performed with the help of standard computer programs.

Results and Discussion

The dolomite powder was chosen for the investigation. The same filter filled with the sand was equipped nearby. At present only the vertical flow filters filled with the sand are being built in the Lithuania. That is why it is very important to compare the new media with the sand. In order to estimate the efficiency of the dolomite powder filter objectively, we performed the investigations with the sand filter model in parallel.

The contamination of the domestic wastewater before and after cleaning is given in Table 1. The load of the easily decomposing organic pollutants on the filter ranged from 6.4 to 14.0 g BOD_7 m^{-2} d^{-1}. When the wastewater was passing through the vertical 0.8 m long sand layer, 98.2% of the organic pollutants were intercepted on average. The average contamination of the wastewater leaving the filter was 6.6 and ranged from 0.5 to 17.4 mg O_2 L^{-1}. The wastewater was cleaned even better and up to 99.4% in the dolomite powder filter. The average contamination of the wastewater leaving this filter was 2.2 and the maximal contamination was 3.1 mg O_2 L^{-1}.

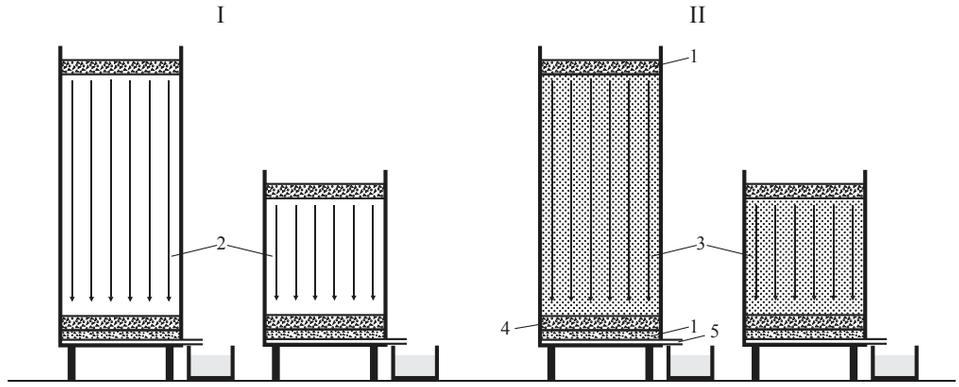

Figure 1. The models of the vertical filters:
I – sand filter, II - dolomite powder filter, 1 – chippings; 2 – fractional sand; 3 - dolomite powder; 4 - fractional gravel; 5 - outflow pipe.

Table 1

The main indices of contamination of the domestic wastewater before and after cleaning mg l^{-1} (min-max-average^{-1})

Wastewater	BOD_7	N_{total}	P_{total}	SS*	pH
Before cleaning	213.0-465.0 358.0	90.0-129.0 108.0	11.0 – 17.0 14.6	82.0-310.0 161.0	7.7-8.0 7.8
After cleaning in the sand filter	0.5-17.4 6.6	18.0-108.0 80.5	0.1-4.1 1.9	1.2-10.0 5.5	7.9-8.2 8.1
After cleaning in the dolomite powder filter	1.0-3.1 2.2	63.0-132.0 92.8	0.01-0.04 0.02	1.6-23.0 9.1	7.9-8.1 8.0

* SS – suspended solids

On the background of the investigation performed, it is possible to draw the conclusion that wastewater cleaning from the easily decomposing organic pollutants (according to the BOD_7 index) functionally depended on the wastewater contamination before the cleaning process (Figure 2). It is seen that the cleaning efficiency in the sand filter depended on the initial contamination of the wastewater more than in the dolomite powder filter. When the contamination of the untreated wastewater rose from 320 to 460 mg O_2 L^{-1} the contamination of the wastewater which underwent treatment in the sand filter went up from 0.5 to 13.9 and the contamination of the wastewater treated in the dolomite powder filter grew from 1.4 to 3.1 mg O_2 L^{-1} only. The data of the first sample where the BOD_7 of the wastewater was equal to 213.0 mg O_2 L^{-1} were ignored when trying to find out the interdependence because the biocoenosis was not formed in the filters and the efficiency of the cleaning process was low.

Dependence of the possibilities to clean the domestic wastewater on the quantity of the suspended solids in the wastewater before cleaning is given in Figure 3. The investigation revealed that the efficiency of the cleaning process depended on the duration of the cleaning process more than on the contamination of the wastewater before cleaning. The sand used in the sand filter was coarse and had low quantities of the small solids that is why it washed out more quickly than the dolomite powder which contained more small solids. The wastewater was cleaned from the suspended solids with the efficiency of 96.6% in the sand filter and with the efficiency of 95.8% in the dolomite powder filter. At the end of the investigation the situation changed and the dolomite powder filter started cleaning the wastewater better than the sand filter.

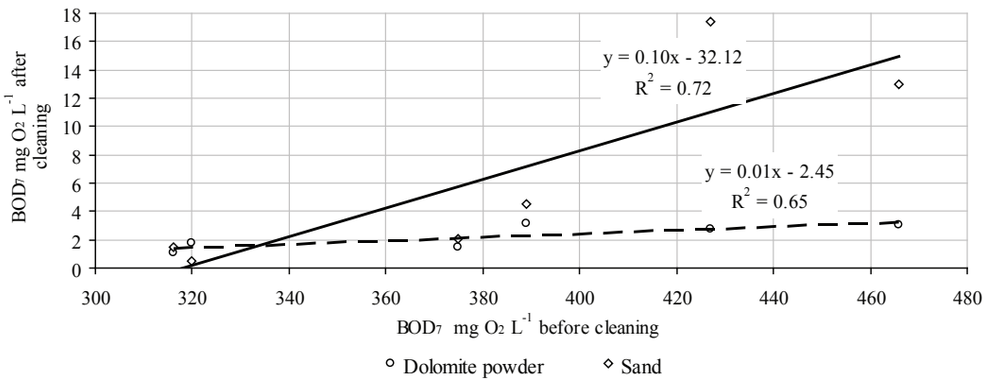

Figure 2. Dependence of the possibilities to clean the wastewater from the organic pollutants on the initial contamination of the wastewater with the pollutants.

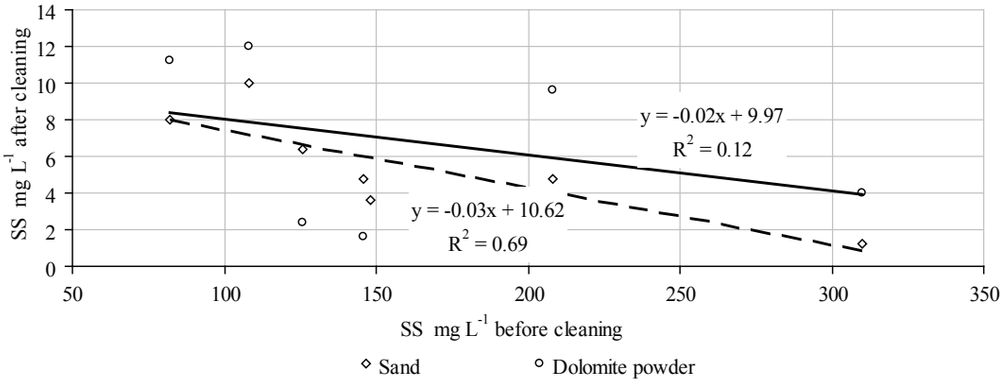

Figure 3. Dependence of possibilities to clean the wastewater from the suspended solids on the initial contamination of wastewater with the solids.

The efficiency of the phosphorus removal depended on the properties of the media which was used for the filtration process. Phosphorus present in the domestic wastewater is active and can form insoluble phosphate minerals with calcium, iron, aluminium and other metals. Therefore, the force of absorption depends on their quantity in the media used for filtration. In the model of the sand the general phosphorus was removed from the wastewater with the efficiency of 87.0%. The investigations showed that the general phosphorus was removed with the efficiency of 99.9% in the dolomite powder filter. The maximal quantity of the general phosphorus reached only 0.04 mg L^{-1} in the wastewater which underwent filtration in the dolomite powder filter. The average load of the filter with the general phosphorus was equal to 0.44 g m^{-2} d^{-1} and ranged from 0.33 to 0.51 g m^{-2} d^{-1}. Each of the media has a limited power of adsorption and at the moment the media is filled with phosphates, their removal ends up (Gasiūnas and Strusevičiene, 2008). Taking into account the fact that in the period of 2 months the cleaning efficiency had no tendencies to decline, it is possible to make the conclusion that the dolomite powder filter will be removing phosphorus from the wastewater to the allowable norm of 4 mg L^{-1} for a much longer period than the sand filter.

General nitrogen was removed from the wastewater with the efficiency of only 8.2 – 25.5% in both the modelled filters. Therefore, additional means are necessary for its removal from the vertical filters where the quantities of the wastewater being cleaned exceed 5 m^3 d^{-1}.

The active reaction of the wastewater is very important for the normal cleaning process. The optimal environment allowing the biological processes to take place requires the pH range of 7-8. Despite the media used in the filters, the alkalinity increased in both the models but their pH was near or in the optimal range.

In the filter of the dolomite powder the wastewater was cleaned more effectively than in the sand filter. Therefore, it is purposeful to equip such a filter for cleaning of one family's domestic wastewater and to continue the investigations. A special attention has to be paid to the changing possibilities of phosphorus removal during a certain time span.

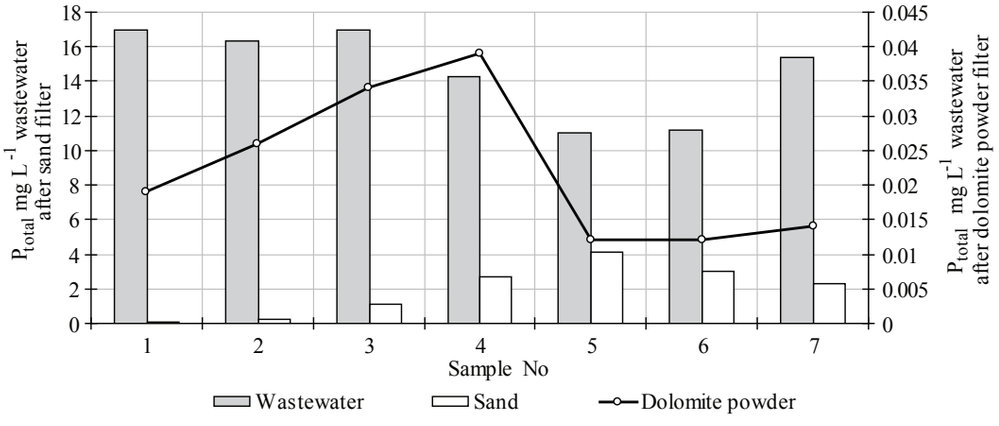

Figure 4. Contamination of the wastewater with the general phosphorus before and after the treatment in the sand filter and the dolomite powder filter.

Conclusions

1. The organic pollutants were removed from the domestic wastewater with the bigger efficiency in the dolomite powder filter than in the sand filter, the efficiency was equal to 99.4% and 98.2% respectively. In the first filter the average level of removal was equal to 2.2 and in the second was equal to 6.6 mg O_2 L^{-1} according to the BOD_7.
2. The dolomite powder filter was less reactive to the initial contamination of the wastewater with the organic pollutants: when their quantity rose from 320 to 460 mg O_2 L^{-1} (according to the BOD_7 index) in the wastewater that was not treated with the filters, subsequently their quantity rose from 1.4 to 3.1 in the wastewater cleaned with the dolomite powder filter and from 0.5 to 13.9 mg O_2 L^{-1} in the wastewater cleaned with the sand filter.
3. General phosphorus was cleaned in the dolomite powder filter with the efficiency of 99.9% (and with the efficiency of 87.0% in the sand filter). Therefore, it is possible to make the conclusion that the dolomite powder filter will be removing phosphorus from the wastewater to the allowable contamination level of 4 mg L^{-1} for a much longer period than the sand filter.
4. General nitrogen was removed from the wastewater with the efficiency of 13.0% in the dolomite powder filter. That is why some additional means have to be used in the vertical filters with the output of more than 5 m^3 d^{-1} of the domestic wastewater.

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INFLUENCE OF THE HYDRAULIC LOAD ON THE WASTEWATER TREATMENT EFFICIENCY IN THE FILTERS WITH DIFFERENT FILTER MEDIA

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Abstract. In order to avoid the problem of stoppage in the filters of vertical filtration, we tried to search for the filter media which was coarse and could clean the wastewater to the allowable contamination level. For this purpose the dolomite chippings were chosen and the modelling investigation was performed. Two modelled filters taking 0.2 m^2 area each were equipped: one was filled with the sand and the other was filled with the dolomite chippings.
The results revealed that the initial contamination of the wastewater had a much bigger influence on the wastewater cleaning process than the hydraulic load. The wastewater was cleaned with the efficiency of 95.9% and never exceeded the allowable level of 30 mg O_2 L^{-1} in the dolomite chippings filter during the trial with the hydraulic load 0.03 m^3 m^{-2} d^{-1}. When the hydraulic load was doubled the efficiency of the wastewater cleaning process decreased to 80.5% and the dependence of the cleaning process on the initial contamination of the wastewater increased. In order to ensure the successful removal of the easily decomposing organic pollutants from the wastewater up to their allowable contamination level, the quantity of the pollutants in the untreated wastewater must not exceed 220 mg O_2 L^{-1}.
Key words: wastewater cleaning, sand filter, dolomite chippings filter, hydraulic load.

Introduction

Recently, the sand-reed filters of vertical filtration became very popular in the country. They are widely used for cleaning of the domestic wastewater coming from the settlements and homesteads. The filters are used to clean various quantities of the wastewater: from 1 to 500 m^3 of the wastewater per day. Recently the authorities started to use them for cleaning of the domestic as well as industrial wastewater. The filters are known for their high cleaning efficiency and low energy consumption (energy is needed only for transporting of the wastewater). They work well when the load is fluctuating (for example, in the children camps and the camping sites equipped for the travel trailers – campers, remote hotels). Their construction is simple, their exploitation is uncomplicated therefore the qualified maintenance personnel is not necessary which is very important in the rural areas. The treatment of the slime is minimal; it is possible to treat unsettled wastewater.

BOD_7, COD and suspended particles are removed from the domestic wastewater very efficiently. When the load of filters according to the BOD_7 is equal to 4.6 g m^{-2} d^{-1} the efficiency of the organic pollutants removal reaches 97.0%. In order to reach the normative level of cleaning according to the BOD_7 which is equal to 29 mg O_2 L^{-1}, the load of the vertical filters must not exceed 19.0 g m^{-2} d^{-1}. The efficiency of removal of the suspended particles in the vertical filter reaches 87.3% (Gasiūnas and Strusevičius, 2006). The filters not only ensure efficient wastewater cleaning which complies with all the requirements of hygiene but perfectly correspond and meet the needs of nature.

One of the shortcomings of the vertical sand filters is their stoppage. In order to eliminate this problem, a filter media which has a coarse granulometric composition has to be used. Dolomite chippings 2-5 mm were chosen as the media and modelled investigation was performed.

The aim of the investigation was to determine the possibilities to use the dolomite chippings as a filter media in the filters of vertical filtration.

Materials and Methods

The modelled investigation was carried out in the Water Research Institute of Lithuanian University of Agriculture. The model is represented in the article "Modelling of the wastewater treatment in the filters of vertical flow with the dolomite powder media". The domestic wastewater coming from Aristava village (Kėdainiai district, Vilainiai Eldership area) which underwent the primary septic treatment was used for the investigation. The same wastewater was poured into the both filters at the same time. The research lasted for 2 months. The wastewater was poured into the filters each day. The samples were taken once a week.

In 2008 we performed the investigation with the hydraulic load of 0.03 m^3 m^{-2} d^{-1} and in 2009 we performed the investigation with the hydraulic load of 0.06 m^3 m^{-2} d^{-1}.

The analyses of the wastewater were conducted in the certified chemical analysis laboratory of the Water Research Institute of Lithuanian University of Agriculture. The unified methods were applied (Unified Study Methods..., 1994). The following indices were measured: BOD_7, pH, $N\text{-}NO_2$, $N\text{-}NO_3$, $N\text{-}NH_4$, general N, general P, suspended solids.

Mathematical and statistical analysis of test study results was performed with the help of regression analysis.

Results and Discussion

The wastewater is characterized not only by the quantitative value – its hydraulic load but by the level of contamination also. The level of contamination with

the organic pollutants (BOD_7) usually falls in the range from 250 to 450 mg O_2 L^{-1}, the level of contamination with the suspended solids falls in the range from 250 to 450 mg L^{-1}, the level of contamination with the nitrogen compounds falls in the range from 40 to 80 mg L^{-1}, the level of contamination with the phosphorus compounds falls in the range from 8 to16 mg L^{-1} (Rimeika, 2006; Radzevičius et al., 2008). The contamination of the domestic wastewater mostly depends on quantity of the water used. The contamination of the domestic wastewater before and after its treatment in the filters is given in Table 1. We can see that the wastewater was contaminated with the easily decomposing organic and biogenic pollutants in the year of 2008 more than in the year of 2009. The level of contamination of the wastewater fluctuated in the wide range therefore we could find not only the dependence of the cleaning possibilities on the hydraulic load but on the initial contamination as well.

Table 1

The main indices of contamination of the domestic wastewater before and after cleaning mg l^{-1} (min-max-average^{-1})

Wastewater	BOD_7	N_{total}	P_{total}	SS*	pH
The hydraulic load is equal to 0.03 m^3 m^{-2}					
Before cleaning	213.0-465.0 357.0	90.0-129.0 108.4	11.0 – 17.0 14.6	82.0-310.0 161.0	7.70-8.0 7.8
After cleaning in the sand filter	1.5-13.0 7.7	18.0-108.0 80.4	0.02-4.1 1.9	1.2-10.0 5.5	7.9-8.3 8.1
After cleaning in the dolomite chippings filter	7.3-25.1 14.6	57.0-113.0 99.1	0.7-3.4 1.8	7.0-96.0 44.8	8.0-8.3 8.1
The hydraulic load is equal to 0.06 m^3 m^{-2}					
Before cleaning	108.0-512.0 290.6	34.0-106.0 78.4	4.0-13.2 9.2	61.0-198.0 101.4	7.3-7.7 7.5
After cleaning in the sand filter	1.5-17.5 4.6	56.0-105.0 77.9	1.3-5.1 3.7	2.0-28.4 9.4	8.0-8.2 8.1
After cleaning in the dolomite chippings filter	15.8-137.0 56.7	52.0-76.0 67.2	3.9-7.0 5.0	26.0-112.0 51.4	7.9-8.1 8.0

* SS - Suspended Solids

The load of the filter models with A_n g m^{-2} pollutants was calculated according to Formula (1) (Strusevičius and Strusevičiene, 2007)

$$A_n = C\,Q / F \quad (1)$$

Where C is the concentration of the pollutant in the wastewater (g m^{-3})
Q is the hydraulic load of the filter in m^3
F is the area taken by the filter model in m^2
The load of the filter models with the pollutants (g m^{-3}) is given in Table 2.

Table 2

The load of the filter models with the pollutants (g m^{-3})

Year	BOD_7	N_{total}	P_{total}	SS
2008	6.4-14.0 10.7	2.7-3.9 3.2	0.3-0.5 0.4	2.5-9.3 4.8
2009	3.2-15.4 8.7	1.0-3.2 2.4	0.1-0.4 0.3	1.8-5.9 3.0

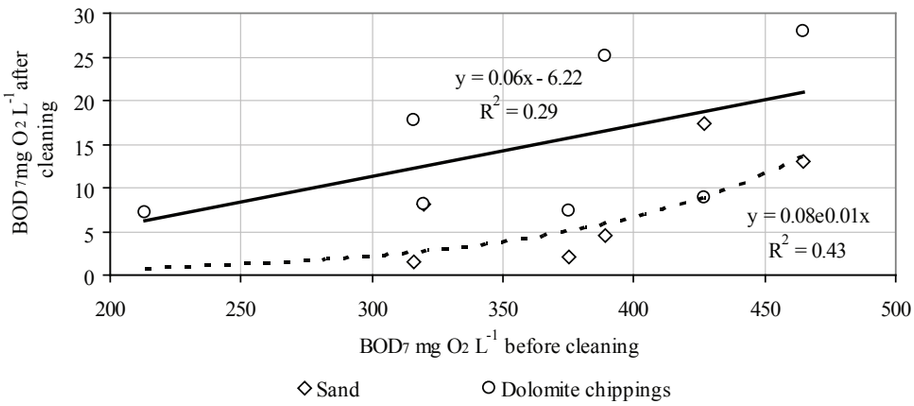

Figure 1. The dependence of the possibilities to remove the organic pollutants from the wastewater on the initial pollution when the hydraulic load is equal to 0.03 m^3 m^{-2}.

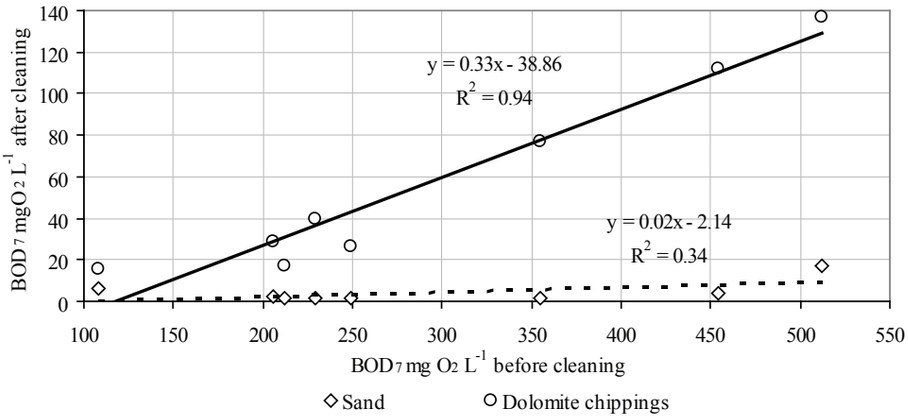

Figure 2. The dependence of the possibilities to remove the organic pollutants from the wastewater on the initial pollution when the hydraulic load is equal to 0.06 m^3 m^{-2}.

The load of the filter models with the pollutants fluctuated in the wide range: in 2008 the BOD_7 was changing by 2.2 times, the N_{total} was changing by 1.5 times and the P_{total} was changing by 1.7 times and in 2009 the ranges fluctuated by 4.8, 1.4 and 4.0 times respectively.

On the background of the results received, the functional dependence of the possibilities to clean the wastewater from the easily decomposing organic pollutants (according to the BOD_7 index) on the initial pollution of the untreated wastewater was found. The dependence when the hydraulic load of the filters was equal to 0.03 m^3 m^{-2} (Figure 1). The dependence when the hydraulic load of the filters was equal to 0.06 m^3 m^{-2} (Figure 2).

According to the equations received, we calculated the quantity of the organic pollutants in the cleaned wastewater. The initial pollution was changing in the range from 150 to 450 mg O_2 L^{-1} (Table 3)

Table 3

The quantity of the organic pollutants (BDS_7) in the cleaned wastewater mg O_2 L^{-1} and its dependence on the initial quantity of the pollutants and the hydraulic load of the filters

Hydraulic load m^3 m^{-2}	150	200	250	300	350	400	450
Sand filter							
0.03	0.4	0.7	1.2	2.1	3.7	6.3	11.0
0.06	1.3	2.5	3.6	4.8	5.9	7.1	8.2
Dolomite chippings filter							
0.03	2.5	5.4	8.3	11.2	14.1	17.0	19.9
0.06	10.4	26.9	43.3	59.8	76.2	92.6	109.0

According to the regulation (Regulation for Wastewater..., 2007) governing the use of the cleaning facilities the output of which does not exceed 5 $m^3 d^{-1}$, the average annual contamination of the wastewater with the easily decomposing organic pollutants (BOD_7) cannot exceed 35 mg O_2 L^{-1} after cleaning, the momentary contamination cannot exceed 58 mg O_2 L^{-1}. The sand filter guaranted cleaning of the wastewater to this level both with the hydraulic load of 0.03 and 0.06 m^3 m^{-2} d^{-1} and with the initial contamination fluctuating in the range from 108 to 512 mg O_2 L^{-1}. In the year of 2009 the wastewater was cleaned in the sand filter model more efficiently (according to the BOD_7 index). The efficiency reached 98.4% and in 2008 it reached 97.8% despite the fact that the hydraulic load was twice lower. The cause for this phenomenon was 18.6% higher initial contamination of the wastewater in the first year. In the dolomite chippings model with the hydraulic load of 0.03 m^3 m^2 d^{-1} the domestic wastewater was cleaned up to the allowable norms. The efficiency of the cleaning process was 95.8%. When the hydraulic load was doubled the efficiency decreased to 80.5% and the dependence of the cleaning process on the initial contamination rose. Applying the regression equation received, we estimated that when the hydraulic load is equal to 0.06 m^3 m^{-2}, the dolomite chippings filter can guarantee removal of the easily decomposing organic pollutants (BOD_7) from the wastewater up to the allowable norms only on the condition that the initial quantity of the pollutants in the wastewater does not exceed 225 mg O_2 L^{-1}. Since the contamination of the wastewater can reach up to 450 mg O_2 L^{-1}, the contamination level has to be reduced in half before the wastewater can be treated in the dolomite chippings filter. The primary treatment of the wastewater usually is performed in the septic tank with three chambers. The decrease in the pollutant concentration (removal efficiency in percents) after the wastewater passes all three chambers depends on the time period spent in the chambers. Before cleaning the wastewater in the dolomite chippings filter, the wastewater has to spend 10 days in the septic tank. In this case the pollutant removal efficiency will be as follows: BOD_7 removal efficiency will reach 51%, the N_{total} removal efficiency will reach 28%, the P_{total} removal efficiency will reach 32%, and the suspended particles removal efficiency will reach 65% (Radzevičius et al., 2008). For example, in order to clean the domestic wastewater produced by the family consisting of 4 persons 8 m^3 capacity septic tank with three chambers will be needed for the primary treatment and 13.5 m^2 dolomite chippings filter will be needed for the deep cleaning of the wastewater.

The received regression equations will help to optimize the parameters of the cleaning facilities equipped with the vertical dolomite chippings filters dependent on the initial pollution of the wastewater.

The dependence of the possibilities to clean the domestic wastewater on the hydraulic load and the quantity of the suspended solids in the wastewater present before it's cleaning is given in Figures 3 and 4. The dependence was present in both the sand filter and the dolomite chippings filter models. As the investigation revealed, in the first filter with the hydraulic load of 0.03 m^3 m^2 d^{-1} the suspended solids were removed from the wastewater with the efficiency of 96.6% and when the load was doubled the efficiency decreased to 90.7%. In both cases the allowable contamination level of 30 mg L^{-1} was not exceeded. The efficiency of removal of the suspended solids was lower in the dolomite chippings filter and exceeded the allowable norms by 72.2 and 49.3%. The biggest level of the wastewater contamination was at the beginning of both trials and reached 112 mg L^{-1}. That is why it is necessary to prewash the dolomite chippings before equipping the filter.

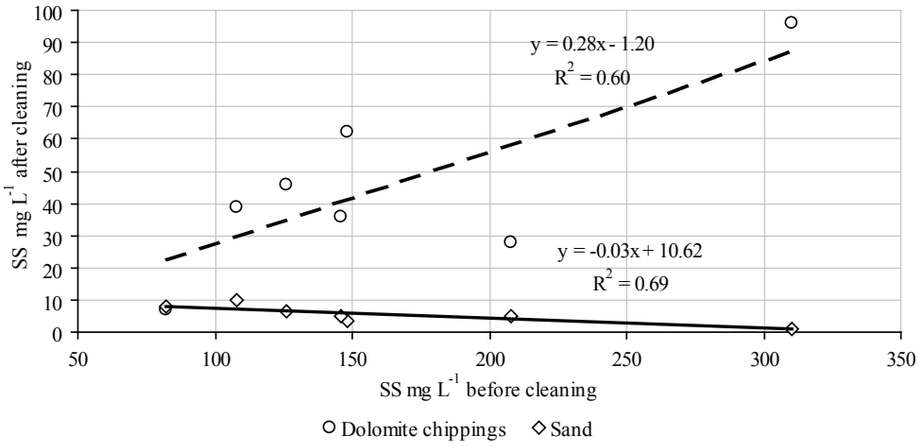

Figure 3. The dependence of the possibilities to remove the suspended solids from the wastewater on the initial pollution of the wastewater with the solids when the hydraulic load is equal to 0.03 m^3 m^{-2}.

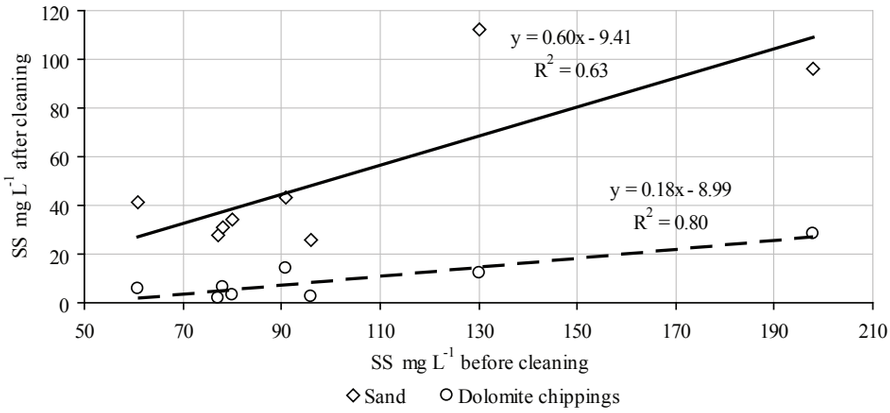

Figure 4. The dependence of the possibilities to remove the suspended solids from the wastewater on the initial pollution of the wastewater with the solids when the hydraulic load is equal to 0.06 m^3 m^{-2}.

The efficiency of phosphorus removal depends on the properties of the filter media. The power of absorption depends on the quantities of AL, Fe and Ca present in the filter media. There are 20-30% of Calcium oxide (CaO), 17-22% of Magnesium oxide (MgO) and 37-48% of Carbon dioxide (CaO_2) in the dolomite chippings. Taking into account the chemical composition of the dolomite chippings, it is possible to assert that the conditions necessary for the removal of the P_{total} in the dolomite chippings filter are favourable. Removal of phosphorus in the filter models and the dependence of the removal on the initial contamination of the untreated wastewater and hydraulic load are presented in Figures 5 and 6.

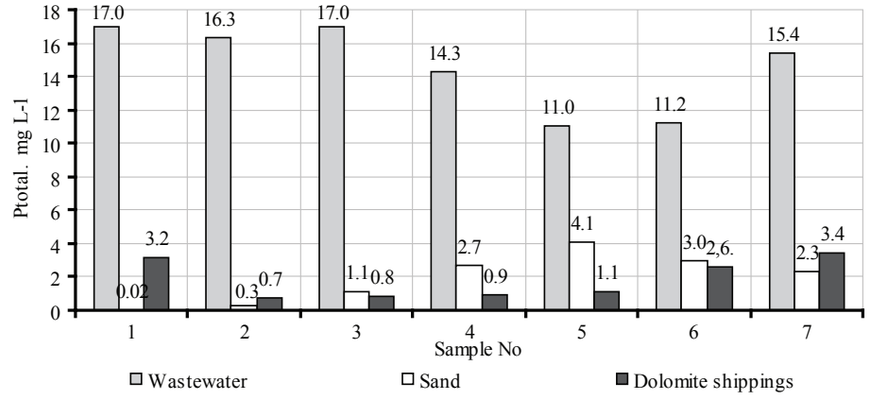

Figure 5. The dependence of the possibilities to remove the P_{total} from the wastewater on the initial pollution of the wastewater when the hydraulic load is equal to 0.03 m^3 m^{-2}.

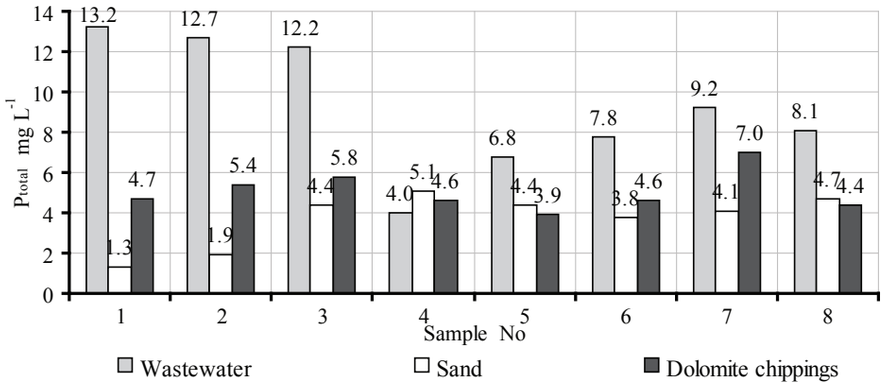

Figure 6. The dependence of the possibilities to remove the P_{total} from the wastewater on the initial pollution of the wastewater when the hydraulic load is equal to 0.06 m^3 m^{-2}.

The investigation revealed that the P_{total} was removed from the domestic wastewater in the sand and dolomite chippings filter models almost with the same success. The efficiency of the cleaning process was 87.7 and 87.7% respectively. The quantity of phosphorus in the cleaned wastewater did not exceed the allowable norms. When the hydraulic load doubled, the cleaning efficiency decreased to 59.8% in the sand filter and to 45.7% in the dolomite chippings filter. The worse efficiency in the latter filter was determined by the fact that the wastewater passed through the dolomite chippings quicker and the contact with them was shorter than with the sand in the sand filter.

As the majority of the authors are noticing (Ciupa, 1996; Kadlec, 1985) the high phosphorus removal efficiency is reached only at the beginning of the process and later, when the ground gets saturated with phosphates, the efficiency decreases to the minimum. In the most filters the phosphorus removal efficiency does not exceed 50% (Verhoeven and Merleman, 1999). The phosphorus removal efficiency in the vertical filter receiving the wastewater from the public catering institution "Pastogė" decresed from 60 percents at the beginning of the year to 20 percents at the end of the year (Gasiūnas and Strusevičius, 2004). It is clear that the phosphorus removal efficiency will decrease in the dolomite chippings filter too.

The N_{total} was removed from the wastewater with the efficiency of 25.8-0.6% in the sand filter and with the efficiency of 8.6-14.3% in the dolomite chippings filter.

The vertical filters with the dolomite chippings used as the filter media are viable. The wastewater is cleaned with less success in the filters to compare them with the sand filters but due to the coarse fractions (2-5 mm) the danger of stoppage disappears. It is also possible to increase the hydraulic load and at the same time to decrease the size and price of the filters.

Conclusions

1. In the dolomite chippings filter the wastewater was cleaned with the efficiency of 95.9% when the hydraulic load was 0.03 $m^3\ m^2\ d^{-1}$. The allowable level of contamination which was 30 mg $O_2\ L^{-1}$ was never exceeded. When the hydraulic pressure was doubled the efficiency of the wastewater cleaning decreased to 80.5% and the dependence on the initial contamination of the wastewater increased.
2. The dolomite chippings filter can ensure removal of the easily decomposing organic pollutants (BOD_7) to the allowable norms when the hydraulic load is equal to 0.06 $m^3\ m^{-2}$ only on the condition that the initial contamination of the wastewater does not exceed 220 mg $O_2\ L^{-1}$.
3. Taking into account the fact that not all the pollutants were removed from the wastewater to the allowable norms, the vertical dolomite chippings filters can be equipped only in the places where the output of the domestic wastewater does not exceed 5 $m^3\ d^{-1}$ because in this case only the BOD_7 quantities in the cleaned wastewater are regulated by law.

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RESEARCH OF SURFACE WASTEWATER IN THE TERRITORY OF MEAT PROCESSING COMPANY

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Abstract. Pollution and treatment efficiency of surface (rain) wastewater, forming in the production territory of meat processing company LTD 'Krekenavos mėsa' (centre of Lithuania in Kėdainiai district), were investigated in the period 2004-2009. On the surface of the company territory the precipitation water turns to surface wastewater, which is collected and sent down to treatment equipment. Wastewater samples were taken before and after biological treatment. The samples were investigated in the Chemical Analysis Laboratory of the Water Research institute of Lithuania University of Agriculture certified by the Environment Ministry of the Republic of Lithuania The following indices have been determined: biochemical oxygen demand (BOD_7) – by titrometric method, suspended solids (SS) – by gravimetric method, having filtered the substance through a mid-thickness filter. 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. During six years of investigation average wastewater pollution with suspended materials was 35.0 mg L^{-1}, which by 14% exceeded the BAC. Suspended solids determined BOD_7 concentrations in surface wastewater by 46%. The best treatment effect was received in the purification of oil products - 96%, suspended solids - 60%, organic pollutants - 59%. The wastewater discharged from the company production territory to natural environment was clean as concentrations of the investigated oil hydrocarbons, biochemical oxygen demand and suspended solids in the surface wastewater were 26, 4 and 2 times respectively lower than biggest available concentration.
Key words: surface wastewater, pollution, treatment efficiency.

Introduction

Surface wastewater – precipitation and other water (pavement or transport washing, watering, etc.), which gets on the surface of urbanized territory and must be collected by the territory administrator with wastewater treatment systems and discharged to the environment or to the wastewater treatment systems owned by other persons (Del paviršiniu..., 2007).

In 2008, total amount of surface (rain) wastewater discharged to surface water bodies was 51.2 mln m^3, which was by 5.8 mln m^3 less than that in 2007. In Lithuania only a small part of all collected surface wastewater undergoes some treatment. In 2008, only 9.4% of discharged wastewater was cleaned to meet the set standards, 1.1% - was insufficiently cleaned and even 89.4% - was not treated. During the last 8 years part of treated surface wastewater has increased approximately by 3%, of that the wastewater cleaned to meet the set standards – approximately by 2%. Meantime, the surface wastewater treatment does not receive sufficient attention in Lithuania (Aplinkos..., 2008).

Domestic and industrial wastewater receives some treatment while surface wastewater has been put into the group of relatively clean waters. However, the amount of precipitation absorbed by modern artificial roofing and pavement overlay is approximately 10 times lower than that absorbed by natural covers. Therefore, infiltration decreases and accumulation of surface wastewater in the territories increases. The pollutants washed off from roofs and streets together with surface wastewater get to removal systems and reach water bodies where they deposit in the form of bed sediments. The deposits, which are significant in amount chemical oxygen demand (COD) 0.3-0.5 $gO_2\ g^{-1}$ and have biodegradation period of 25-30 days, can significantly reduce the concentration of dissolved oxygen in the water body and thus disturb the process of self-purification. The amount of pollutants accessing together with surface wastewater must be limited to maintain normal depuration regime in the water body (Jakubauskas and Račys, 1997).

The issue of surface wastewater management does not lose its urgency as a lot of harmful substances such as oil products and heavy metals get to environment from hard cover surfaces. Up to 80% of heavy metals combine with solid materials transported by rainwater, e.g. sand and silt. To protect nature from harmful pollutants, the rainwater that flows down the area surface covers must be cleaned.

Concentrations of biochemical oxygen demand (BOD_7), suspended solids and oil products are the master indices characterising contamination of surface wastewater. Suspended solids have the strongest influence on water quality as they form deposits in surface water bodies. Their concentration in surface wastewater fluctuates from 10 mg to several grams per litre.

The territory and atmosphere contamination level, hydrogeological characteristics of the territory, time of pollution accumulation, flush (precipitation) intensity and duration as well as characteristics of surface covers are the main factors determining the amount of pollutants that can get to open water bodies together with surface wastewater.

Some factors (hydrogeological characteristics of the territory, characteristics of surface covers) are specific to the territory and have constant values, while others (time of pollution accumulation, flush intensity and duration) have randomly changing values.

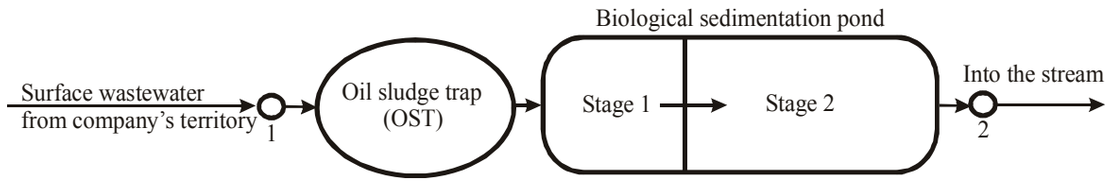

Figure 1. Technological scheme of surface wastewater treatment facilities.

Rain (atmospheric) wastewater concentrates on soil surface, on roofs of buildings, after precipitation or during snow melting. This wastewater is polluted with water dissolved atmospheric and mineral materials at various degrees. Concentration of pollutants, i.e. amount of pollutants per wastewater volume unit, mg L^{-1} or g m^{-3}, describes the wastewater composition. The materials spread in rain wastewater are in different concentrations depending on the territory sanitary condition, transport intensity, air pollution, management of the environment and other factors. Rain wastewater pollution with pervading materials is considered to be 5-10 times lower that that of domestic wastewater. The rain wastewater discharge depends on rain (rainfall) intensity, duration, time of water soaking into ground, etc. (Burinskiene et al., 2003).

The investigation of surface (rain) water has been carried out in newly built meat processing company where industrial and domestic wastewater is provided to the city wastewater treatment facilities and surface wastewater from processing territory is collected by sewage and cleaned in the biological treatment ponds.

Following the order of the Lithuanian Republic minister of Environment, concerning provisions of surface wastewater management regulation, which sets environmental requirements for surface wastewater collection, cleaning and discharge in order to prevent environmental pollution the company tackles one of environmental problems – management of surface wastewater.

The aim of the work is to investigate pollution of the surface wastewater, collected in the company territory, and its treatment efficiency, and establish the conformity with the requirements to surface wastewater disposable to the environment.

Materials and Methods

Pollution and treatment efficiency of surface (rain) wastewater, forming in the production territory of meat processing company LTD 'Krekenavos mėsa' (centre of Lithuania in Kėdainiai district), were investigated in the period 2004-2009. On the surface of the company territory the precipitation water turns to surface wastewater, which is collected and sent down to treatment equipment. This consists of oil sludge trap and two-stage biological treatment pond. The useful volume of oil sludge pollutants trap is 158 m^3, that of biological pond – 1500 m^3. The latter is of two stages – 1/3 of the pond (in the zone of wastewater inflow) is of 1.8 m depth and is used for dust and sand deposition, 2/3 of the pond are of 0.7 m depth and planted with water plants (Fig. 1).

Wastewater samples were taken from the well (1) in the company's territory before the oil sludge trap and from another well (2) after a biological treatment. During 2004 – 2007 research period, samples were taken once a month, and in 2008 – 2009 they were taken once in a quarter. The samples were investigated in the Chemical Analysis Laboratory of the Water Research institute of Lithuania University of Agriculture certified by the Environment Ministry of the Republic of Lithuania (Unifikuoti nuoteku..., 1994). The following indices have been determined: BOD_7 – by titrometric method (Vincler); suspended solids (SS) – by gravimetric method, having filtered the substance through a mid-thickness filter. 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.

The following dependence was used to calculate the quantitative indices of surface wastewater collected from the enterprise territory (Dėl aplinkosaugos..., 2004):

$$W_m = 10 * H * F * \alpha * K \text{ m}^3, \quad (1)$$

Here: W_m – annual surface wastewater amount m^3;
H – mean precipitation amount during the period of investigation mm;
F – area of processing territory ha;
α – surface runoff coefficient;
K – 0.9 (when snow is removed from the processing territory).

Table 1

Amount of precipitation during study period, mm

Indices	2004	2005	2006	2007	2008	2009
Precipitation mm	556	418	465	669	574	726
% from perennial rate	94	71	79	113	97	123
Average air temperature of a day °C	7.1	7.1	7.7	8.0	8.5	7.1
Deviation from the norm	+0.8	+0.9	+1.5	+1.8	+2.3	+0.9

The data from Dotnuva Meteorological station, which is the closest to the meat processing company, (Table 1) were used to calculate the surface wastewater discharge from the company territory.
Mathematical and statistical analysis of the test study was performed with the help of standard computer study as well as with the help of standard computer program 'Excel'. The data of investigations and calculations were analysed with the help of correlation analysis.

Results and Discussion
The year of 2005 was the driest year in the period of investigation: 71% of perennial precipitation rate and average air temperature of a day exceeded the perennial one by 0.9 °C. In 2004, 2006 and 2008 average precipitation was less than the norm and made 94, 79 and 97% respectively. In 2007 and 2009, the climate was humid: precipitation exceeded the perennial norm by 13 and 23%, average air temperature of a day also was higher than the perennial one by 0.8 – 2.3 °C respectively.
As modern roof and asphalt covers do not absorb rainwater, almost total rainwater that reached them was collected to rain canalisation and directed to the treatment system. The following equation shows strong dependence between the amount of surface (rain) wastewater and the precipitation (r=0.99):

$$y = 30.483x - 64.329 \quad (2)$$
$$(r = 0.99; F_{fact} = 527{,}4 > F_{theor95\%} = 2.0)$$

Here: x – amount of precipitation mm;
y – amount of surface (rain) wastewater m^3.

Suspended solids have the strongest influence on water quality as they form deposits in surface water bodies. Figure 2 presents fluctuation of suspended solids content in the surface water during the period of investigation.
The period of the maximum of the highest pollutants' concentration is known to depend on precipitation dynamics and time they reach the collector (Молотков and Шифрин, 1977). The investigations have established that the majority of pollutants from the company territory gets to the treatment system together with low and medium intensity rain.
According to the surface wastewater treatment regulations, approved by the order No D1-193 of the LR Minister of Environment on April 2nd, 2007, the maximum momentary concentration of suspended solids should not exceed 50 mg L^{-1} (Dėl paviršiniu..., 2007). Figure 2 shows that the observed momentary concentrations of these materials exceed BAC and fluctuate from 68 to 220 mg L^{-1}.
After the wastewater has passed all stages of treatment, the amount of suspended solids decreases and meets the set requirements, except the case on April 19th, 2006 (66 mg L^{-1}) when the concentration of these solids in the precipitation was established to be 49 mg L^{-1}.
The above mentioned regulations provide that average annual concentration of suspended solids should not exceed 30 mg L^{-1}. The data presented in the Table 2 show that the amount of suspended solids exceeded BAC in surface wastewater which flew down the company territory in 2004 and 2006.

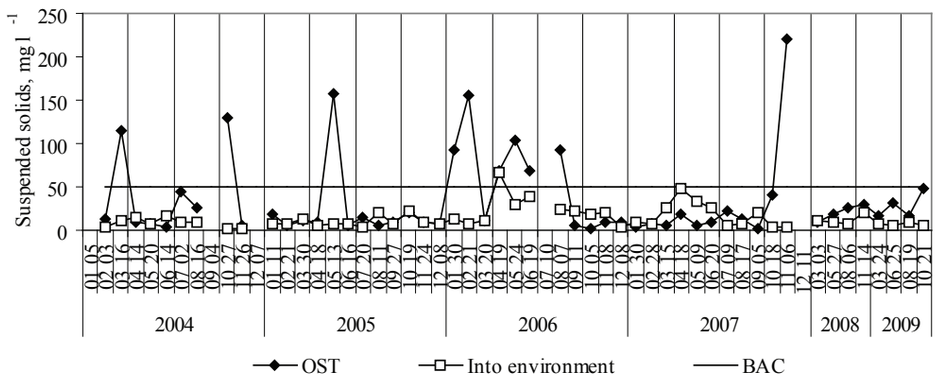

Figure 2. Fluctuation of suspended solids in surface water.

Table 2

Average annual concentrations of suspended solids in wastewater and in the water discharged to natural environment mg L^{-1}

Indicies	2004	2005	2006	2007	2008	2009
Wastewater	39.3	22.7	56.2	31.5	20.6	28.3
Into environment	8.5	10.1	23.1	17.4	12.2	7.0

The surface wastewater that reaches natural environment is cleaned as having passed treatment equipment concentrations of suspended solids annually decreases by 78, 56, 59, 45, 41 and 75%.

It is known that up to 90% of organic materials, determining BOD_7 concentration, are suspended solids, and contamination with other pollutants i.e. oil products and heavy metals is of accidental character (Jakubauskas and Račys, 1997). Contamination of surface wastewater with organic compounds is directly related to suspended solids (Fig. 3).

In the period 2004-2009 biochemical oxygen demand in rain wastewater in the enterprise surface water has been established to be determined by suspended solids, by 48% (r=0.69; t_{fact}=6.84>F_{teor}=2.0, n=52) respectively.

Samples of the surface wastewater, released to natural environment, have low values of the highest concentrations of oil hydrocarbons, which fluctuate from 0.02 to 3.14 mg L^{-1}, and these are from 250 to 1.6 times lower than BAC (Fig.4).

Oil and oil products is one of the most common and hazardous ground and water pollutants, the composition of which changes due to environmental impact and natural communities of oil oxidizing microorganisms require long time for their complete decomposition (Čipinytė and Grigiškis, 2000; Leahy and Colwell, 1990).

During five years of investigations the wastewater from the company processing territory did not contain big amounts of oil products, in 2004, 2005, 2006, 2008 and 2009 average annual concentrations did not exceed the BAC: 0.17, 0.06, 0.06, 0.06 and 0.33 mg L^{-1}. The treatment equipment cleaned the wastewater by 65, 5.2, 67, 50 and 79%. In 2007, due to reconstruction works involving exploitation of hired machinery, the content of oil products in rain wastewater increased up to 98 mg L^{-1}, but after treatment (97%) the released wastewater contained 3.1 mg L^{-1}.

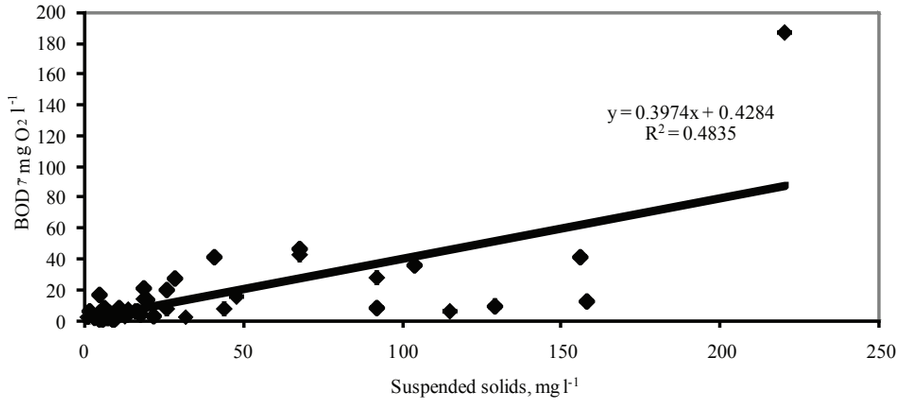

Figure 3. Relation between suspended solids and organic compounds.

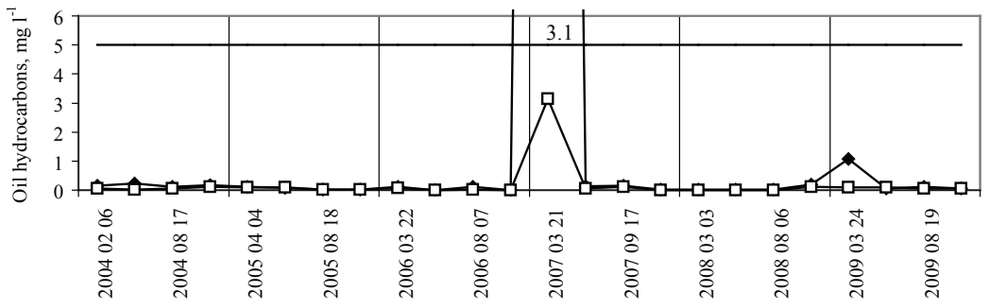

Figure 4. Fluctuation of oil hydrocarbons in surface wastewater.

Wastewater — Into the environment — BAC

Table 3

Fluctuation of pollutants concentration during the biological treatment of wastewater

Pollutants	Measure unit	Biggest allowable concentration	Wastewater before treatment	Wastewater after biological treatment	n	Treatment efficiency, %
SS	mg L^{-1}	30	220-1.2 35.0	66.0-1.4 14.1	51	60
BOD_7	mg L^{-1} O_2	28.75	187.0-0.81 15.5	26.0-2.2 6.3	52	59
Oil	mg L^{-1}	5	98.0-0.0 4.2	3.14-0.0 0.19	24	96

Note. Numerator – fluctuation ranges of concentration, denominator – average concentration.

Data presented in Table 3 shows the following surface water treatment in biological treatment pond efficiency: oil products - 96%, suspended solids - 60%, organic polluting materials - 59%.

Conclusions

1. Surface wastewater has been established to be the most polluted with suspended solids: during six years of investigation the average pollution was 35 mg L^{-1}, which exceeded BAC by 14%.
2. The index of organic pollution has no impact on corresponding environmental requirements.
3. The oil product content increase in the wastewater is of accidental character, however, quality of the water released to natural environment meets the standards.
4. The best treatment efficiency is as follows: oil products – by 96%, suspended solids – by 60%, organic materials – by 59%.
5. The wastewater released to natural environment from the enterprise territory meets the environment as its average concentration in surface wastewater collected from the company territory is half as big as BAC.

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DISTRIBUTION OF NITROGEN AND PHOSPHORUS COMPOUNDS IN FILTER MEDIA OF CONSTRUCTED WETLAND

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Abstract. The objective of the present studies is to estimate a distribution of nitrogen and phosphorus compounds in filter media of horizontal filters. The studies were carried out in 2009 within two wastewater treatment facilities of horizontal flow in Lithuania. From both treatment facilities sand samples of different depth and separate profiles in the direction of water flow were taken. These samples were used to determine sandmoisture and concentration of $N\text{-}NO_3$, $N\text{-}NH_4$ and total P.
The measurements of sand moisture showed that the filtration of wastewater through the sand is in process only in the lower layer of sand filter and near the distribution pipe. Moisture regime in the sand influences the composition of nitrogenous compounds in it. In the part of the filter, where sand's moisture is lowest, nitrate concentration is highest. Ammonia concentrations are completely opposite. In the lower part of the filter anaerobic conditions are dominant and nitrification processes stop. Analysis of phosphorus concentrations in filter's sand showed similar tendencies as nitrogen analysis. In the upper part of the sand phosphorus concentration turns out to be 2-3 times lower than in the lower part of the sand. In the filters of horizontal flow, part of the sand contributes little or does not contribute to the wastewater treatment process at all; therefore, it is advisable to use wastewater recirculation for the improvement of nitrogen and phosphorus removal. For that purpose in the part of the filter not included in the treatment process the filter of vertical flow could be arranged.
Key words: wastewater treatment, constructed wetlands, filtration.

Introduction

Constructed wetland (CW) treatment systems are divided into groups according to water flow. In filters of subsurface flow the wastewater is flowing below the ground surface. The filters consist of excavated beds filled with sand in which marshy plants are growing. In filters of horizontal flow (HF) the wastewater flows horizontally from the inflow zone through the body of the filter, where it is purified.

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 (biochemical oxygen demand), 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 and Mauring, 1997; Haberl et al., 1995; Vymazal, 2002). Representative natural and constructed treatment wetlands reviewed by R.H. Kadlec (1994) ranged from highly successful to poor in percent removal of total Kjeldahl N (3–98%), NH_4-N (14–98%), NO_2-N+NO_3-N (38–96%). In the Czech Republic, total N removal efficiency is 41.6%, in Denmark it is 42.9% (Vymazal, 2002).

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 and Patrick, 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 and Baker, 1989; Reddy and D'Angelo, 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).

Phosphorus within constructed wetlands is removed from wastewater via physical, chemical and biological processes occurring between the wetland substratum, vegetation and wastewater stream (Kim and Geary, 2000). Biological oxidation of phosphorus within CW converts most phosphorus species to an orthophosphate (soluble) form (Cooper et al., 1996; Kadlec and Knight, 1996). Phosphate can also form precipitate with iron and aluminium oxides leading to new mineral compounds (Fe- and Al-phosphates). These compounds allow the removal of phosphorus from a wastewater via sedimentation and filtration (Richardson and Craft, 1993; DeBusk and Dierberg, 1999). In the aerobic conditions when pH fluctuates from neutral to acidic, iron ions with the valency of 3 cohere with phosphates to make stable complexes. When conditions change into anaerobic, and sand is flooded, iron ions with valency of 3 are reduced to valency of 2. This process determines lower adsorption as well as release of phosphates. (Faulkner and Richardsson, 1989). According to R.H. Kadlec (1985), every soil has its own limited power of adsorption and when it is saturated, the movement of phosphates is not obstructed. The data of J.T.A.Verhoeven shows that in most filters the efficiency of phosphorus removal is not greater than 50%. (Verhoeven and Meuleman,1999).

Research on horizontal flow filters carried out in Lithuania indicates that average total N removal efficiency reaches 37-44% and phosphorous compounds removal about 14-41%. (Gasiunas et al., 2005)

The objective of the investigation has been to estimate a distribution of nitrogen and phosphorus compounds in filter media of horizontal filters.

Materials and Methods

Research was carried out in 2009 in two wastewater treatment facilities with filters of horizontal flow in Lithuania. One of them was wastewater treatment facilities (WWTP) of Lifosa factory. The start of their operation dates back to 2001. These treatment facilities are used to treat domestic wastewater of phosphoric fertilizers' plant. Wastewater from the septic tank is distributed to 3 filters. The area of one filter is about 2000 m^2 and hydraulic load - 200 m^3 d^{-1}.

The other object selected for investigation was wastewater treatment facilities in Pagiriai settlement. They are being operated from 1996. After the purification in septic tanks, wastewater is directed into four implemented filters, each area being 250 m^2 and hydraulic load reaching 20 m^3 d^{-1}.

The construction of filters in both wastewater treatment facilities is similar. Chipping 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 7-12 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 – 5.0 m. Filters are planted with common reed (*Phragmites australis*).

From both treatment facilities in September - October months sand samples were taken, in depths of 20, 40, 60 and 80 centimetres and cross-sections with the distance of 1, 2 and 4 metres from the distribution pipe going to collection pipe (Fig. 1). Sand samples in cross-sections within the indicated distances were taken 4-6 times. Sand's laboratory analysis was carried out using commonly accepted methods of ground analysis. For mathematical analysis of data regression analysis was applied.

Results and Discussion

After the purification in septic tanks, wastewater is directed into horizontal filters for biological treatment. The indicies of nitrogen and phosphorus of wastewater supplied into the filters in the moment when sand samples were taken are presented in Table 1. As we can see, wastewater in Lifosa treatment facilities are not so heavily contaminated with nitrogen but more contaminated with phosphorus compared with the Pagiriai treatment facilities. Therefore, nitrogen removal is analysed by using Pagiriai and phosphorus removal by using Lifosa treatment facilities.

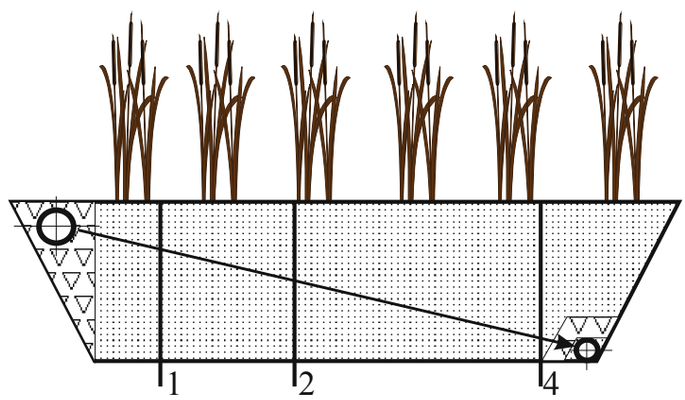

Figure 1. Principal scheme of horizontal flow filters with the cross-sections of sand samples.

sand chippings direction of water flow

Table 1

Wastewater indices at the moment when sand samples were taken

		N total, mg L^{-1}	$N\text{-}NO_3$, mg L^{-1}	$N\text{-}NH_4$, mg L^{-1}	P total, mg L^{-1}
Lifosa WWTP	Influent into the filter	11.6	0.015	6.84	7.31
	Effluent out of the filter	6.02	4.58	0.6	3.94
	Treatment efficiency %	48.1	-	-	46.1
Pagiriai WWTP	Influent into the filter	29.1	0.009	21.2	2.3
	Effluent out of the filter	21.1	3.3	12.4	1.9
	Treatment efficiency, %	27.5	-	-	17.4

Treatment processes in filters depend on moisture regime in filtration medium. That indicates the condition (aerobic, anaerobic or anoxic) in which the treatment is performed. The measurements of sand moisture, when filters are loaded, showed that one part of the filter is much drier, than the other one. The data of moisture analysis are given in the diagram in Figure 2. Correlation coefficients show that moisture of sand depends on depth more than on the distance in the profile of filter. Although correlation coefficient of sand moisture dependence on the distance from inlet is not reliable, up to 50 cm deep this correlation is clearly seen. The driest sand is above the collection pipe while going to the distribution pipe its moisture gradually increases. It shows that filtration of wastewater through the sand is in process only in the lower layer of 60-80 cm and near the distribution pipe.

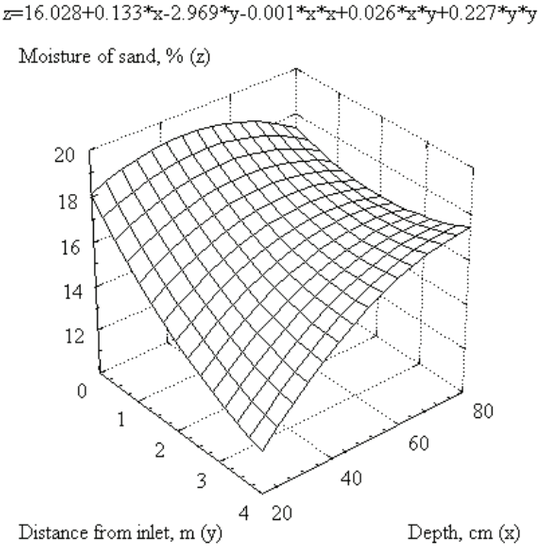

Figure 2. Moisture of the sand in the filter (z) with respect to the depth of sand (x) and distance from inlet (y).

when z=f(x) r=0.53, p=0.00015;
z=f(y) r=0.23, p=0.13

Moisture regime in the sand influences the composition of nitrogenous compounds in it. The data of $N\text{-}NO_3$ analysis are given in the diagram in Figure 3. The research on nitrate concentration in sand showed that in the part where sand moisture is the lowest, nitrate concentration is the highest. In deeper layers, nitrogen concentration declines to zero. That is the consequence of moisture regime. In the lower part of the filter anaerobic conditions are dominant and nitrification processes stop. Significant correlation is observed only in $N\text{-}NO_3$ dependence on the depth of sand samples taken.

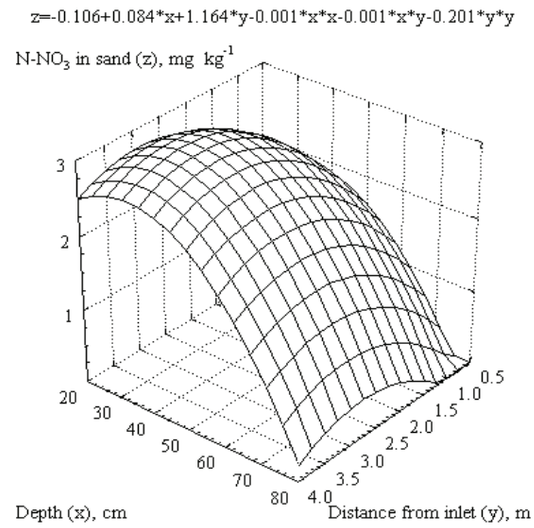

Figure 3. $N\text{-}NO_3$ concentration in the sand (z) with respect to the depth of sand (x) and distance from inlet (y).

when z=f(x) r=0.54, p=0.00011;
z=f(y) r=0.27, p=0.077

Ammonia concentrations are completely opposite (Fig. 4). There is a clear correlation of sand depth, when deeper than 50 cm, ammonia concentration rises sharply. That is the consequence of moisture regime.

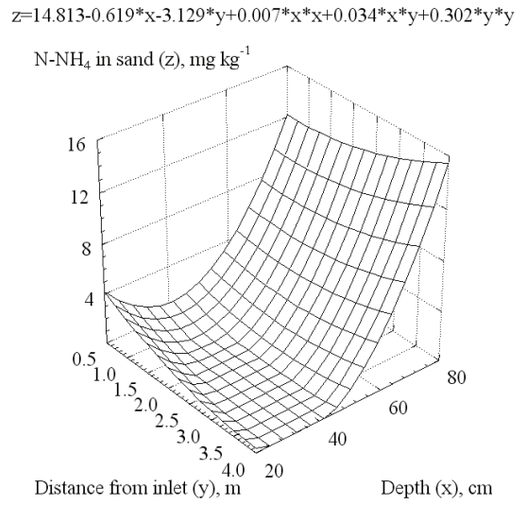

Figure 4. $N\text{-}NH_4$ concentration in the sand (z) with respect to the depth of sand (x) and distance from inlet (y).

when z=f(x) r=0.70, p=0.0000
z=f(y) r=0.02, p=0.87

Measurements of nitrogen composition in wastewater effluent after treatment in filters of horizontal flow showed that almost 70% of total

nitrogen is in the form of ammonia, indicating that wastewater treatment processes occur in anaerobic environment (Gasiunas and Strusevičius, 2006). Having analysed 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. Similar results were obtained by other researchers, too (Cooper, 1999; Cooper et al., 1996).

From the given analysis it can be seen that in the filters of horizontal flow a part of filtration body does not or very little contributes to the wastewater treatment process. We can claim that approximately one third of the filter near the collection pipe is not used.

Key processes in the N cycle include ammonification, nitrification, and denitrification. Nitrification - denitrification reactions are the dominant removal mechanisms of nitrogen in constructed wetlands. Nitrification occurs in aerobic regions of the water column, soil-water interface, and the root zone (Reddy and D'Angelo, 1997). Nitrogen removal in filters consists of three stages:

- ammonification (anaerobic conditions)
  $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$
- nitrification (aerobic conditions)
  $2\ NH_4^+ + 3\ O_2 \leftrightarrow 4\ H^+ + 2\ H_2O + 2\ NO_2^-$
  $2\ NO_2^- + O_2 \leftrightarrow 2\ NO_3^-$
- denitrification (anoxic, anaerobic conditions)
  $NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_2$

Nitrogen mineralisation and ammonification are in process and take place in the septic tank. In filter's body nitrogen nitrification and denitrification occur, and this way nitrogen is removed. Because of the anaerobic conditions, nitrification and denitrification are only partial. That is why ammonia nitrogen in the effluent of the filter is dominant. Only about 40-50% of total nitrogen is removed from wastewater.

The removal of nitrogen from wastewater is important. Nitrogen in ammonia form is more harmful to the environment than the one in nitrate form. Following this reason, the part of the filter that does not participate in wastewater treatment could be used for additional nitrogen removal. This goal could be obtained by introducing wastewater recirculation. In the part of the horizontal filter, the filter of vertical flow has to be installed. In such a system, part of wastewater is returned to the part of the filter with vertical filtration. In the upper part, aerobic conditions are prevailing, therefore, in sufficient amount of oxygen, nitrification occurs. When reaching the lower part of the sand, wastewater enters the zone with anoxic and anaerobic conditions. These are suitable for denitrification process by which nitrogen is removed from wastewater. Thereby, there is no need to implement additional installations to improve efficiency of nitrogen removal and at the same time, the part of the filter not involved in the treatment process, is put into use. Principal scheme of water recirculation is presented in Figure 5.

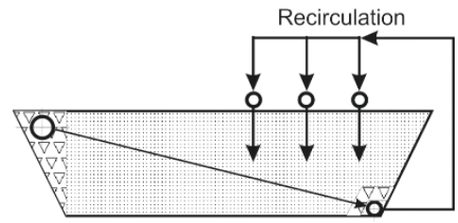

Figure 5. Principal scheme of water recirculation.

The data of total P analysis are given in the diagram in Figure 6. Analysis of phosphorus concentrations in filter's sand showed similar tendencies as nitrogen analysis. In the upper part of the sand phosphorus concentration turns out to be 2-3 times lower than in the lower part of the sand. This fact confirms the statement that in filters of horizontal flow, part of the sand does not participate in the treatment process. In this diagram strong phosphorus concentration's dependence on the distance to the inlet zone can be seen. Phosphorus is coprecipitated with iron, aluminium, and calcium compounds, located in the filter medium. Phosphorus adsorption in the filter medium is limited and works more intensively from half to one year (Gasiūnas and Strusevičius, 2008). Later on it decreases to 20-30%. When wastewater recirculation introduced, phosphorus removal would increase for additional sand volume and would be involved in the treatment process.

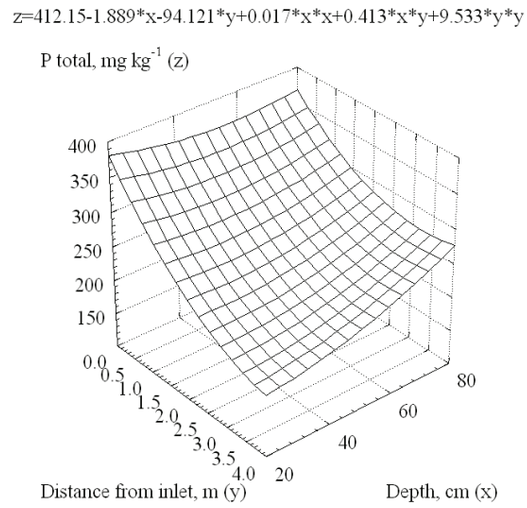

Figure 6. P total concentration in the sand (z) with respect to the depth of sand (x) and distance from inlet (y).

when z=f(x) r=0.23, p=0.078;
z=f(y) r=-0.42, p=0.0008

Conclusions

In the filters of horizontal flow part of the sand little or does not contribute to the wastewater treatment process at all; therefore, it is advisable to use wastewater recirculation for the improvement of nitrogen and phosphorus removal.

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THE INFLUENCE OF NEOGENE LITHOLOGY ON THE LITHUANIAN RIVER HYDROLOGIC REGIME

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Abstract. Due to the recently increasing frequency of extreme changes in river runoff regime, scientific literature deals with the characteristics of runoff formation. Works are carried out in analyzing climate changes and a lot of attention falls on land–use structures. Following thorough analysis of the lithological structure of river basins in separate costal zones, this article aims at evaluating river runoff formation characteristics. The basin lithological factor was calculated based on Quaternary map of Lithuania M 1:200000 and Lithuanian river map M 1:50000 using ArcGis software. In order to carry out more thorough analysis of the influence of lithology in given territories, sections of 0–20 m, 50–200 m, 200–500 m, 500–800 m, 800–1000 m and >1000 m were established, calculating the distance in meters from the riverbank. Eight river basins of typical lithological structure (sandy, loamy, argillaceous) were selected and examined. The period of the years 1960–2007 was analyzed as this period saw the greatest amount of precipitation (up to 33% probability), and relation between the runoff and precipitation was established as well as that with the lithological structure, established following the derivation of a hydromodule.
Key words: lithology, river runoff, precipitation, basin.

Introduction

The distribution of river runoff throughout the year is determined by climatic and bedrock surface factors. Climate influences the overall wateriness during the year and runoff regime phase periods. Bedrock surface (the size of a river basin, its lithological composition, and forest area in the river basin) might cause fundamental changes to the runoff regime formed by climatic factors (Gailiušis et al., 2001; Uhlenbrook et al., 2001).

Recently, cases of ill–timed floods throughout the world have come to the news more and more frequently. It has been estimated that the amount and intensity of precipitation has increased 10 times during the second half of the 20th century (Pfister et al., 2004).

In the context of global climate change, Lithuanian climatologists have not yet recorded fundamental changes in multi–annual precipitation patterns but have established its clear seasonal distribution, i.e. winter season precipitation has increased significantly while that of summer season has seen a significant decrease (Galvonaitė and Valiukas, 2005; Bukantis et al., 2001; Bukantis and Rimkus, 2005).

A number of researchers engage in the analysis of runoff formation conditions, particularly while analyzing the impact of land–use structures on river runoff (Jones and Grant, 1996; Ashagrie et al., 2006). H. Pauliukevičius (2006) looked into the impact of land–use on small river basins runoff. The research has demonstrated slight and moderate inverse correlation of average annual runoff module with forest area and direct correlation with arable land area in small river basins with varied land–use in the end of a low–wateriness period and the beginning of a higher wateriness period.

However, the number of scientific research focusing on the aspects of runoff formation in terms of lithological structure of a river basin is scarce; moreover, the existing ones deal with it in terms of water quality since infiltration characteristics of lithological structures determine the quality of both runoff and water (Kevin et al., 2000; Alan, 2004).

Following thorough analysis of the lithological structure of river basins, this article aims at evaluating river runoff formation characteristics.

Materials and Methods

Eight river basins of typical lithological structure were selected from river basins throughout the territory of Lithuania where long–term water measurements take place, namely, sandy ones including Ula (Zervynos water measurement station), Miltuva (Zindaiciai), and Zeimena (Kaltanenai–Pabrade); argillaceous ones including Verkne (Verbyliskes), and Sesuvis (Skirgailiai); loamy ones including Nevezis (Panevezys–Dasiunai), Levuo (Kupiskis), and Akmena–Dane (Tubausiai) (Fig. 1). The lithological factor of the basins was calculated based on Quaternary map of Lithuania M 1:200000 and Lithuanian river map M 1:50000 using ArcGis software. Four classes were identified according to soil composition: 1 sand, 2 loam–sandy loam (further on referred to as loam), 3 clay and 4 peat, with relative infiltration indices ascribed to them for the purpose of further analysis. Lithological analysis of selected parts of river basins was carried out and, where it was possible and long–term water measurement station data were available, 'clearest' territories in terms of analysis were identified. In order to carry out more thorough analysis of the influence of lithology in given territories, sections of 0–20 m, 50–200 m, 200–500 m, 500–800 m, 800–1000 m and >1000 m were identified, calculating the distance in meters from the riverbank. Each sections' lithological structure was established. Lithuanian Hydrometeorological Service data of runoff and meteorological conditions (precipitation) in the year 1960 – 2007 were used. The year with the greatest amount of precipitation (up to 33% probability) was analysed and relation between the runoff and precipitation was established as well

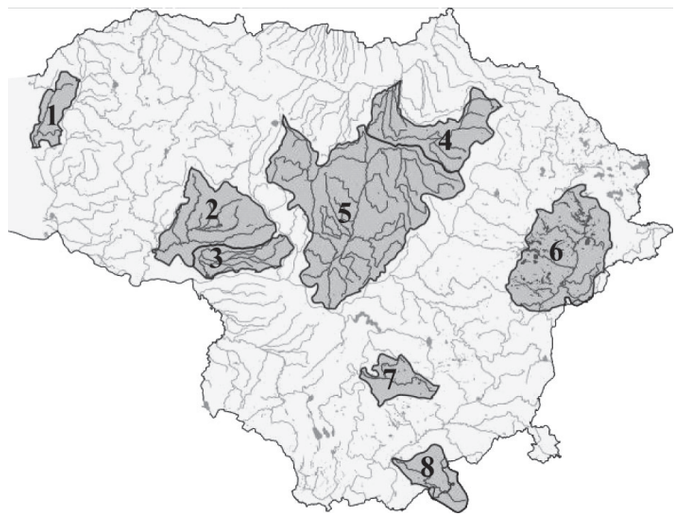


Figure 1. Analyzed river basins within the territory of Lithuania:
1 - Akmena-Dane, 2 - Sesuvis, 3 - Mituva, 4 - Levuo, 5 - Nevezis, 6 - Zeimena, 7 - Verkne, 8 - Ula basins.

as that with the lithological structure, established following a derivation of a hydromodule.

Results and Discussion

The calculation of the percentage of sections area in the analysed basins revealed that more than 60% of the basin territory is covered by sections of 50–200 m and 200–500 m along all rivers except for Zeimena and Verkne (sections of 50–200 m, 200–500 m and 500–800 m respectively) and Ula where sections of 50–800 m cover approximately 40% of the basin territory, the section of >1000 m covers over 35% of territory. This distribution of section areas is directly influenced by the density of hydrographic net (Jablonskis et. al., 2007). This structure was considered in further calculations.

Ula basin is covered by sand in 72.3%, of the overall 453.1 m^2 of basin area within its Lithuanian territory, 15.3% is covered by loam, 0.8% is covered by clay and 11.8% is covered by swamps and peat bogs. Loam takes the northern part of the middle reaches stretching in large sections of an average of 4 km^2, while clay is found in the southern part of the middle reaches. The percentage of sand, moving further from the riverbank, changes gradually from 52% to 80% of the section area, while the change of the percentage of loam is 10–15% in the sections of 0–200 m and >1000 m and 21–19% in the sections of 500–1000 m. Clay is found only in the section of >1000m in the percentage of 2.1%. The analysed area of 379 m^2 (Zervynos water measurement station) covers the upper and middle reaches of Ula river, located in the territory of Lithuania. In this territory, the percentage of sand makes 68.3% of the basin area and changes gradually from 46.8% to 75.6% across sections (Table 1). Loam, covering 17.8% of basin area, constitutes 20.2–20.8% in the section of 500–1000 m and 11.2–16.5% in other sections. Clay is found in the southern part of the middle reaches, in the section of >1000 m where it takes 2.6% of the section area. Swamps and peat bogs stretch in the upper reaches and the middle reaches, in the percentage of 38.4–29.9% in the littoral (sections of 0–200 m) and 11.8–6.5% in further sections.

Sandy structures cover 60.5% of the overall 773.4 km^2 of Mituva basin area, loam constituting 17.4%, clay making 20.9% and swamps and peat bogs constituting 0.9% of the area. The basin is distinctive for 82% of its clay areas that are found in two holdings of 50–65 km^2 located on both sides of Mituva river in its middle reaches, and 78% of loam areas found in the upper reaches. The percentage of sand is relatively unvaried in the sections of 0–500 m (57–59%), increasing more significantly (69–82%) in the sections of 800–>1000 m. The percentage of loam is 10–19% in all sections, except for the section of 800–1000 m where it reaches 21%. Clay makes 24–21% in the sections of 0–500 m and 14–0% in further sections. The analysed area of 403 m^2 covering the upper reaches and the middle reaches (Zindaiciai water measurement station) is covered by sand in 59.6% of the area, with a rather equal distribution (57.7–63.5%) in the sections of 0–1000 m, and 44.1% in the rest of the territory, namely, the section of >1000 m. The percentage of loam is approximately 20% in the sections of 0–800 m, and 35.7–45.9% in furthest sections; whereas clay makes 16.4–18.1% in the section of 0–800 m and only 3.9–1.5% in remaining sections. This basin structure, considering infiltration characteristics of wet clay, is likely to influence rapid change of runoff in terms of precipitation. Particularly small swamp and peat bog areas, covering only 0.5% in the sections of 0–1000 m, make 8.0% of territory in the section of >1000 m.

Table 1

Lithological Structure of the Analyzed Rivers

Lithological group	River, Measurement station	Section	Lithological structure, %			
			sand	loam	clay	swamps and peat bogs
Sandy	Ula, Zervynos	All	68.3	17.8	0.9	13.3
		0–50 m	46.8	11.2	0.0	38.4
		50–200 m	53.6	16.5	0.0	29.9
		200–500 m	66.0	22.2	0.0	11.8
		500–800 m	71.9	20.2	0.0	7.7
		800–1000 m	71.6	20.8	0.0	7.5
		over 1000 m	75.6	15.2	2.6	6.5
	Mituva, Zindaiciai	All	59.6	22.8	16.9	0.3
		0–50 m	60.8	19.9	16.4	0.5
		50–200 m	59.9	22.6	17.3	0.2
		200–500 m	57.7	24.2	18.1	0.0
		500–800 m	63.5	19.8	16.6	0.2
		800–1000 m	59.7	35.7	3.9	0.2
		over 1000 m	44.1	45.9	1.5	8.0
	Zeimena, Kaltanenai–Pabrade	All	57.1	22.2	0.7	13.7
		0–50 m	28.8	9.2	0.5	17.3
		50–200 m	54.1	23.0	1.2	21.7
		200–500 m	61.1	27.1	0.7	11.1
		500–800 m	64.2	26.0	0.4	9.4
		800–1000 m	66.3	22.4	0.7	10.3
		over 1000 m	66.1	20.7	0.7	12.4
Argillaceous	Verkne, Verbyliskes	All	43.8	35.3	11.8	1.1
		0–50 m	28.9	25.6	12.1	15.6
		50–200 m	35.8	35.8	16.5	11.8
		200–500 m	40.4	38.2	16.4	4.9
		500–800 m	49.2	36.3	9.7	4.6
		800–1000 m	55.5	34.0	5.6	4.8
		over 1000 m	59.9	34.7	0.9	4.5
	Sesuvis, Skirgailiai	All	39.5	29.1	27.0	4.0
		0–50 m	41.6	21.8	26.8	6.3
		50–200 m	36.1	28.1	30.8	4.9
		200–500 m	34.4	33.1	30.4	2.0
		500–800 m	41.0	35.0	21.8	2.2
		800–1000 m	50.7	33.2	12.3	3.8
		over 1000 m	75.8	12.2	3.7	8.3
Loam–sandy loam	Levuo, Kupiskis	All	15.1	71.2	1.2	13.0
		0–50 m	23.7	55.6	1.4	17.2
		50–200 m	16.6	68.2	1.4	13.7
		200–500 m	9.8	80.9	1.1	8.2
		500–800 m	10.5	76.4	0.6	12.5
		800–1000 m	19.5	57.2	1.2	21.7
		over 1000 m	15.0	48.5	1.2	34.9
	Akmena–Dane, Tubausiai	All	5.7	87.0	4.0	3.6
		0–50 m	8.0	81.5	4.2	6.3
		50–200 m	5.3	87.4	3.9	3.3
		200–500 m	4.0	90.5	4.0	1.5
		500–800 m	7.8	86.9	2.9	2.4
		800–1000 m	5.8	78.6	3.9	11.7
		over 1000 m	0.0	67.4	16.5	16.1
	Nevezis, Panevezys–Dasiunai	All	21.7	68.7	0.9	8.5
		0–50 m	26.9	57.1	0.8	12.7
		50–200 m	22.2	66.4	0.9	10.4
		200–500 m	18.5	74.6	0.9	5.9
		500–800 m	19.1	74.4	0.9	5.7
		800–1000 m	26.1	69.1	0.9	4.0
		over 1000 m	41.4	49.9	1.0	9.4

55.8% of the overall Zeimena basin area of 2792.7 km^2 is covered by sand, 24.2% is covered by loam and 0.7% is covered by clay. According to a number of authors (Gailiušis et al., 2001; Jablonskis et al., 2007), areas with 7% of territory covered by lakes and 12.4% covered by swamps and peat bogs influence equal distribution of wateriness.

Lithological structures are equally distributed across the basin, only areas of loam and clay may be considered more significant in four territories in the upper and lower reaches. Swamps and peat are distributed in the sections of 0–200 m (16–20%) with the approximate percentage of 9% in further sections. Areas of sand that cover as few as 28% in the section of 0–50 m, increase significantly up to 54% in the section of 200–500 m and continue increasing gradually, reaching 65% in the section of >1000 m. Loam covers 9% on the banks (section of 0–50 m) and largest areas, making 29%, are found in the sections of 200–800 m. The analysed territory is located between Kaltanenai and Pabrade runoff measurement stations; it includes the area of 1828 km^2 covering Zeimena middle reaches with a larger area of sand covering 57.1% of territory, reaching over 64% in the sections of 800–>1000 m. The percentage of loam is smaller (26.0–27.1% in the section of 500–800 m) with small amounts of clay (Fig. 2). The percentage of lakes is not different from the overall percentage in the basin, namely, 7%; swamps and peat bogs make approximately 19% in the littoral (in the sections of 0–200 m) and approximately 10% in further sections.

Clay covers 13.3% of the overall Verkne basin area of 727.5 km^2, most of it located in the lower reaches with a few holdings of the size of 0.2–0.3 km^2 located in the middle reaches. Loam areas are distributed equally throughout and make 34.5% of the basin are, varying from 35% to 37% in separate sections. The amount of sand, which makes 43.4% of the basin area, increases gradually from 31% to 59%. Swamps (7% of the basin) are mostly located in 0–200 m littoral areas with the percentage of 11–15%. The examined area of 694 km^2 is distinctive for its relatively low sandiness (28.9–40.4% in the sections of 0–500 m) and loam structures (25.6–38.2% in the sections of 0–500 m) as well as seemingly low percentage of clay, namely, 11.8% of the basin in the sections of 0–500 m with 93% of it located in one large holding in the lower reaches of the river.

The overall Sesuvis basin area of 1915.7 km^2 includes 27% of clay, most of its overall area of 340 km^2 distributed in one–piece holdings on both sides of Sesuvis middle reaches, in the littoral section of 0–500 m it makes 27–31% and in the middle reaches sections of 0–500 m it makes 48%. Loam (making 29% of the basin area) covers the northern and eastern part of the middle reaches and the upper reaches. Sand covers 39% of the lower reaches' basin area with greatest amount (74%) located in the section of >1000 m. The analysed basin territory of 1880 km^2 is characterised by high sandiness in the sections of 1000 – >1000 m (50.7–75.8%) and large amount (33.1–35.0%) of loam in the sections of 500–1000 m. Closer to the bank, relatively large areas of clay are located in the sections of 0–500 m, covering 26.8–30.8% and particularly in the middle reaches – 48.9%.

In middle Lithuania, the overall area of Nevezis river basin of 6140.5 km^2 is covered in loam structures of 69%, which makes 57–66% in the sections of 0–200 m and 800till>1000 m, and over 75% in the sections of 200–800 m. Sand is scattered in holdings of 10–80 km^2 throughout entire basin and takes 22% of the basin area, found in largest areas of 27–28% in the sections of 0–50 m and >1000 m and in smallest ones of 18–19% in the sections of 200–800 m. Areas of clay (making 1% of the basin area) of the size of up to 6 km^2 are encountered throughout the entire basin with the largest concentration (6%) located in the section of 800–1000 m. The percentage of lakes in the basin is 0.4 % and that of swamps is 8%. The analysed area of 4400 km^2 located between Panevezys and Dasiunai water measurement stations is covered in loam of 68.7%, making 74.8% in the section of 200–800 m and 49.9–69.1% in other sections. Swamps and peat bogs cover 9% of the territory with larger part (10.4–12.7%) found along the rivers (in the sections

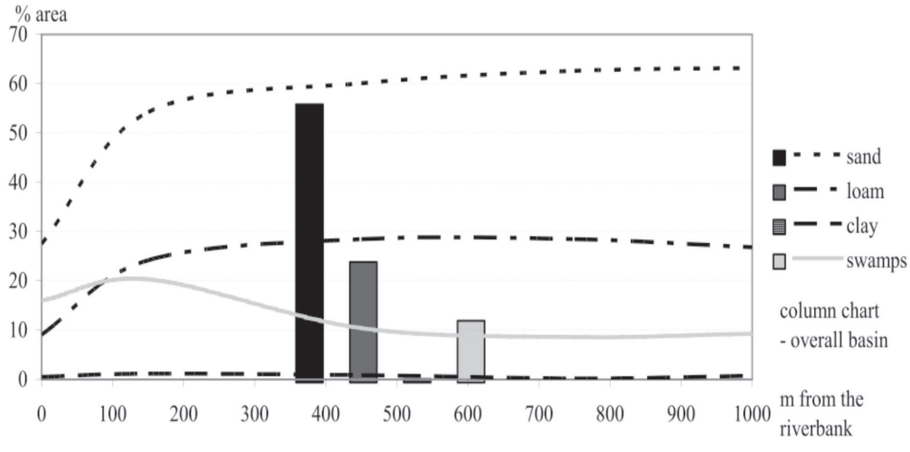


Figure 2. Change of lithological formations of the river Zeimena, distance from the bank.

of 0–200 m and >1000 m) and making 4.0–5.9% in the sections of 200–1000 m.

The combination of lithological structures in the overall Levuo river basin of 1628.8 km^2 is the following: 96% of clay area is located in the lower reaches, 52% of sand is located in the middle reaches and 48% of loam is located in the upper reaches. Looking at separate sections, sand (35% of the basin area) makes 30–44% in the sections of 0–200 m and 500–1000 m, and 56% in the section of >1000 m. The lowest percentage of sand (28%) is encountered in the section of 200–500 m. Loam (47% of the basin area) is found in lower percentage (21–37%) in the sections of 0–50 m and 800–>1000 m and makes 50–57% in the remaining part, namely, the sections of 50–800 m. Swamps and peat (12%) cover the greatest area (27%) in the section of 200–500 m.

The area selected for the examination covers the upper reaches of the river Levuo, Kupiskis water measurement station. Here loam takes 71.2% of the territory, covering bigger part of the area in all sections and reaching 80.9–76.4% in the section of 200–800 m. The sand is distributed as follows: 16.6–23.7% are found in the sections of 0–200 m and 800till>1000 m and smaller amounts, approximately 10%, are found in the sections of 200–800 m. The greatest percentage (34.9%) of swamps and peat bogs, covering 13.0% of the overall area, is located in the section of >1000 m (Fig. 3).

Almost 82% of the overall Akmena–Dane river basin of 580.2 km^2 is covered by loam, the percentage of which is 81–89% in the sections of 50–800 m and over 57% in remaining sections. Sand makes 14% of the basin area, with its holdings distributed in the lower reaches and the western part of the middle reaches. Areas of clay (1.7%) ranging 1.4–0.4 km^2 are distributed in the upper reaches. The part of the basin that was selected for examination covers 192 km^2 (water measurement station by Tubausiai), 87% of which is covered by loam. Biggest percentage of loam (86.9–90.5%) is found in the sections of 50–800 m, but the smallest percentage (67.4%) is found in the section of >1000 m. Sand makes 5.7% of the territory with the greatest percentage (7.8–8.0%) found in the sections of 0–50 m and 500–800 m. Attention should be drawn to clay and swamps in the section of >1000 m where they make 16% of the area each.

Following the identification of the year that saw large amounts of precipitation (up to 33% probability), runoffs of respective years were chosen and expressed in a hydromodule. Research showed that precipitation does not have direct influence on river runoff. Evaporation naturally plays an important role, but lithological structure of the river basin determines the flow of precipitation to surface–water and its evaporation from the surface of the basin.

The analysis of rivers with sand making approximately 60% of their basins showed that in case of average annual level of precipitation of 1.45% probability, the probability of the Ula river runoff reaches 30.37%, that of Zeimena reaches 51.03% and that of Mituva reaches 9.71% (Fig. 4). This variation in runoff distribution was determined by other lithological structure elements and, most importantly, their distribution in separate sections. The greatest influence in Ula and Zeimena river basins was caused by swamp areas taking 13.3% and 13.7% of the overall basin area respectively and, as it is widely known, swamps are a good water reservoir. Mituva basin is distinctive for abundant areas of both sand and clay, particularly in the middle reaches. The analysis of the influence of the amount of precipitation on runoff in separate seasons led to a conclusion that in case of maximum precipitation (1.45% probability) in the Ula river, the river runoff in spring was 44.83%, in summer it was 20.04%, but in autumn it was 34.50% probability. Since the river basin contains large number of swamps and almost no clay areas (they make 0.9% of the basin, and all are located in the furthest section, in the south of the middle reaches), precipitation has no significant influence on the river runoff. The situation in Zeimena river is rather different. Here, in case of high level of precipitation, the river runoff probability in spring was 30.37%, in summer it was 32.44%, but in autumn it was 51.03%. The river, similarly to Ula, contains large sandy areas and a rather significant

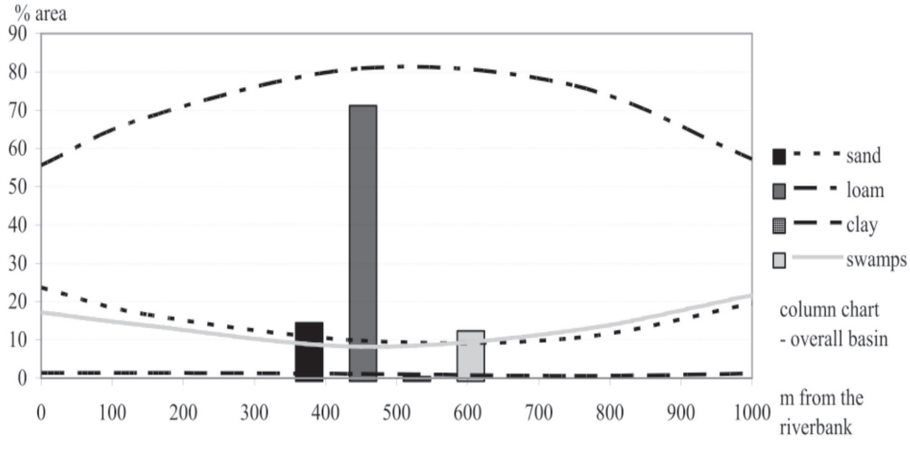


Figure 3. Change of lithological formations on the river Levuo, distance from the bank.

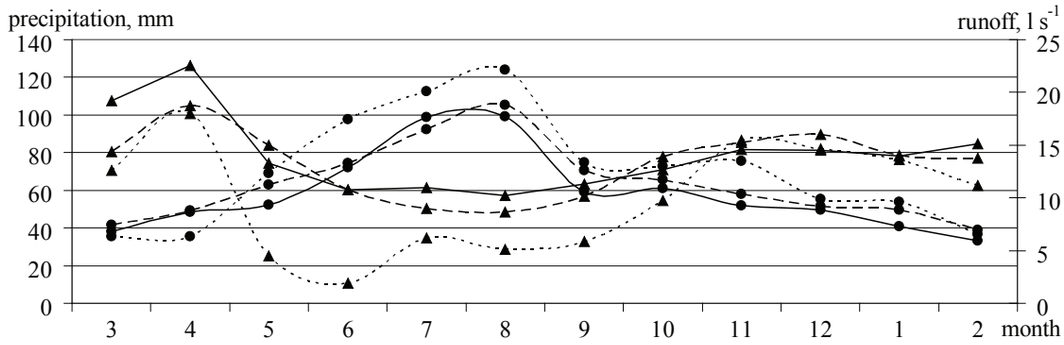
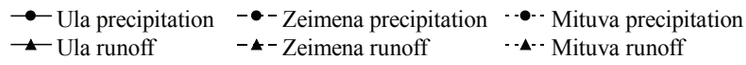


Figure 4. Distribution of runoff and precipitation in maximum precipitation years in the group of rivers with sandy lithology.



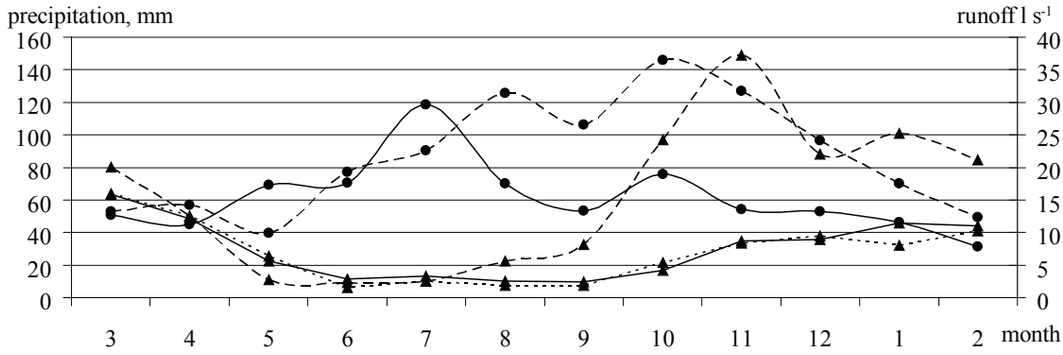
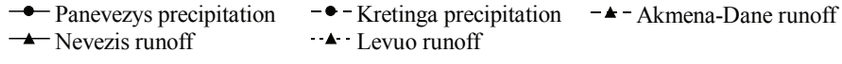


Figure 5. Distribution of runoff and precipitation in maximum precipitation years in the group of rivers with loamy lithology.



swamp area (13.7% of the basin); moreover, Zeimena basin includes approximately 0.7% clay areas located in four holdings. Mituva river runoffs in different seasons in case of maximum level of precipitation have been identified as follows: in spring it was 7.64%, in summer it was 5.58% but in autumn it was 3.51%. This river presents rather significant differences from the previously analysed sandy ones as Mituva basin contains, next to sandy holdings, numerous clay areas that constitute 16.9% of the basin and are distributed mainly in the lower reaches. Therefore, it has been established that in rainy periods with high amounts of precipitation, close–grained lithological structures are capable of preventing infiltration, which results in the water reaching the river channel through the surface flow, thus, increasing the river runoff.

Analyzing rivers with basins where loam areas make over 70%, it has been noticed that in case of an average level of precipitation probability of 1.45%, which constituted maximum amount of precipitation in the analysed period, river runoffs in Akmena–Dane river corresponded to 11.78%, that of Levuo corresponded to 32.44% and that of Nevezis corresponded to those of 26.24% probability (Fig. 5).

Seasonal analysis suggested that the runoffs in Akmena–Dane, in case of maximum precipitation, in the season of spring met 28.31% of probability, in summer it met 11.78% of probability, but in autumn it met 22.11% of probability. Similar situation is observed in cases of Nevezis and Levuo rivers, but in the latter one the probability of established runoff showed that the runoff is smaller than that in Nevezis river. In case of maximum level of precipitation, runoff probability in Levuo and Nevezis rivers changed respectively as follows: 40.70% and 32.44% in spring, 53.10% and 46.90% in summer, and 13.84% and 11.78% in autumn. This difference might arise due to the fact that swamps make 13.0% of the overall area in Levuo river basin; moreover, they are more equally distributed throughout all sections. Bigger amounts of loam have greater influence on seasonal runoff, which was revealed while analysing the change of Akmena–Dane river runoff throughout a year.

The analysis of the change of runoff in Sesuvis river suggested that in case of maximum level of precipitation the river runoff was 5.58% while in Verkne

river it was 11.78% of probability. Seasonal analysis showed that in spring the runoff probability in Sesuvis river was 22.11%, and in Verkne it was 38.64%. In summer the runoffs changed respectively 5.58% and 24.17%, but in autumn they were 3.51% and 17.98% of probability. The runoff probability of Sesuvis river is influenced by clay areas mainly distributed in the middle reaches and covering up to 30% of the section area. In Verkne basin the correlation of precipitation and runoff is reduced by the presence of swamp areas making over 7% and those of loam making up to 35% of the basin. The situation of the river resembles that of Mituva as the areas of all lithological structures in their basins are similar.

Conclusions

In the analysed basins of rivers attributed to the group of rivers with sandy lithology (over 60% of sand), sand areas in the sections increase moving to the direction opposite the river bank from 28.8% to 75.6% of section area; loam areas are the largest in the sections of 200–800 m (20.2–36.3%); clay areas are distributed unequally. Sand areas of over 50% in the basins, separate parts of basin or sections have inversely proportionate influence on the river runoff.

It has been established that larger (over 12 km^2) homogenous argillaceous areas have double impact on the runoff: direct in periods with precipitation probability of 11.78–55.17% and inversely proportionate in the period with precipitation probability of 69.63–98.55%. In river basins of the loamy group of rivers, loam areas make 68.7–87.0% of the basin area with largest loam areas registered in the sections of 200–500 m. With loam percentage in a river basin, part or section of a basin lower that 70%, the characteristics of correlation of precipitation and runoff resemble those of sandy river basins and in case of those with loam percentage higher than 70%, the relation between precipitation and runoff resembles that of argillaceous basins.

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SEASONAL VARIATIONS OF DISSOLVED ORGANIC MATTER IN THE UPPER REACHES OF NEVEZIS RIVER IN MIDDLE LITHUANIA

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Abstract. The pollution of the river water with organic matter deteriorates the chemical, biological and microbiological quality of the water and has a negative effect upon the biological variety of the water environment. The paper analyses the study period (1996 – 2000) seasonal change of organic matter in the upper reaches of the river Nevezis (study sites upstream and downstream Panevezys). The highest amount of organic matter (according to chemical oxygen demand and biochemical oxygen demand) got into the river under the influence of concentrated pollution, the fewer amount – under the influence of agricultural pollution and in the course of natural processes.

The concentration of organic substances in the river water had a seasonal character: rivers with a better ecological state (the Juosta) were more polluted with organic matter in spring, when water temperature was below 10 °C, but rivers with a worse ecological state (the Nevezis upstream and downstream Panevezys) – in summer (water temperature was higher than 10 °C). This may be related with fresh pollution; in the former case organic matter might have come from the environment together with the runoff, in the latter case – due to decomposition of water vegetation and fauna residues in the river itself.

In all rivers water temperature was by 0.1 – 4.4 °C higher in 1996 – 2000 in comparison to that in 1986 – 1989, a significant temperature increases were observed in winter and autumn. The water temperature arose mostly below the town.

Key words: organic matter, bichromate oxidation, permanganate oxidation, biochemical oxygen demand.

Introduction

Organic matter contains all chemical carbon compounds except oxides and carbonates. Organic matter is most related with living organisms. Natural water always contains organic matter. There are two main ways for organic matter to accumulate in rivers: together with pollutants from the basin and due to processes taking place in a water body. In the former case organic matter get to rivers with industrial and household runoff, humus and plant residues leached from the soil, etc. In the second case, big amounts of these materials form in eutriphicated rivers during the process of water plants decay and vital activity of microorganisms (Коновалов et al., 1989; Никаноров, 1989).

The richer flora and fauna, the more organic material accumulates in the water body. However, big amount of organic matter is not always the indicator of intensive life development, as occurrence of carbohydrates, proteins and fats in the water may be result of human economical activity. First of all, this disturbs water gas regime (Tilickis, 2005). In summer growing algae consume biogenic materials and give off oxygen; this causes the river water satiation with oxygen, and accumulation of organic matter and their decomposition products. Disintegration of big mass of algae causes oxygen deficit in river water. Temperature, BOD (biochemical oxygen demand) and salt content influence the concentration of dissolved oxygen, while re-aeration stops the decrease of oxygen (Vaidelienė et al., 2008).

The most important self-purification process is biochemical oxidation i.e. aerobic disintegration of organic matter, which is performed by microorganisms. Oxygen is necessary for breaking complex organic molecules down into simple inorganic ones. The microorganisms that participate in the process of self-purification determine its speed (Benoit, 1971).

Increased amount of organic matter indicates the pollution level of the water body. The river water contamination with organic matter reduces chemical, biological and microbiological quality of the water and has negative influence on water environment biodiversity.

The aim of the paper is to ascertain the peculiarities of seasonal change of organic matter in the upper reaches of the river Nevezis.

Materials and Methods

The Nevezis catchment, which covers 6140 km^2, is located in middle Lithuania lowlands. The article analyses water quality data in the upper reaches of the Nevezis (site of the river catchment upstream and downstream Panevezys). The Juosta is the right side affluent of the Nevezis in the upper reaches of this river. The Nevezis upstream Panevezys and the Juosta are attributed to the rivers influenced by non-point agricultural pollution, and the Nevezis downstream Panevezys – the river influenced by concentrated pollution.

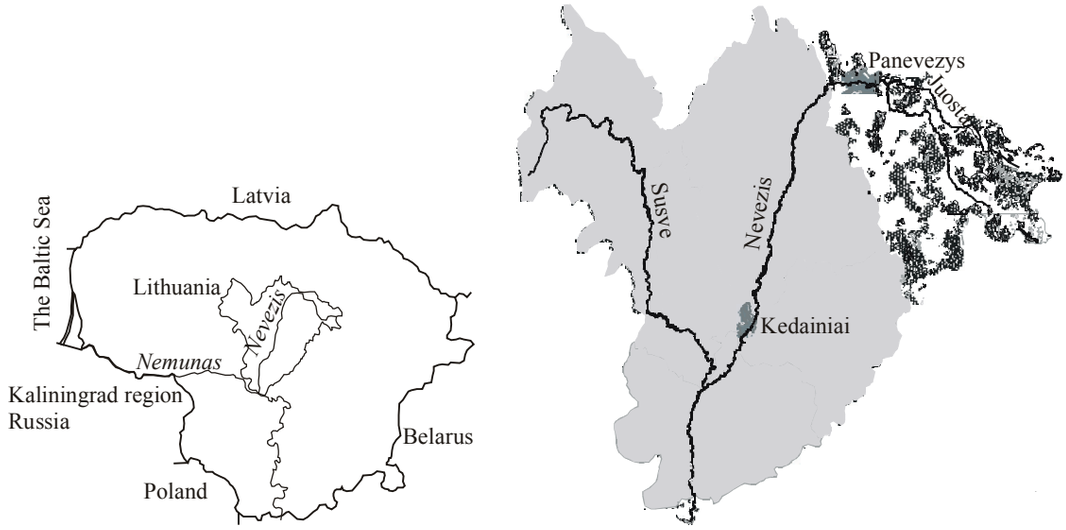

Figure 1. Scheme of Nevezis catchment.
- river, - town, - the Nevezis catchment excepting upper reaches of river, - forest

Table 1

Description of study sites (Gailiušis et al., 2001; Povilaitis, 2006; Šileika et al., 2007)

No	Sampling site	Distance from the outlet, km	Catchment area, km^2	Arable land, %	Forest, %
1	Nevezis upstream Panevezis	150.3	746	53.6	37.9
2	Nevezis downstream Panevezis	124	1266	53.9	35.3
3	Juosta	1.0	273.3	51.0	40.1

The lowest groundwater runoff (0.5–1.0 L (s km^2)$^{-1}$) gets to the rivers of Middle Lowlands, and this makes 10–17% of the annual runoff, the highest runoff (4–5 L (s km^2)$^{-1}$) – to the rivers in the south-eastern part of Lithuanian territory. Here groundwater runoff makes approximately half of all rivers‘ runoff (Gailiušis et al., 2001). The main characteristics of the investigation sites are presented in Table 1.

The water quality data (chemical oxygen demand and biochemical oxygen demand) received from Joint Investigation Centre at the Ministry of Environment was used in this work. The water samples were taken monthly, following the State Monitoring programme.

Chemical oxygen demand value, which is called permanganate (COD_{Mn}) or bichromate (COD_{Cr}) oxidation depending on the oxidator applied (potassium permanganate or bichromate), enables to indicate the total organic matter concentration in water. Potassium bichromate is a stronger oxidator – it oxidizes 95 – 98% of organic matter existing in the water. Potassium permanganate oxidises only easily oxidixable organic compounds that usually make 25 – 50% of total organic matter.

Biochemical oxygen demand (BOD_7) – the amount of oxygen, which is used in seven day period for biochemical oxidation of organic particles under aerobic conditions.

The study period (1996 – 2000) data is divided into four seasons: winter (XII-II months.), spring (III-V months.), summer (VI-VIII months.) and autumn (IX-XI months.).

Results and Discussion

According to organic matter content, good ecological situation in the river should be characterised by the mean annual BOD_7 concentration fluctuating from 2.30 to 3.30 mg O_2 L^{-1} (Preliminarus…, 2008). The most heavy pollution with organic matter is established in the Nevezis downstream Panevezys. In the period 1996–2003 in this site of investigation water was established to be of very good ecological condition 6 times, good – 11 times, medium - 21 times, bad – 14 times, or very bad 7 times (Fig. 2). The highest amount of organic matter came with household waste. According to the data of 2002, BOD_7 in the wastewater discharged from Panevezys city fluctuated from 9 to 60 mg O_2 L^{-1} (on average 28 mg O_2 L^{-1}) (Miesto…, 2002). Very good ecological condition in the Nevezis upstream Panevezys was established 29 times and in the Juosta – 49 times, respectively, good condition – 18 and 7 times, medium – 11 and 4 times bad – 2 and 0 times.

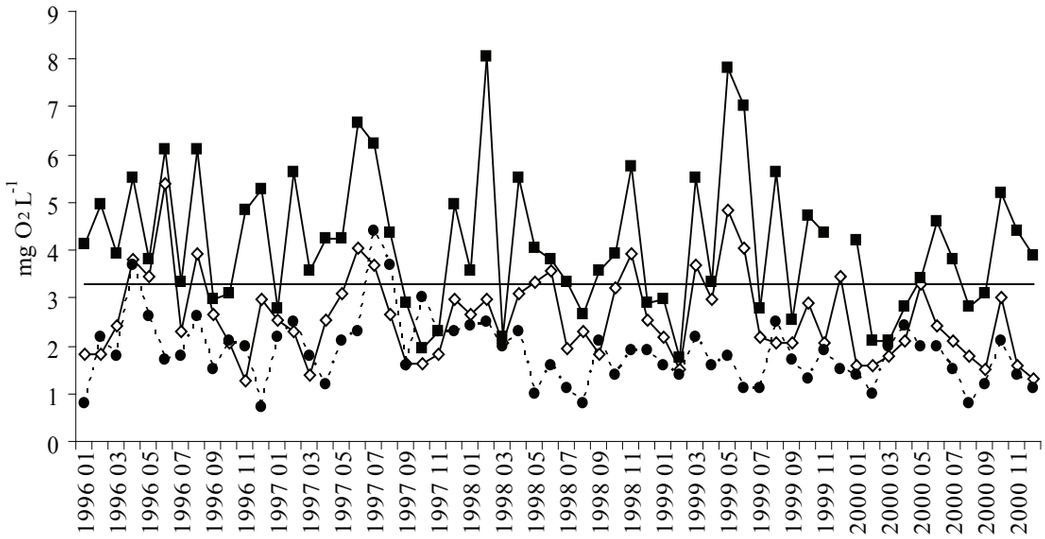

Figure 2. Organic matter in water of rivers by BOD_7.

Nevezis upstream Panevezys
Nevezis downstream Panevezys
Juosta
Good ecological condition

Despite the period, most samples from the Nevezis upstream and downstream Panevezys (up to 73%) had the ratio pf permanganate and bichromate oxidations higher than 40%; thus, humus organic compounds should dominate in the water (Table 2).

Table 2

Ratio of permanganate and bichromate oxidation in river water

Period, months	COD_{Mn}/COD_{Cr} ratio group					
	<40%			>40%		
	COD_{Cr}	COD_{Mn}	Number of samples	COD_{Cr}	COD_{Mn}	Number of samples
	Average, mg O_2 L^{-1}			Average, mg O_2 L^{-1}		
	Nevezis upstream Panevezys					
XII-II	40.3	10.3	4	22.7	11.9	11
III–V	49.5	13.0	4	30.4	16.3	11
VI–VIII	54.8	14.2	5	30.3	16.6	10
IX–XI	38.8	8.0	4	23.6	12.6	11
	Nevezis downstream Panevezys					
XII-II	63.2	18.3	4	31.4	15.4	11
III–V	50.8	13.0	4	34.6	18.1	11
VI–VIII	64.0	17.8	6	38.4	19.2	9
IX–XI	40.0	9.0	4	31.9	17.2	11
	Juosta					
XII-II	28.0	7.2	10	24.6	11.6	5
III–V	34.6	7.6	8	28.1	14.4	7
VI–VIII	27.4	7.8	12	20.0	10.5	3
IX–XI	29.3	7.5	11	21.8	10.1	4

The fact that the river runs out of the peat bog may be one of the factors determining this condition. Literature sources indicate (Šileika et al., 2007) that peat bog, rich in organic matter due to incomplete decomposition of bog vegetation, has serious influence on water quality in the upper reaches of the Nevezis.

Ratio of permanganate and bichromatic oxidation enables to determine the origin of the surface water organic matter. Dominance of humus compounds in the water shows this ratio to be higher than 40%, if newly formed organic compounds predominate – the ratio is less than 40% (Unifikuoti…, 1994). High COD_{Cr}, but low COD_{Mn} values show that organic material is not decomposed to simple forms. In such cases it is possible to state that the materials have reached the water recently and are related with fresh pollution or very intensive activity of microorganisms. Meanwhile, high COD_{Mn} and relatively low COD_{Cr} values inform about progressing destruction processes of these materials in organic matter rich water (Klimas, 2002).

In the Juosta (80% of samples) the COD_{Mn}/COD_{Cr} ratio is less than 40%, except in spring. Concentration of organic matter in this river is lower than that in the Nevezis. This may be related to intensive activity of microorganisms. The speed of biochemical oxidation of organic matter is in proportion to the concentration of remaining unoxidated organic matter (Schroepfer et al., 1964). In spring, when easily dissoluble or stable organic matter predominate, the number of water samples is similar.

Literature sources (Kaiser et al., 2001) state that change in composition of dissolved organic matter during a year influences the migration of these materials. In summer and in autumn soluble organic matter form under the influence of decay processes (as a result of strong oxidation), in winter and in spring they are leached out like sediments of recently destroyed biomass. In the latter period organic matter is characterized by increased mobility, strong biodegradation and weak interaction with metals.

The highest total concentration of organic matter in the investigated rivers was observed in spring (III–V months) and in summer (VI–VIII months) (Table 3). The river of better ecological condition (the Juosta) was more polluted with organic matter in spring, while the Nevezis upstream and downstream Panevezys – in summer. During spring floods organic matter reached the rivers together with surface runoff. In warm and sunny period concentration of organic matter is higher than that in cold and not sunny time due to intensive photosynthesis in surface water bodies (Diliūnas and Kaminskas, 2003).

In winter, when rivers are fed with groundwater, they have the lowest concentrations of organic matter (Никаноров, 1989). The following average amounts of organic matter have been established in groundwater: 2.2 (according to COD_{Mn}) and 7.1 mg $O_2 L^{-1}$ (according to COD_{Cr}) (Arustienė and Juodkazis, 2001).

Water temperature is one of the factors influencing physical, chemical, biochemical and biological processes that take place in water. The photosynthesis processes are available in the light period of the day when temperature is positive. The oxidation intensity increases at the increment of positive temperatures (Tilickis, 2005).

Table 3

Concentration of organic matter in different periods

Index	XII-II months	III–V months	VI–VIII months	IX–XI months
Nevezis upstream Panevezys				
COD_{Cr}	27.40±11.60	35.50±13.00	38.50±15.40	27.70±15.10
COD_{Mn}	11.47±3.90	15.40±4.30	15.80±3.50	11.30±3.90
COD_{Mn}/COD_{Cr}	0.46±0.17	0.48±0.16	0.46±0.16	0.46±0.17
BOD_7	2.29±0.66	2.93±0.89	2.96±1.10	2.21±0.76
Nevezis downstream Panevezys				
COD_{Cr}	39.90±18.20	38.90±13.1	48.70±20.60	34.10±14.90
COD_{Mn}	16.20±4.90	16.70±4.60	18.70±3.70	15.00±5.50
COD_{Mn}/COD_{Cr}	0.44±0.12	0.47±0.15	0.42±0.13	0.48±0.19
BOD_7	4.08±1.65	4.13±1.48	5.28±3.34	3.71±1.10
Juosta				
COD_{Cr}	26.87±6.40	31.60±11.70	25.90±5.40	27.30±6.20
COD_{Mn}	8.67±2.50	10.80±4.80	8.35±1.90	8.17±2.13
COD_{Mn}/COD_{Cr}	0.34±0.12	0.37±0.16	0.34±0.12	0.31±0.11
BOD_7	1.70±0.63	2.03±0.62	1.93±1.00	1.83±0.47

Note. Average, mg $O_2 L^{-1}$ ± standard deviation.

Table 4

The water temperature (°C) in periods

Period, months	Nevezis upstream Panevezys		Nevezis downstream Panevezys		Juosta	
	1986 – 1989	1996 – 2000	1986 – 1989	1996 – 2000	1986 – 1989	1996 – 2000
XII-II	0.6	5.0	1.7	6.1	0.8	1.0
III–V	7.3	8.0	7.8	8.7	8.6	8.2
VI–VIII	17.8	18.4	18.7	18.8	17.9	18.1
IX–XI	9.2	10.4	9.9	11.4	8.2	8.4

The highest water temperature in all periods (9.5 – 11.3 °C) was established in the Nevezis downstream Panevezys, and the lowest one (1.0 – 18.1 °C) – in the Juosta (Table 4). The water temperature being by up to 1.1 °C higher in the Nevezis downstream Panevezys than that upstream the city indicates the influence of the city.

In all sampling sites temperature was by 0.1 – 4.4 °C higher in 1996 – 2000 than that in 1986–1989. In the Nevezis downstream and upstream Panevezys the water was warmer than water in the Juosta. Significant increase of water temperature was observed in winter (XII-II months) and autumn (IX-XI months) of 1996 – 2000, e.g. in the Nevezis below Panevezys it was higher by 4.4 and 1.5 °C, respectively, than that in 1986 – 1989.

No significant influence of water temperature on the change of organic matter has been established in the investigated rivers. However, the tendency that total concentration of organic matter (according to COD_{Cr}) in the investigation sites was higher in spring when water temperature exceeded 10 °C was determined (Table 5).

These differences were more significant in the river that had more organic matter (the Nevezis above and below Panevezys). In spring, higher content of stable organic matter (according to COD_{Mn}/COD_{Cr}) was established in the river of better ecological condition (the Juosta) at the water temperature below 10 °C, while in the river of worse ecological condition – at the water temperature above 10 °C. This may be related with fresh pollution; in the former case organic matter might have come from the environment together with the runoff, in the latter case – due to decomposition of water vegetation and fauna residues in the river itself. The highest concentration of biochemical oxidizable organic matter in the Nevezis upstream and downstream Panevezys was in spring (during the entire period water temperature was higher than 10 °C), in the Juosta – in spring (water temperature did not reach 10 °C).

Table 5

Changing concentration of organic matter in relation to water temperature

Period, months	Range of water temperature, °C							
	< 10				> 10.1			
	COD_{Cr}	COD_{Mn}	COD_{Mn}/COD_{Cr}	BOD_7	COD_{Cr}	COD_{Mn}	COD_{Mn}/COD_{Cr}	BOD_7
	Nevezis upstream Panevezys							
XII-II	27.4	11.5	0.46	2.29				
III–V	32.2	15.5	0.52	2.92	49.0	15.0	0.31	2.95
VI–VIII					38.5	15.8	0.46	2.96
IX–XI	29.4	12.7	0.53	2.37	25.7	9.7	0.39	2.02
	Nevezis downstream Panevezys							
XII-II	41.0	16.4	0.44	3.99				
III–V	35.8	16.9	0.50	4.33	51.7	16.0	0.31	3.33
VI–VIII					48.7	18.7	0.42	5.28
IX–XI	37.3	17.8	0.58	4.19	31.9	13.1	0.41	3.39
	Juosta							
XII-II	26.9	8.67	0.34	1.7				
III–V	33.6	11.36	0.36	2.07	28.7	10.1	0.38	1.98
VI–VIII					25.9	8.4	0.34	1.93
IX–XI	25.6	8.17	0.33	1.82	29.8	8.2	0.29	1.85

Conclusions

1. The organic matters existing in river water differ in their origin, and their concentration depends on anthropogenic influence and the processes taking place in the river:
   In the river Nevezis, different from the Juosta, humus compounds predominate (COD_{Mn}/ COD_{Cr}>40%).
   The biggest amount of organic matter (according to COD_{Cr} and BOD_7) gets into the river from the city.
2. Concentration of organic matter in the river water is of seasonal character: the highest values are in spring (III–V months) and in summer (VI–VIII months). The river of better ecological condition (the Juosta) was more polluted with organic matter in spring when water temperature was below 10 °C, and river of worse ecological condition (the Nevezis upstream and downstream Panevezys) – in summer (water temperature was higher than 10 °C). This may be related to fresh pollution; in the former case organic matter might have come from the environment together with the runoff, in the latter case – due to decomposition of water vegetation and fauna residues in the river itself.
3. The highest water temperature was established in the Nevezis downstream Panevezys, which was due to the city impact. The change of the river water regime was observed. In all rivers water temperature was by 0.1–4.4 °C higher in 1996 – 2000 in comparison to that in 1986-1989, a significant temperature increases were observed in winter and autumn.

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MINERAL NITROGEN AND PHOSPHATE CYCLES IN DIFFERENT CROP ROTATIONS

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Abstract. A current investigation compared various intensive crop rotations (Norfolk, row crops, cereals, short term grass) grown on Cambisols. The study results showed significant effects of N-fertilization of the agroecosystem on mineral N concentration in drainage water and its leaching process. The highest N concentration in drainage water and leaching was determined in the conditions of cereals and row crops rotations. No major impact of the crop rotation on phosphates concentration in drainage water was determined. The average leaching of one by drainage did not exceed 100-140 g ha^{-1} within a 7 year study period. A experiment was arranged during 1997-2003 years in the Kėdainiai distrct, Lipliunai willage. A rational and well-considered fertilization ensures high crop productivity and profitable farming as well as steady, which is the main condition for reduced non-point source pollution of water.
Key words: crop rotations, nitrogen, phosphorus, drainage water, leaching.

Introduction

Statements about the intensive farming as the main factor enhancing non-point source pollution of the environment are frequent in the literature. As the results of studies carried out in Lithuania and other countries have shown, the expansion of agricultural land use in river catchments induces higher nitrogen and phosphorus concentrations in river water (Heathwaite, 1993; Hoffman et al., 2000; Honish et al., 2002; Jaynes et al., 2001; Stalnacke et al., 1996; Šileika et al., 2002; Thysen, 2001). The studies carried out in Endocalcari endohypogleyic cambisols (CMg-n-w-can) were aimed to evaluate the agro-ecological aspects of cropping systems of different intensity.

The results of the research have also shown that non-point source pollution of water is directly related to climatic conditions, fertilizer uptake crop rotations and farming activity in general (Bakhsh et al., 2001; Burt and Haylock, 1993; Claeson and Staineer, 1996; Hoffman et al., 2000; Sharpley et al., 2001). According to the results of long-term studies carried out in Rothamsted UK, with optimal fertilization N leaching does not exceed 30 kg ha^{-1} per year, and N concentration in drainage water does not exceed 11.3 mg N L^{-1} (maximum allowable N leaching determined in EU Standards is 34 kg ha^{-1} per year according average rainfall amount in the UK), while 120 years ago under analogous conditions N leaching by drainage was 74% more intensive due to low crop productivity and poor farming (Groeneveld et al., 2001). Also, in the UK P excess reached 1000 kg ha^{-1} in grass areas as well as in regions of arable land within the last 65 years (Withers et al., 2001).

Previously recommended multi-field systems (7 to 9 rotation units or more) now are replaced by crop rotations containing 4 units. As the results of current investigations show, cereals concentration in a crop rotation might be increased even to 100% without any adverse effect to crop productivity (a crop rotation should contain legume crops, too). Possible ways for the compensation of bad pre-sowing by the application of mineral fertilizers are being investigated. The studies carried out in the Czech Republic showed that the cultivation of monoculture leads to better crop productivity than the application of traditional Norfolk crop rotation. However, in the case of one-crop system it is more complicated to regulate NPK balance, besides soil resources are being wasted, which requires larger rates of applied mineral fertilizers. To avoid adverse effects on crops, the selection of different plant species is recommended (Misa and Kren, 2001).

From the agricultural standpoint of different crop rotations, the technologies of land cultivation and fertilization are evaluated quite properly; however, from the points of view of environment protection and water pollution those technologies are underestimated. Obviously, the areas covered with unfertilized or moderately fertilized perennial grass ensure less losses of the leaching of chemical compounds than the areas with other crops cultivated. The largest amounts of chemical elements are leached from a fallow (Hugins et al., 2001; Meissner et al., 1998). The application of one-crop system (monoculture) enhances N migration through a soil profile (Anderson, 1997; Bakhsh et al., 2001). The changes in the soil enhanced by different crops cultivated affect the quality and pollution of surface and ground water. Obviously, 67% of leached N is soil nitrogen (Addiscott, 1998; Dunn, 1999); however, the data about its forms, dynamics and migration in a soil profile of human-affected agro-ecosystems is rather scarce in Lithuania. Moreover, the qualitative indices of the agro-ecosystem are affected not only by N cycles, but also by the migration of different phosphorus compounds and other nutrients in it.

On the basis of the data obtained, we have made the hypothesis that non-point source pollution of the agro-landscape is inversely proportional to the synthesis of total biomass of the ecosystem, and all the available means ensuring high crop productivity actually reduce the potential risk of water pollution.

Materials and Methods

The study was conducted in Lipliunai (Kedainiai district, Middle Lithuania) in the basin of the river

Table 1

Application of crop rotations

Years	Treatments (crop rotations)			
	I Nofholk 6.7 ha	II Row crops (43%) 11.5 ha	III Cereals 12.5 ha	IV Short term grasses (71%) 14.5 ha
1997	Spring barley+ undercrop	Fodder beans	Spring barley	Short term grass
1998	Short term grass	Sugar beet	Spring barley	Short term grass
1999	Winter wheat	Spring wheat	Spring triticale	Short term grass
2000	Sugar beet	Sugar beet	Spring barley	Short term grass
2001	Spring barley+ undercrop	Spring wheat	Winter rye	Short term grass
2002	Short term grass	Sugar beet	Spring wheat	Short term grass
2003	Winter wheat	Spring wheat	Winter rape	Winter wheat

Graisupis. The studies were carried out in the period from 1997 to 2003. Experimental site was drained by separate tile drainage systems. Every drainage system had a different crop rotation with its typical complex of agricultural means (Table 1).

Annual precipitation amount was 456-659 mm during the study period with 298-388 mm of this falling during the period of crop growth (April-October); average annual temperatures of the periods mentioned were 6.8-8.2 °C and 13.4-15.1 °C respectively. The peak drainage runoff (11-40% of annual rainfall) occurred in winter and spring.

Soil of the study object are Endocalcari endohypogleyic cambisols, with light and sandy loam textures. The agro-chemical characteristics and variations of the soils are listed in Table 2.

Only mineral fertilizers were applied on crop fields (Table 3). The cultivated crops included: sugar beet 'Belmonte', spring barley 'Ula', winter wheat 'Portal', 'Arona', winter rye 'Duoniai', perennial grass red clover 'Liepsna' + timothy 'Gintaras II'), spring wheat 'Nandu', winter rape Valesca, fodder beans 'Ausra', triticale 'Bolero'.

Drainage water discharge was measured volumetrically twice a week and daily runoff was calculated by the linear interpolation. Drainage water samples were taken every 2 weeks. Monthly nutrient leaching was calculated having multiplied the average monthly nutrient concentration by the monthly drainage runoff value.

Table 2

Agro-chemical characteristics of topsoil layer and its variation

Treatment	pH_{KCl}	meq kg^{-1}		Available mg kg^{-1}		percentage	
		hydrolytic acidity	sum of adsorbed base	P_2O_5	K_2O	humus	total N
I	7.1	6.3	300	218	125	1.80	0.14
II	7.2	7.9	320	185	172	2.77	0.21
III	7.2	9.0	280	197	92	2.98	0.20
IV	7.2	6.3	360	174	82	2.70	0.18
x	**7.2**	**7.4**	**315**	**194**	**118**	**2.56**	**0.18**
Sx	0.025	0.66	17	14	20	0.26	0.02
V%	0.7	18	11	10	34	20	17
Rv	0.1	2.7	80	44	90	1.18	0.07

Table 3

Total fertilization of crop rotations during the study period kg ha^{-1} active matter

Treatment (Crop rotation)	Nutrients			
	N	P	K	Total
1. Norfolk	344	128	172	644
2. Row crops	798	336	660	1794
3. Cereals	547	104	293	944
4. Short term grass	156	46	65	267

Soil samples for the agrochemical analysis were taken twice a year (before sowing and after harvesting) in three replications. All soil analyses were made from each 20-cm deep soil layer down to 1m deep.

The crop yield was harvested mechanically. The area of the test fields of crops and grass was 30 m^2, row crops covered the area of 45 m^2. Crop yield was measured in 6-8 replications. The energy uptake of crops (GJ) was calculated. The energy transformation coefficient was calculated having divided the crop total energy yield by the energy uptake necessary for yield to grow.

Soil pH was determined potentiometrically in a soil suspension in 2 M KCl; humus amount was determined by the method of Tiurin (Anonymous, 1965); total N was calculated by Kjeldal's procedure; available P_2O_5 and K_2O were measured by AL method, hydrolytic acidity was determined in Kappen method (1M sodium acetate and weighted ratio of soil 1:2.5); the sum of adsorbed bases was calculated by Kappen-Hilkovic method (from the extraction of 0.1 *M* HCl solution and weighted ratio of soil 1:2.5). Mineral N amount (NH_4^+-N+NO_3^- -N) in the soil was measured from the extraction of 0.2 *M* KCl using a flow injection analyzer (FIA star 5012, AN 551, ASN 65-31-84 and ASN 50-01-84).

Concentrations of NH_4^+-N, NO_3^- -N and PO_4^{3-} -P in drainage water were determined colorimetrically by the flow injection using a FIA star 5012 analyzer. For both soil samples and water samples NH_4^+-N concentration was determined by the gas diffusion method; NO_3^- -N was calculated by the Cd reduction method; PO_4^{3-} -P was determined by the ammonium molybdate method (AN-562, ASN 11-02-92 and ASN 50-01-84).

To determine the exact amount of dry matter of plants, samples of plant material were taken and dried at the temperature of 105 °C. N and P content was determined after the digestion with sulfuric acid, hydrogen peroxide and Se catalyst (N – by Kjeldhal method, P – colorimetrically by the ammonium vanadate method) (Allen et al., 1974; Dyke, 1994; Fomin and Fomin, 2001).

The data was processed according to the methods of mathematical statistics. Errors were calculated individually for each treatment. Methods of disperse analysis and correlation-regression were applied (Dyke, 1994).

The following symbols and abbreviations are used in the article: x – arithmetical or weighted mean, Rv – amplitude of variation, V% - coefficient of variation, Sx –standart error, r – coefficient of double correlation, R – coefficient of polynomial correlation, η – correlation relation, x_{extr} – extreme of function, LSD_{05} – limit of the reliable (95%) difference, * and ** connections reliable at the 95 and 99% probability levels, a.m. – active matter, HTC – hydrothermal coefficient.

Results and Discussion

NP concentration in drainage water. According to the average data, the highest N_{min} ($N\text{-}NH_4^+ + N\text{-}NO_3^-$) concentration (13.1-13.9 mg^{-1}) in drainage water was determined when cultivating the rotations of row crops and cereals (Figure 1).

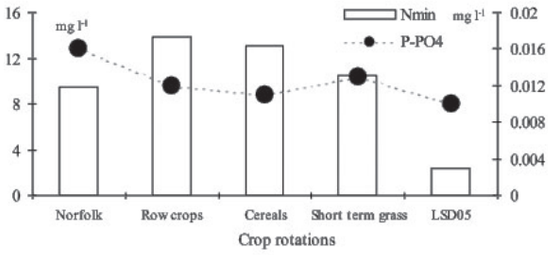

Figure 1. Influence of different crop rotations on the average annual concentration of mineral nitrogen and phosphates in drainage water.

The cultivation of perennial grass as well as Norfolk crop rotation reduces the concentration by 20-32% (by 10.5 and 9.5 mg L^{-1} respectively). Actually, such results were much determined by the productivity of field crops and related agricultural factors and soil characteristics (Figure 2).

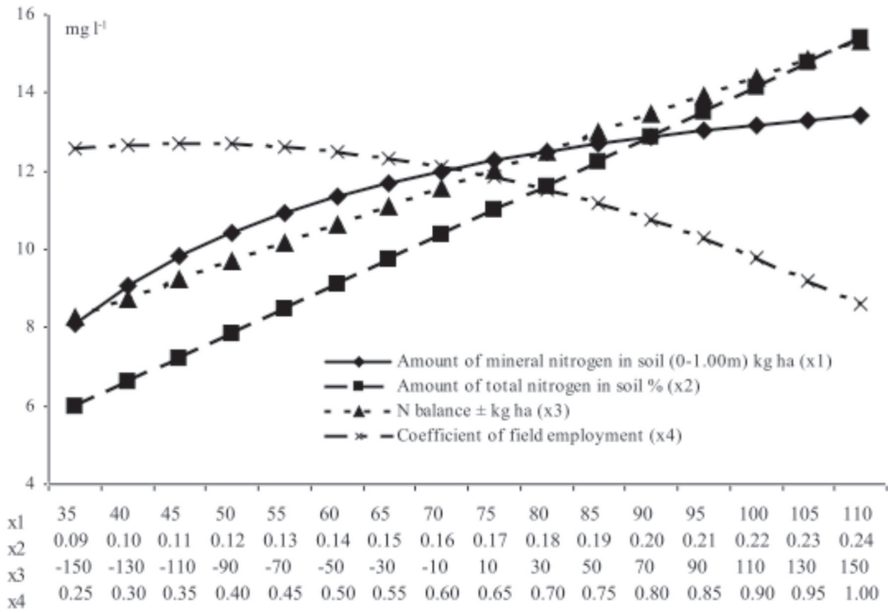

Figure 2. The dependence of mineral nitrogen concentration in drainage water on the environmental factors.

Higher rates of applied nitrogen fertilizers kg ha^{-1} active matter.m. (x), excess N balance and larger amounts of N_{min} and N_{total} contained in the soil contribute to the increase in N_{min} concentration in drainage water mg L^{-1} (z), while higher crop productivity GJ ha^{-1} (y) and more intensive field cultivation reduce the concentration of N_{min}. z=12.6+0.03x-0.02y; R=0.41*. As the investigations carried out in the state Iowa (USA) have determined, the concentration of NO_3^- in drainage water does not exceed 10 mg L^{-1} (i.e. maximum pollution of drinking water) when low rates (about 30 kg ha^{-1} per year) of N fertilizers are applied (Jaynes et al., 2001). According to the results of our studies, only well-balanced agricultural technologies might ensure non-excess N balance in the agro-ecosystem and maintain high quality of drainage water, i.e. low concentrations of N compounds contained in it. A linear inverse connection between the annual energy transformation coefficient of plant-growing activity (x) and N_{min} concentration in drainage water (y, mg L^{-1}) was determined: y=12.92-0.032x; r=0.46; probability – 98%. Thus, the essential precondition for reduced non-point source pollution with nitrogen is common efficiency of agricultural technologies, not the total amount of applied fertilizers.

No major effect of the applied crop rotation on $P\text{-}PO_4^{3-}$ concentration in drainage water was determined. Considering the average data, $P\text{-}PO_4^{3-}$ concentration was fluctuating within the range of 0.011-0.016 mg L^{-1} (Figure 3). As the data analysis has shown, P concentration (y, mg L^{-1}) was inversely proportional to the annual precipitation amount (x_1, mm) and the productivity of field crops (x_2, GJ ha^{-1}).

$y = 0.00054+6.763x_1$ $r = 0.39$; probability – 96%;
$y = 0.0131x+0.0000015x_1^2$ $r = 0.40$; p
robability – 96%.

NP leaching by drainage water. The amount of N_{min} (z_1) and $P\text{-}PO_4^{3-}$ (z_2) leached in drainage was directly proportional to the drainage runoff (x, mm) and the concentrations of mentioned elements in it (y, mg l^{-1}):

$z_1 = 15.865+1.282x+0.121y$; $R = 0.96$**;
$r_{concentration} = 0.85$; $r_{runoff} = 0.96$;
$z_2 = 0.011+0.567x-0.00001y$; R=0.89**;
$r_{concentration} = 0.69$; $r_{runoff} = 0.89$.

Despite the essential influence of precipitation amount and drainage runoff on the leaching process, the applied crop rotation and related factors determining its productivity also make a significant effect. According to the summarized data of a 7-year period, one-crop systems (monocultures) of cereals and rotations of row crops were most distinct for the highest rates of leached mineral nitrogen (141 and 113 kg ha^{-1} respectively) (Figure 3).

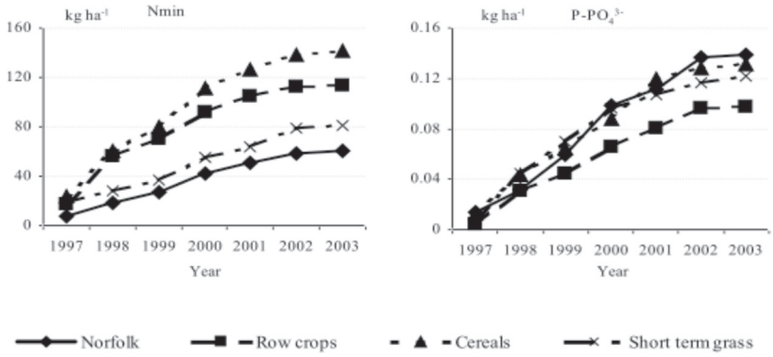

Figure 3. Influence of the different crop rotations on cumulative leaching of mineral nitrogen and phosphates.

In the areas of short term grass and Norfolk crop rotations the leaching of N_{min} was noticeably less intensive (by 28-43% and 47-57% respectively). Such results were mostly predetermined by N fertilization of crops and N balance. More intensive cumulative N fertilization of the agro-ecosystem results in more intensive N_{min} leaching by drainage. The least losses of N_{min} leaching are observed under the conditions of deficit cumulative balance of nitrogen. However, when deficit N balance changes into the excess one, the leaching process of N_{min} gets more intensive. As the data collected by many researchers in Lithuania and other countries show, the advanced agricultural technologies and efficient application (not the rates) of mineral fertilizers are among the essential preconditions for reduced non-point source pollution of water with nitrogen (Groeneveld et al., 2000; Sileika and Guzys, 2003).

Insufficient mobility of P compounds and their rapid solubility in the soil as well as low P concentration in drainage water determine insignificant amounts of the compounds leached by drainage. Regardless of the applied crop rotations, the leached amount of $P\text{-}PO_4^{3-}$ was changing within the range of 100 to 140 g ha^{-1} during a 7-year study period. However, the volume of leaching process is also subjected to common regularities. More intensive P fertilization of the agroecosystem slightly increases the leached amounts of $P\text{-}PO_4^{3-}$ by drainage in a progressive function. Efficient mineral fertilization ensures a higher total productivity of crops (x, GJ ha^{-1}) and reduces the cumulative losses of phosphates leached by drainage (y, g ha^{-1}): $y = -17.86+0.352x-0.0002x^2$; $\eta = 0.83^{**}$; $x_{extr} = 880$

The least cumulative losses of phosphates leaching were determined in the most productive rotation of row crops

$y_1=34.606+0.14x_1$; r=0.81; probability = 99%;
$y_1=62.98+0.284x_2+0.000628x_2^2$; η=0.79;
probability = 99%; extr.=-226;
$y_2=0.0576x30.1089$; r=0.73; probability = 99%.

In summary, only rational, well-considered and efficient fertilization might ensure stable concentration of nutrients in the agro-ecosystem, which would enhance higher productivity as well as limit non-point source pollution of the agro-ecosystem.

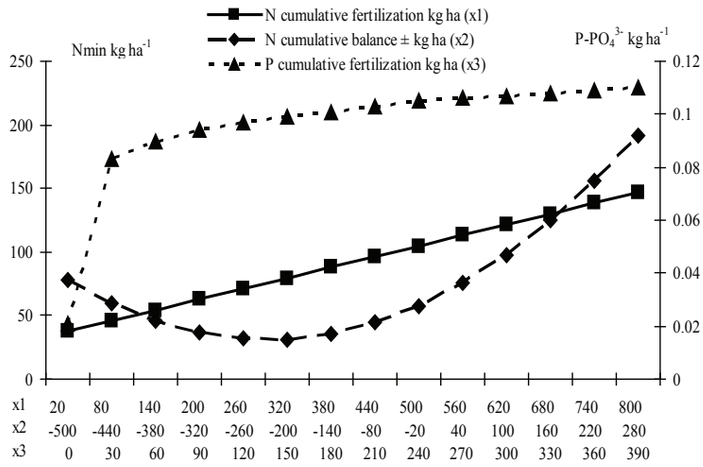

Figure 4. The dependence of mineral nitrogen (y1) and phosphates (y2) leached by drainage on cumulative N (x1) and P (x3) fertilization and cumulative N balance.

Conclusions

1. The rotation of row crops was considered as the most productive: here the total energy yield reached 980 GJ ha^{-1} within a 7-year study period. The productivity of cereals, short term grass and Norfolk rotations was 26-32% lower, though the rotation of perennial grass was distinct for the highest energy efficiency.
2. N_{min} concentration in drainage water depends on crop rotation, crop productivity and N fertilization. The excess N fertilization may result in higher N_{min} concentration. The cultivation of crops in a field for a longer period may reduce N_{min} concentration significantly. The highest average N_{min} concentration in drainage water (13.1-13.9 mg L^{-1}) was determined in one-crop system (monoculture) of cereals and rotation of row crops.
3. The amount of nitrogen leached by drainage is mostly determined by N fertilization and N balance in the agro-ecosystem. The highest total N_{min} leaching was determined in the rotations of cereals and row crops (113 and 141 kg ha^{-1} respectively). The changing of deficit N balance into the excess one results in more intensive N_{min} leaching.
4. No major impact of the applied crop rotation on phosphates concentration in drainage water was determined.
5. The average leaching of phosphates by drainage did not exceed 100-140 g ha^{-1} within a 7-year study period. No major impact of the applied crop rotations on phosphates leaching was determined.

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THE MAXIMUM RUNOFF CHANGES IN VENTA NEAR PAPILE AND KRAZANTE NEAR PLUSKIAI RIVERS

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Abstract. Global warming undoubtedly influences the flow of rivers. It is essential to observe the climate changes, trace, analyse and forecast how they could influence the environment and, especially, how it can influence the flow of rivers. In this article two maximum flows of basins of two different rivers are analyzed: the river Venta (above Papile) and the river Krazante (above Pluskiai) during the period 1968 – 2008. Climatic parameters, such as the precipitation and the average air temperature, observed in the weather stations of Siauliai and Laukuva, influence the changes in flows the most. The correlation between the precipitation and maximum change of the flow was estimated though it was not strong: the ratio of correlation in the river Venta was 0.66, in the river Krazante the same ratio was 0.72. Significant negative trends of the both analyzed rivers during the spring period and significant negative trends of the river Venta during the period of winter have been established by the use of statistical analysis of the results obtained from a non-parametric Mann-Kendall test and linear regression test. This specific analysis is performed by using TREND programme.
The collected data which were obtained to show that the most watery decade of the rivers Venta and Krazante was during the period 1978 – 1987, which formed 36% flow in the river of Venta and 35% in the river of Krazante for the whole period of forty years.
Key words: flow, climate change, river, basin, hydro model.

Introduction

A runoff is a significant part of water circulation cycle, the size of which depends on two phenomena: precipitation and evaporation. These phenomena depend on climate. In the latter years the climate is changing a lot and this change is inevitable. It is forecasted that the climate could change very severely in the nearest future. Climate changes will affect more and more water recourses, that is why it is so important to evaluate runoff changes of Lithuanian rivers according to different climate changes. It is also very important to look at climate changes, record and analyse analyse them as well as forecast the influence it could have on the environment, especially how it could influence the runoff of the rivers. Lithuanian scientists are already recording some tendencies of climate change. There are consolidated seasonal transitions in a circulation of atmosphere. In the last decade of 20th century, winters became warmer, long periods of frost decreased, contrast of seasons declined, middle seasons lengthened, strong heats assert in more occasions and a quantity of precipitation in winter increases (Meilutyte-Barauskiene, 2009).

In Lithuania, there are a lot of investigations carried out, which analyse annual change of precipitations quantity and the quantity change during different seasons. It is established that the mean air temperature during the period 1991 – 2006 rose from 0.7 °C to 1 °C compared with the period 1961 – 1990. This shows that the climate is warming very rapidly. The strongest tendencies of the warming are in the north and west Lithuania, but the quantity of precipitation during the period 1991 – 2006 compared with the period 1961 – 1990 changed unevenly: in the whole country the precipitation decreased in September, November and December, but increased in January, February and October. In the western part of Lithuania the quantity of precipitation decreased from 18 to 35 percent in July. In the middle and eastern Lithuania the precipitation decreased from 21 to 22 percent in June (Kazys et al., 2009; Rimkus et al., 2007).

O.I.A Aziz and D.H. Burn (2005) established an overflow's rate of the temperatures in December and February, March and April this year. They affirmed that rising temperature accelerates snow melting, which brings an overflow in April. All in all, January, February, March and annual minimal streams show the ratio with rain in October, which could bring more substantial overflow. Increased temperatures in late winter and early springs show that snow started melting earlier, and it also caused earlier overflows in spring. This phenomenon could also be the cause of decreased overflows in summer: May and June.

The purpose of this work is to determine the tendencies of maximum runoff change in Venta (near Papile) and Krazante (near Pluskiai) rivers, in view of climate conditions and different sizes of river basins.

Materials and Methods

For these researches two rivers in the west hydrological areas are chosen: Venta (near Papile) and Krazante (near Pluskiai) (Fig. 1). West region has more precipitation, longer rainy autumn, softer winter, cooler spring and summer. There are a lot of thaws and overflows in winter. There are also chosen two meteorological stations Siauliai and Laukuva. These are the nearest to the analysed rivers.

Venta is one of the biggest rivers in Lithuania. Its length is 343.3 km, but in the territory of Lithuania its length is only 184.2 km. The territory of Venta basin near Papile is 1570 km^2. A dominant depth of course is 1 – 2 metres. A valley of Venta is announced as a geological reserve. In 1933, in Papile a hydrological area was formed, where the measures of water level, water temperature, precipitation and water reserve in snow are performed.

Table 1

Characteristics of the river basins

Hydrological regions of Lithuania	Rivers	Hydrological observation station	Basin area, km^2	Forests, %	Lakes, %	Swamps, %	Distance, km	Number of feeder
Western	Venta	Papile	1570	30	1.1	8	343.3	68
	Krazante	Pluskiai	221	22	0.3	16	87.4	23

Figure 1. Venta and Krazante rivers.

Krazante is the biggest tributary of Dubysa with the length of 87.4 km. The upstream is marked with shallows, thresholds of dams, by Kelme it increases a grade, stream and stony shoals. The territory of basin near Pluskiai is 221 km^2. A width of the course is 5 – 12 metres, depth is from 0.5 to 1.5 meters. There is a hydrological station, where the level and temperature of water and the precipitation are fixed.

In this article hydrological and meteorological phenomena of the period of 40 years (1968 – 2008) are analysed: these are flows, precipitation and mean air temperature, which is obtained from the hydro-meteorological service of Lithuania. Homogeneous series are made, and a trend of these series towards time is analysed. The non-parametric Mann-Kendall test of statistical analyses, which is recommended by World meteorological organisation, is used to establish the trends of the river runoff (30% level of reliability) and the significant positive or negative trends (5% level of reliability) (Meilutyte-Barauskiene et al., 2008).

A correlation between precipitations and flows is also established.

In the Mann – Kendall test n conequences of time (X_1, X_2, X_3,.., X_n) are changed in their appropriate lines (R_1, R_2, R_3,.., R_n) (it has been started from the lowest till n).

Statistic S of the test is calculated:

$$S = \sum_{i=1}^{n-1}\left[\sum_{j=i+1}^{n} sgn\left(R_j - R_i\right)\right], \quad (1)$$

Here: sgn(x) = 1, as x > 0; sgn(x) = 0, as x = 0; sgn(x) = -1, as x < 0.

A degree of dependence between these two orders is described by a correlation coefficient, which is calculated in a formula (2) below:

$$r_{xy} = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2(y-\bar{y})^2}}, \quad (2)$$

here: x,y – members; $\bar{x},\bar{y} - \bar{x},\bar{y}$ – averages (Sakalauskas, 2003).

Results and Discussion

On the basis of the analysed maximum flows of these two rivers during 40-year period (1968 – 2008) it is seen that their trends of changes are very similar. In this period the repetition frequency of the rivers maximum flows is almost even, although, because of larger precipitation the river Krazante separates in more often increasing water. There is a smaller basin and it could bring larger changes. Because of different basin sizes of these two rivers the flows separate 4 times.

A long queue of observations gives us a possibility to evaluate the variations of the runoff and separate the changes of watery and dry years. According to calculated probabilities (Fig. 2) most watery years in Venta river were 1985, 1980 and 1987 when the wateriness was 1.69 – 6.52% and the biggest consistency in this river was in 1976, 2006 and 2000. The maximum flow was 98.31 – 93.48%. The most watery years in Krazante river were 1974, 1985 and 1998, and the biggest consistency was observed in 1972, 2003 and 1996. The highest and the lowest probabilities of wateriness in this river remain the same as in Venta.

According to the picked records, the decrease of trends of maximum flows was noticed in the Krazante river. This shows the increase of dry years. These changes in the Venta river are imperceptible.

After calculating a variation of months' runoff in the rivers Venta near Papile and Krazante near Pluskiai, it is obvious to be substantial. The hydro module in the basin of Venta changes from 4.93 L s^{-1} km^{-2} in August to 41.03 L s^{-1} km^{-2} in March. The hydro module in the basin of Krazante changes from 9.28 L s^{-1} km^{-2} in June to 66.65 L s^{-1} km^{-2} in March. The common hydro module during a 40-year period in the basin of Venta is 17.24 L s^{-1} km^{-2}, and in the basin of Krazante it is 1.7 times bigger: 29.16 L s^{-1} km^{-2}.

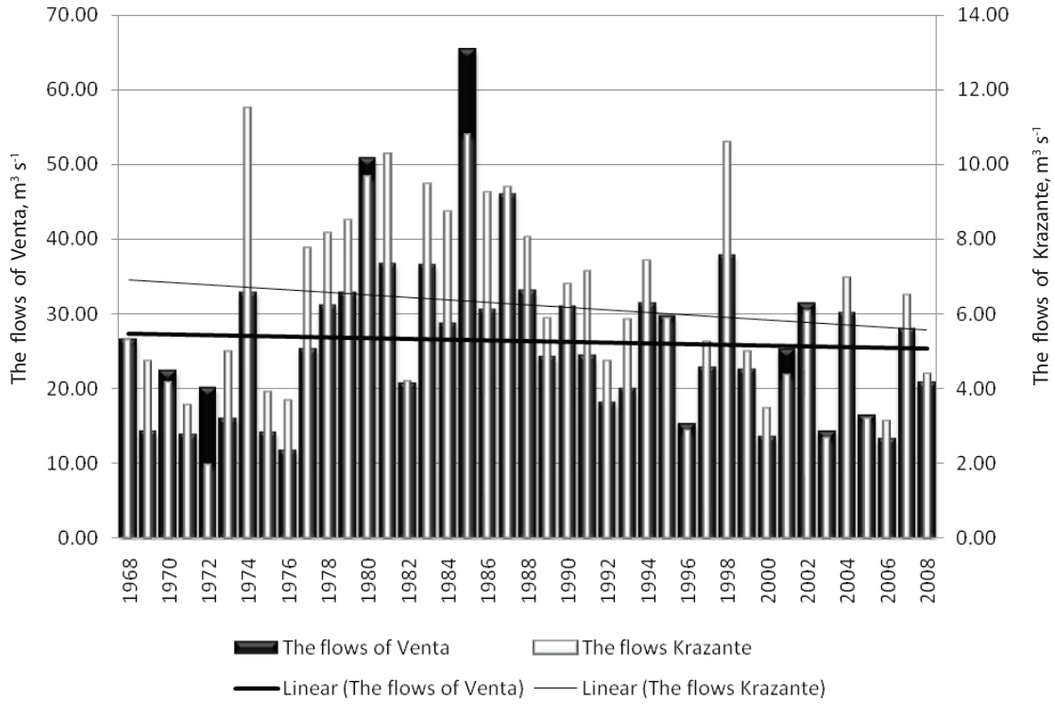

Figure 2. The maximum flow of the rivers Venta (near Papile) and Krazante (near Pluskiai) in 1968 – 2008.

Next, in Figure 3 the change of seasonal maximum flows from 1968 is illustrated. From this analysis it is seen that the most watery period in Venta and Krazante was the period 1978-1987. In Venta it composed 36% of all maximum flows during 1968 – 2008, and in Krazante – 35%. In Venta this period was different because the runoff in autumn was more remarkable than in winter, but in Krazante the flows in autumn were the same as in winter.

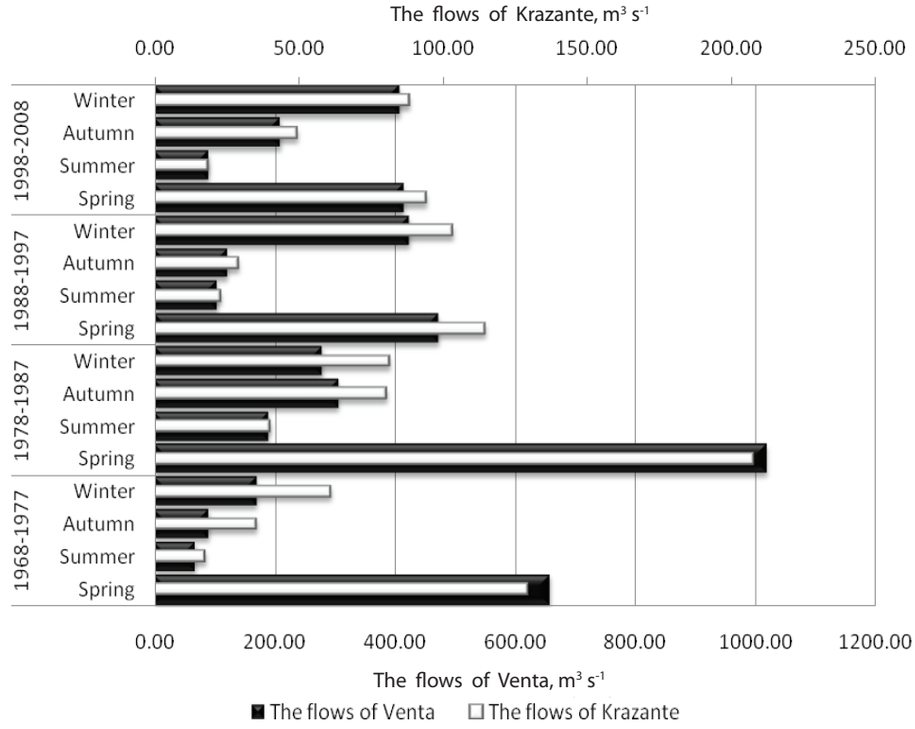

Figure 3. The maximum seasonal flow of the rivers Venta (near Papile) and Krazante (near Pluskiai).

Table 2

The results of Mann – Kendall and linear regression analysis

Seasons	Rivers	Venta		Krazante	
	Tests	Test statistic	Result	Test statistic	Result
Spring	Mann - Kendall	-2.92	S(0.01)	-2.258	S(0.05)
	Linear regression	-2.425	S(0.05)	-2.665	S(0.05)
Winter	Mann - Kendall	2.673	S(0.01)	1.067	NS
	Linear regression	2.831	S(0.01)	1.076	NS

When spring flooding is over, the intensive decrease of flows goes to regular small flows. At the same time in rivers of Lithuania the period of runoff starts which, ends after the autumn rainfalls (Kriauciuniene and Kovalenkoviene, 2007). The decreases of maximum in both rivers when the runoff period begins in summer are observed, substantial changes in Krazante in autumn, slightly observable changes in Venta. These changes could be influenced by different sizes of the basins. In a big basin bigger precipitation doesn't make so large runoff changes, but in a smaller basin stronger rainfalls make more noticeable runoff changes.

In this analysed period the biggest runoff is seen in spring, although the trend of decrease of maximum flows is also observed during this season. In this period the minimum changes are distinct in summer, although there is a narrow increase of wateriness observed. The maximum flow increases in autumn and in winter.

A non-parametric Mann-Kendall test of statistical analysis let us notice the significant negative trends in both rivers in spring. That is decrease of the runoff. There are significant positive trends noticed in Venta in winter which shows the increase of runoff in winter. The same results we get, when we do the test of linear regression. This test certifies it (table 2).

Next, this work reveals the seasonal distribution of precipitation and average air temperature in meteorological stations in Siauliai and Lukuva. In Fig. 4 and 5 it is seen that precipitation in Laukuva meteorological station is fixed twice as much as in Siauliai station. It is probable that the influence is based on location of Laukuva station. The most precipitation in both stations fall in summer, autumn distinguishes with big precipitation too. In spring in these two stations there is more precipitation. In Siauliai station in winter the rainfalls decrease and in Laukuva station only small changes are observed.

The orders of air temperature show the increase of temperature during many years in different seasons. Their changes are influenced by the climate change.

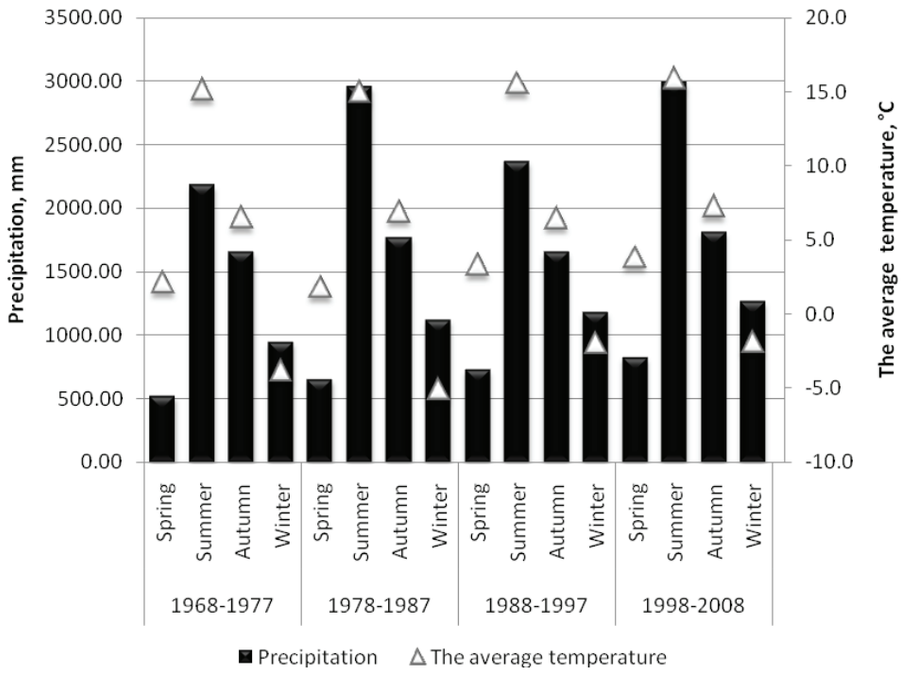

Figure 4. Precipation and average air temperature in Siauliai meteorological station 1968 – 2008.

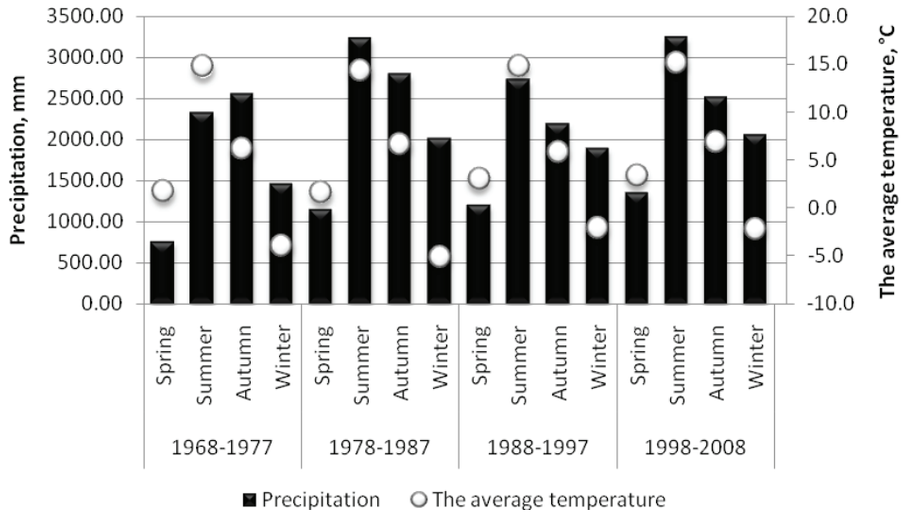

Figure 5. Precipation and average air temperature in Laukuva meteorological station 1968 – 2008.

In this work a correlation between precipitations and maximum flows in Venta and Krazante is established. The correlation in these rivers is substantial, that is $p < 0.005$. In the river Venta the correlation of precipitation and maximum flows is 0.66. In Krazante it is a little stronger – 0.72. In addition, a correlation between precipitation and maximum flows in different seasons is established. There are substantial links in Venta in summer and in autumn, although they are fairly weak: 0.47 ÷ 0.48. In Krazante river the substantial links are in all seasons, except spring. The correlation is from 0.43 in summer to 0.58 in winter and 0.66 in autumn.

In the bar charts 6 and 7 repetitions of flows are analysed. It is observed, that the most substantial flows are fixed in spring. In summer, a period of runoff starts and maximum flows are rare. After October rainfalls maximum flows are seen more often. When precipitation is big enough, it can be seen during winter, too.

The maximum flows in Venta appear more often in March than in April because in a large basin it takes more time when winter is over, the runoff of precipitation changes in a small basin very rapidly, and repetitions of maximum flows are seen mostly in March.

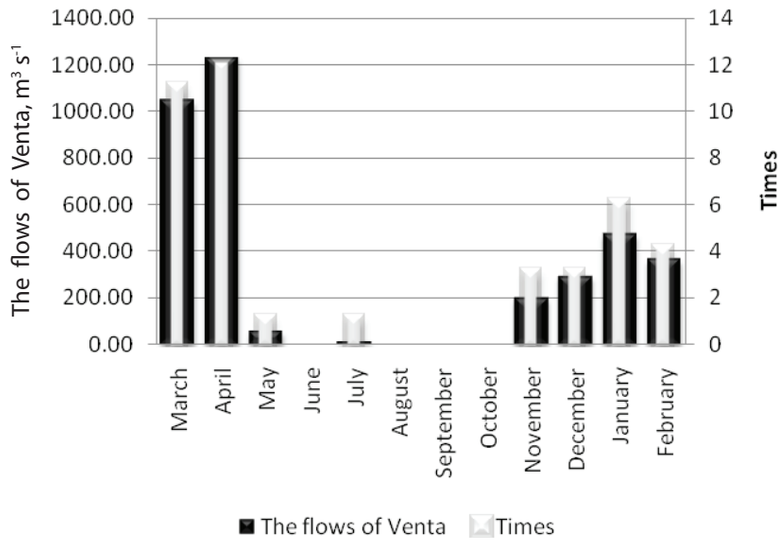

Figure 6. The maximum flow frequency of the river Venta (near Papile).

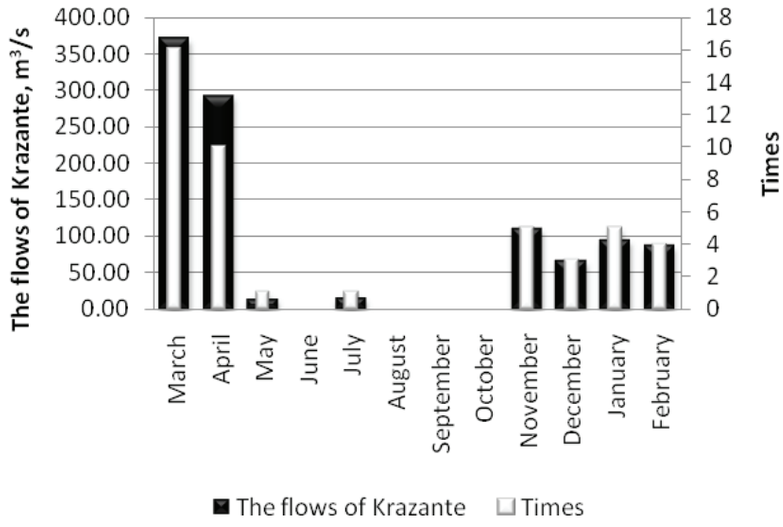

Figure 7. The maximum flow frequency of the river Krazante (near Pluskiai).

Conclusions

1. From a non-parametric Mann-Kendall test of statistical analysis there can also be noticed significant negative trends in both rivers in spring. That is decrease of the runoff. Significant positive trends in Venta are noticed in winter time showing the increase of runoff in this period of the year. The same results are received by making the test of linear regression, and this test certifies it.
2. The common hydro module of 40 years has been calculated. In the basin of Venta it is 17.24 L s^{-1} km^{-2}, and in the basin of Krazante 1.7 times bigger: 29.16 L s^{-1} km^{-2}.
3. In these two rivers during 40-year period safe correlations between precipitation and maximum flows are established although they aren't very strong. The correlation in Venta is 0.66 and in Krazante a little stronger – 0.72.
4. From the established correlation between precipitation and maximum flows in different seasons it can be judged that substantial links in Venta are in summer and in autumn; however it is fairly weak: 0.47 ÷ 0.48. In Krazante the substantial links are noticed in all seasons, except spring. The correlation is from 0.43 in summer to 0.58 in winter and 0.66 in autumn.

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GUIDELINE FOR DEVELOPMENT OF LANDSCAPE SPATIAL COMPOSITION OF THE RESIDENTIAL AREAS

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Abstract. The development of the multi-storey residential areas in the Baltic Sea region shows an inequality that changes the spatial environment of the territory. The major part of the city territory is occupied by the multi-storey residential area that reveals multiple problems of the spatial environment. Therefore, it is necessary to resolve these problems by building new more multi-functional zones in the multi-storey residential areas that would further ensure the sustainable development of the spatial environment. To find the relevant data and material, a scheme of questions for analysis was developed. The scheme reflects all the necessary aspects for the analysis of the landscape composition in multi-storey residential areas. The analysis from the theoretical aspect with the usage of empirical methods determined the current state of the multi-storey residential areas in the Baltic Sea region. The paper presents the study of historical development and the causes of changes, as well as the current state and potential future development of the landscape composition of the multi-storey residential areas. It also reflects the development framework of the landscape composition. The multi-storey residential area that carries a great load of the multi-functional areas, needs an improvement, a renovation and needs to be reconstructed and developed according to all the mentioned characteristics of the spatial environment.
Key words: multi-storey residential area, landscape spatial composition.

Introduction

One of the various city architectural elements is the multi-storey residential areas. These areas create a fixed and specific spatial environment. To determine the development framework of the multi-storey residential area, an analysis of the Baltic Sea region was carried out. In the particular region several important urban planning aspects and factors were investigated. The aim of this research was to explore the functional and structural basic principles of the multi-storey residential area, as well as to determine the framework of the landscape composition.

The landscape composition of the multi-storey residential area is not widely investigated, but, at the same time, is important for a perspective development of any self-government's urban planning infrastructure. The functionality, aesthetical harmony and organization of the multi-storey residential areas can be achieved with successful formation of the spatial composition. Researches determine the most important development features and the current state of the multi-storey residential areas in the Baltic Sea region. Several stages of development are studied and analyzed according to the four-stage base model. The four-stage base model includes the landscape heritage, modern analytical overview, both the positive and the negative tendencies, as well as the improvement level of the spatial development.

The situation in the Baltic Sea region is varied and alternating. A rational and functional development of the spatial environment in the multi-storey residential areas should be facilitated. All the analyzed aspects of the landscape that could provide a functional and organized spatial environment to its inhabitants in the particular multi-storey residential area should be observed. Every fixed factor and the element of landscape models a unitary functionally spatial composition of the multi-storey residential area. The more rational the spatial environment is planned and modeled in the multi-storey residential area, the more sustainable and functionally available it will remain for the next generations.

Materials and Methods

To determine the framework of the development of spatial composition in multi-storey residential area, theoretical and empirical methods were applied. The spatial composition, as well as the urbanized structure of landscape of the selected multi-storey residential areas of the Baltic Sea region was analyzed from the theoretical point of view. For the practical research, to objectively determine the situation, information on several other European countries' experience in planning, sustaining and reconstructing the multi-storey residential areas was obtained and studied. Accordingly, the methodologies one embraces to comprehend the meanings, roles, and consequences of Baltic modernism need themselves to be interrogated (Mansbach, 2006).

The analysis of the spatial composition from the theoretical point of view

Residential areas comprise different types of residential buildings. They are chosen depending on the regional climate, the location and the size of the city, the potential of inhabitation, the demographic situation etc. For the construction of residential areas and building estates, usually different types of building are chosen, which satisfy the specific inhabitation needs of various demographic groups and provide satisfactory sanitary and hygiene living conditions. The construction of diverse residential buildings, alongside with other cultural buildings and edifices, allows modeling different spatial compositions in the residential areas (Briņķis and Buka, 2001). Thus, from the theoretical aspect, the analysis of the data and material was based on the study of territorial and architectonical spatial development process of residential area complexes with the help of the four-

stage base model. The four-stage base model used for the theoretical analysis was obtained from the book by J.Briņķis and O. Buka 'Pilsētu un lauku apdzīvoto vietu kompleksu arhitektoniski telpiskā plānošana' (Complicated spatial architectonical planning in city and rural populated places). The book precisely defines the necessary questions that are suitable for analytical structure and are adequate for optimal research of the multi-storey residential areas in the Baltic Sea region. The first stage deals with the historical overview - what was? The second stage deals with the modern analytical overview - the positive, negative and stagnating tendencies - what is? The third stage looks at the development tendencies. Finally, the fourth stage is the resulting phase that brings forward the suggestions on how to improve the architectonic spatial development. The unitary base model specifies the novelty of the research and analyses (Briņķis and Buka, 2006). From the historical aspect, the analyses were made on the 20th century's multiple constructions of multi-storey residential areas in Sweden, Finland, and Baltic States. The functional organization of the area and space that is directly linked with the artistic image of the building creates a foundation for any modern architectural particularity and originality (Zakamennijs et al., 1966). Accordingly, the development of architecture in the spatial organization and landscape composition of the courtyard. The modern analytical overview presents both the positive and the negative tendencies in the modern multi-storey residential areas. The state of the multi-storey residential territories built in the 20th and the 21st centuries was analyzed separately. The research reveals the current state of the courtyards in these territories. Based on the modern analytical overview the further development tendencies were determined for the multi-storey residential areas. The final and the most important stage of the four-stage base model is the resulting phase of the suggestions for the improvement of the architectonic spatial development. In this stage, all the material from the previous stages was collected and analyzed, and the relevant suggestions for the improvement of the landscape composition for the multi-storey residential areas were put forward. The final stage is still being updated and improved in order to include the correct and rational improvements for the landscape composition framework.

The application of empirical methods in analyzing the multi-storey residential areas of the Baltic Sea region

The empirical methods used comprise the evaluation of the current situation, observation, discussion, interviews, and the investigation of the research security. To perform a thorough analysis and to collect the most relevant information, a specific empirical method was applied in the photo-analysis process of the current state of the multi-storey residential area. For the evaluation of the spatial composition, the main scenery and landscape details, the functionality of the composition, the structure of the urban space, the exploitation possibilities for the inhabitants, the location of courtyards, as well as the duty and wear of the area were observed. The photo-analysis of the current state of the multi-storey residential areas was performed in several cities of the Baltic States, for example, Siauliai, Riga, and Pärnu, and in Stockholm in Sweden. An interview was performed with two groups of respondents, and the investigation of the legal security where the initially gained results need to be supplemented and the research should be continued until the complete information is obtained. One group of respondents comprised 50 people - the inhabitants of multi-storey residential areas. This group of respondents provided a significant insight and their opinions regarding the existing state of multi-storey residential areas. An information obtained concerns the respondents' attitude and considerations toward the courtyards of the multi-storey residential areas, their typical features, functionality, and their current state. Another group of respondents comprised 10 experts. The experts were chosen according to the specifics of architecture, design, and landscape planning. The group of experts enlisted the major problems and inconsistencies, as well as they offered their opinion on the further development tendencies of the courtyards.

Results and Discussion

The results obtained from the four-stage base model present that the current state of the landscape composition in the multi-storey residential areas is diverse. The region contains both the multi-functionally constructed courtyards and the very low-quality multi-storey residential areas. The residential area occupies the main part of the city, and the buildings mainly located in there are residential buildings, administrative, municipal and other buildings, as well as parks, gardens, streets and squares. The residential area is the largest in its amplitude, and takes up 60−70% of the territory in the large cities, and up to 80% in the smaller cities (Briņķis and Buka, 2001).

The analysis of the historical overview shows that the analyzed Baltic Sea region territories have changed and developed over time. Urban planning in Sweden during the 1950s and 1960s was synonymous with land-use planning (Khakee and Stromberg, 1993). The multi-storey residential areas and their courtyards built in the second half of the 20th century were in good condition and satisfied the needs of the territory's inhabitants of that time. The interior of the residential complex was constructed in a natural manner with many green areas with numerous trees and plants (Zakamennijs et al., 1966). The material analyzed proves that there has been a division of functional areas, including several negative features that are also present and unsolved nowadays. There are also well-constructed playgrounds and sports fields for children of any age, resting places for adults, arbors, fountain pools, covered pavilions for drying clothes, and garbage can sheds. All the small landscape elements are handily placed between buildings and trees, except for the liquid fuel containers that are sunk in the ground near the steam shops, which doesn't complement

the interior composition of the square (Zakamennijs et al., 1966). The composition of the courtyards is constructed accordingly to the building plan of the multi-storey residential area. In the development of the 20th century city residential areas, several planning and building systems have occurred that are used in designing building estates. The specific systems are the perimetral structure, group building, row building, combined or miscellaneous building. The perimetral structure is marked by the layout of buildings along the streets of the building estate that enclose the territory. The group building system is marked by the layout of buildings along the perimeter of the territory, as well as it divides the inner space of the quarter into separate courtyards and gardens. In the row building system, the buildings are constructed in parallel rows, orientating the buildings parallelly the main roads and highways. The combined or miscellaneous building system is a compositional join of all the previous systems (Briņķis and Buka, 2001). Approximately 60% of Riga's housing stock has been built after the II World War, during the Soviet period. Most of these are precast panel apartment high-rises. There is more of this type of large, concrete panel housing in Riga than in the developed democratic countries, or even more than in the Eastern Block countries (e.g. Poland had only 35% of such housing stock in 1990; Czechoslovakia had 36%, East Germany - 20%) Increase the density of some residential districts by appropriate infill of various types of residential and service buildings, but preserving the particular character of those districts (Bertaud, 2002). One of the main examples in Latvia is the city Jelgava. After the ravaging war, Jelgava has been successfully rebuilt. The reconstructed city represents the variety of successful building and planning techniques and the high level of commodity and utilities. The spatial organization of the city is also achieved with the help of free planning principles. One of the best examples is the construction of the city's central square (Zakamennijs et al., 1966). Latvia and the capital Riga are undergoing unique and radical changes. These political and economic changes in the country have also influenced the population of Riga and the city structure (Asaris and Marana, 1996).

The next stage of the modern analytical overview revealed an evaluation of the current state of the multi-storey residential area in the Baltic Sea region. Nowadays analytic summary identifing most important positive and negative evolution aspects, transformations in these residential areas. The residential areas together with the building estates is the modern residential building form for organizing new residential territories and for reconstructing the existing building areas (Briņķis and Buka, 2001). At present, the most important task is to create a sustainable city. This task is complicated and difficult for Latvia when compared with other cities and countries that have been able to develop harmoniously without imposed interruption. Latvia is still feeling the negative consequences of the past 50 years of occupation, which were the cause of both environmental degradation and disharmonious development of the city (Asaris and Marana, 1996). These multi-storey residential areas in the Baltic Sea region reflect the mutual inequality in the quality of the environment. Multiple negative features are present in the multi-storey residential areas, affecting the possibility to successfully and functionally organize the courtyard. There are certain problems in housing development in Europe that are related both to the ageing of the housing fund and the news social and economic conditions. Residential districts in Europe differ significantly bearing characteristic features of the era when they were built. There is also a large diversity of dwellings that accommodate the needs of different social classes. Yet the place and role of these diverse territories in the urban structure, their interrelation, adequacy of the dwellings to the requirements of their residents and to contemporary housing standards provoke a number of questions that are essential to the overall development of cities and to provision of quantitative and qualitative housing for the city dwellers (Treija, 2007). The same problem occurs in the courtyard interior planning in these residential areas. There are imperfections of functional zones and technical solution, overloading with parking places, contamination of spatial environment, depreciation of free recreational spaces. There are multi-storey residential areas constructed in the last several years that do not agree with the aesthetically and functionally effective and successful courtyard planning. The specialists have not thought enough about the accessibility of the environment and rational exploitation of the functional areas for people of all age categories inhabiting these residential areas. The residential funds are wearing off, and there is a disproportionate expansion of the residential areas. The residential areas should be located in the healthiest and in the most natural and the highest territories of the city. The great significance in the inhabitation process of these territories has the solar and wind regime. The full insolation and aeration of these territories have to be performed. Another great significance in inhabitation of such territories have the nearby located forests that beneficially affect the sanitary condition of the city and the organization of resting places for its inhabitants (Briņķis and Buka, 2001).

Development tendencies are very important factors in multi-storey residential areas. The processes of the last decades - the housing sector reform, social differentiation of the population, etc. - have resulted in serious changes in the situation and problems pertaining to the large-scale residential districts. New residential developments are in different stages of implementation within the territories of the existing districts and in the areas bordering on them. The new developments considerably change the existing structure of districts and create preconditions for spatial as well as social conflicts (Treija, 2008). In the Baltic Sea region, one can observe several stages of development tendencies. The courtyards of the multi-storey residential areas are well established, adapted to inhabitants' needs, but they are not in accordance

with the rest of the city's buildings, transport systems, and landscape. There is another opposite tendency where the main accent is put on the architecture of the new multi-storey residential area, but the ideas and solutions for the landscape composition of the courtyards are abandoned. Some of the positive examples of the significant development tendencies in multi-storey residential area are to be found in Tapiola in Finland, and in the new residential area Hammarby Sjostad in Stockholm in Sweden. Such areas can be created with the help of progressive functional, economic and aesthetic factors that deal with the questions concerning the quality of the living space and conditions in the broad urban planning aspect. The streets, roads and alleys of the residential area are to be planned as a unitary system, including all the building estates that shape a residential area. The density of the streets should be determined by organizing a comfortable transmigration of the inhabitants from their residential buildings to the city transport stations or stops (Briņķis and Buka, 2001). The spatial structure of large cities evolves very slowly and can evolve only in a few directions. On a large scale, it is never possible to bring back to nature the land that has been already developed. Planners should therefore have a good understanding of the potentials and liabilities inherent to the current spatial organization of the city in which they work (Bertaud, 2004).

The spatial environment of Riga is undergoing active development with its direct impact being exerted also on the large-scale residential districts - by quantity the most significant part of the living environment of Riga. Since about 60% of the city dwellers reside in large-scale residential districts, which constitute approximately 40% of the housing stock of Riga, the future prospective for these territories is an urgent topic in the context of the urban development in Riga. Altogether 13 large-scale residential districts were constructed in Riga over a period of about 35 years, starting from the mid 1950s. At that time large numbers of groups of this type of residential buildings were built in various parts of the city (Treija, 2008). The improvements of spatial development in the multi-storey residential areas are necessary not only in Latvia, but also in the whole Baltic Sea region. The spatial structure of a city is very complex. It is the physical outcome of the subtle interactions over centuries between land markets, and topography, infrastructure, regulations, and taxation. The complexity of urban spatial structures has often discouraged attempts to analyze them and ad fortiori to try to relate urban policy to city shape (Bertaud, 2002). In such residential areas the development in landscape composition is an important and significant aspect that would create better living conditions for the area's inhabitants. Some of the main frameworks in planning the multi-storey residential area are: the improvement of the functional areas, reaching aesthetically high criteria, the development of the engineer-technical solutions, the maintenance of the surrounding environment and its renovation in places where it is needed. All aspects should be observed in maintaining the individualities of the natural landscape, determining successful functional and compositional solutions and plans in the spatial environment. Urban planners, however, should constantly monitor the impact that specific policies may have on city shape. They should be aware of the effect of the most common planning tools - land use regulations, infrastructure investments and taxation - on the spatial organization of a city. They should make sure that the urban shape resulting from their actions will be consistent with the objectives set by elected officials (Bertaud, 2004).

The unfavorable attitude of the inhabitants towards the living environment, dysfunctional spatial planning that causes irreversible negative consequences is only a small part of the bigger problems in the multi-storey residential areas. These methods were affirmed by the group of 50 respondents, who emphasized that the situation in the multi-storey residential areas will remain unchanged in the following five years, and that they would like to maintain or modernize the specific stylistics of the inner squares of each of the multi-storey residential areas in the Baltic Sea region. The inhabitants accentuate that the poorly constructed and low-functional planning of the area is not suitable for children playgrounds; there is a notable draught as well as a significant load of the population in the nearby multi-storey residential areas. The group of experts emphasizes that often in their professional work process they come across low-functional courtyards in the multi-storey residential areas. For further development they advise to replan, improve and aesthetically rework the unattractive, degraded multi-storey residential territories. They would prefer that each Baltic Sea region multi-storey residential area was maintained or modernized according to the specific stylistics of their quarter or community. A great problem is the affect of the numerous inhabitants of the nearby residential areas, which poses an inconvenience to the functionality of the courtyard. Currently, the quality of large-scale residential districts does not comply with the modern requirements and does not meet the social and recreational needs of inhabitants. While the quality of individual flats is gradually increasing, the public open space continues to degrade because it is still seen as being of secondary importance. In order to determine development directions for large-scale residential districts, it is necessary to elaborate complex criteria for evaluation of the quality of the living environment. The principal task for further development of the living environment is the creation of a multi-funcional and intensively utilised urban environment along with the preservation of the identity of the place, its improvement and harmonisation of environmental scale. As seen from a wider perspective of urban environment, priorities should be renovation and modernisation of the already existing densely populated areas, their humanisation ensuring accessibility to high-quality goods, services and public transport services. Such undertakings would motive population not to leave their dwellings

and would not permit expansion of cities (Treija, 2008).

Conclusions

1. Each multi-storey residential territory in the Baltic Sea region is independent and shapes a certain spatial environment in a certain place and time. Today the existing residential fund is often paid little attention to which causes many irreversible problems for its further development. The ground principles of the functional structure planning are all the landscape composition elements and spatial environment features. The determined frameworks of the landscape composition in the multi-storey residential area show that its further developments will be able to create a more successful planning and more pleasant spatial environment for those territories which have features of degrading environment. A part of the multi-storey residential territory often undergoes unreasonable courtyard and residential area reconstructions. The great multi-functional load on the multi-storey residential area often remains unnoticed.
2. The main features on the multi-storey residential areas that, if developed and improved, may define the ground principles and framework of the landscape composition, should be included in the development of the urban planning. The studied and analyzed examples of multi-storey residential areas of the Baltic Sea region, as well as the aspects of their modeling, formation and development, clearly reflect the ongoing processes in the researched sphere. Sweden and Finland present multiple successful reconstruction examples of the multi-storey residential areas, which could also be applied reconstructing the Baltic country residential regions. The enlisted solutions for the problems would improve the spatial development processes of the multi-storey residential areas. The multi-storey residential areas are the witnesses of time, and sometimes the features they carry should be maintained, allowing changes and improvements only in their spatial environment.

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THE DEVELOPMENT OF CULTURAL HISTORICAL PARKS OF LATVIA

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Abstract. The environment relating to the history of civilization is the notion, which more and more is used when thinking about the changes occuring in Latvian culture. In this research are considered all Latvian palace and manor parks and classified as an integral part of the heritage. The research was done from the year of 2009 to 2010. Fundamental principles the quality of today's parks were taken, first of all, evaluating the cartographical and historical materials and available literature sources, secondly, chosen, mostly historically rich and varied parks, evaluating basing on landscape evaluation criterias, and, thirdly, summarizing the qualified parks, for working out qualitative and sustainable park development models in the future researches. Working out the evaluation system and principles of historic parks, it is possible not only to reanimate the historical landscape, but also get back the total landscape atmosphere, in spite of the loss of the main ensembles or their partly ruination. The park qualification, structure investigation, landscape inventory and analysis, as well as European expierence in historic landscape maintaining and development, according to a similar landscape structure, which nowadays successfully functions as a heritage, is the base for an optimal and sustainable culture landscape development. The worked out order helps in understanding and analyzing the meaning of the historic park and its successful development tendency, in which are marked out the most important heritage objects in the particular landscape and they are reverted in a vital pulse and social processes.
Key words: cultural historical park, development possibilities, heritage, landscape classification, landscape conservation.

Introduction

The environment of heritage value is a place made as an intentional result of action in the course of nature of humanity, in case it or some elements, which it has created, have historical, scientific, artistic, scenic or differently preservable cultural value (Pētersons, 2008). In Latvia there are about 300 historic parks both in an urban and country environment, only some of them are cultivated and livens up the landscape as heritage evidence. The other, the greatest part, has lost its cultural history identity or it has declined – with an uncertain garden structure, including the landscape, dendrological and arhitectural value, which keeps in it undescovered, unique Latvian cultural environment.

One of the leading points of view in a human future life planning is an idea about sustainable development. The protection of the cultural and natural heritage is one of the aspects in human and nature relations, which is realized in a human's interests to ensure more qualitative living conditions. To realize those ideas there is a need to arrange the cultural and natural heritage protection processes (Stūre, 2004). In the result of landscape selection inventory in Latvian historic parks, the possible visually most valuable park landscapes were defined, which were described, pictures were taken and valued according to the worked out landscape analysis. While realizing the landscape evaluation of the historic parks, one comes to understanding and finds answers to the questions about the essence and condition of Latvian historic parks, which, in their turn, is the base for a successful and sustainable park development possibility. According to the evaluation results of the historic park landscape and using European expierence in historic park conservation, it is possible to work out successful development models for park cultural environment, which will help in park reviving, conservation, and sustainable using. Due to conservating the cultural environment, we get important territories for social recreation, education, and training.

The main purpose of this research is to get to know the potential of Latvian historic park development and enable the cultural environment reviving, at the same time, supporting their sustainable development.

The main tasks to follow up this purpose are:

- to study the historic gardens, analyze their situation, resources and use potential;
- to analize and propose European expierence in using the historic garden resources;
- to give the possible development models of the historic gardens for their sustainable use.

Materials and Methods

A park is an esthetic greened nature area in its natural or human transformed shape. The sense of the historic park is related to the cultural and historical heritage – stylistics, composition, and multitude of elements. To realize the idea about culture and nature 'wonderfulness' – cultural heritage, which is that world, which should be more conservated than useful and available, we need to arrange the protection processes of this environment (Simmons, 1973).

Cultural historical park classification

The first step is park classification according to certain principles. Landscape classification is a more analytical activity where the landscape is sorted into different types or units, each with a distinct, consistent and recognizable character (Urtane, 2001). In the park classification mapping materials, historical materials, literature sources were used.

According to the mapping materials, palace and manor ensembles, which have national cultural heritage

status, were chosen. In Latvia 134 palace and manor complexes (one building or ruins or all buildings) and 71 parks have national cultural heritage status. Those are landscapes of high value with a rich historical heritage. But as a cultural heritage is regarded every manor garden or park, in spite of its being or not being in the category of cultural heritage.

In the available historical materials about palace and manor ensembles there is an essential information about garden development, stylistic features, composition, dendrology, and other garden elements. The older parks in Latvia were formed already in the 17th century. Until about the middle of the 18th century, parks were formed according to Italian or French regular park example, which are called as regular parks. In the 18th century in England, a landscape or free park style appeared, in which the trees could not be cut, but the waters had only natural shape banks. In Latvia just few regular parks have remained. The most brightest and popular regular park in Latvia is Rundale palace park. In Latvia free park style is mostly found, but now these parks are difficult to enumerate, because they have lost their original style and park composition. Each somehow preserved manor garden or park, whose structure could be still apprehended, reflects the garden art of that time.

In the literature sources an information about Latvian historic parks as an individual value is little mentioned, mostly, these are descriptions about arhitectural objects having a cultural historical value. The parks were formed by adding, outlining and representing an ensemble of a particular palace or manor. Though, the dawn of each architectural object is right in a landscape and its location is very important. A particular place not only enriches the visual attraction of the landscape, but also attaches a sensible meaning. That is why the analysis of the place is important as a context for discovering the cultural heritage, environmental and social relations. In the process of classification, historic gardens were devided according to their location:

- park in a city environment;
- park close to a city environment;
- park in a country environment.

Cultural historical parks in the town are social – need for play and recreation; representative – beautify the town; sanitary – fresh air; moral – control the working class people; and spiritual – the feeling of nature (Bucht, 1997). A group of cultural historical ensembles in a city environment clearly improves the total image of the city and attracts the attention of society and different organizations. Also cultural historical landscapes close to the city create great opportunities both for city inhabitants and tourists, which successfully unites the landscape peace in a suburb and a comfortable infrastructure in a city.

The cultural historical landscape in a country is completely different from that in an urban environment both economically, socially, and mentally. Unlike the city environment, a cultural historical ensemble in a rural environment makes a united and harmonious shared landscape ensemble. It is worth to mention that a park in a rural environment is as a guaranty for high value landscape conservation (Lambert, 2006).

Historical parks were grouped into landscape unit types, which partition is defined by a geomorphological factor and landscape cover characterization:

- hilly scenes;
- lake scenes;
- river scenes;
- woodland scenes;
- mosaic scenes.

Palace and manor complex location after the geomorphological factor mainly defines the type, stylistics and composition of the park it has, as well as the esthetic and visual quality of the park. If the natural relief is typical in palace and manor parks, then a big role is for the green areas, their shape and colours, by which the park ascetism, mystery, originality and ardour forms. Unfortunately, in the course of time the historical relief of the territory may change. It is a natural process, if a man has not taken a part in it.

Landscape cover characterization in a historical park environment is both historically and geographically important. Historically some river or lake served as a place for a park location, but in places, where this nature water was not close, but there was some other functional comfort or some esthetic values, for example, visual open space and high quality views, ponds were made. Woodland and mosaic scenes are historical, but they have also formed nowadays. The closeness of a water, woodland scene, and a historical object creates a varied and high value landscape which is a fascinating landscape having a cultural historical value.

The aim of cultural historical park classification is as much as possible to sum up such cultural historical landscapes which express the variety and resources of Latvian nature.

Cultural historical park landscape evaluation

The evaluation of a concrete landscape or park is closely connected with visual esthetical criteria, but, although they are subjective, they most precisely describe a successful or unsuccessful interaction between the nature and the man. In this case, the question is about a cultural historical park landscape, its present situation quality, available information in historical and today's materials. The study objects are culturally and historically rich parks with esthetically important landscapes. Evaluating the Latvian cultural historical landscape general situation, the main park landscape evaluation criteria, which would characterize a specific park situation both in a historical and today's aspect, are:

- characterization of the garden environment and structure;
- evidences of the cultural and historical heritage;
- analysis of the park landscape;
- evaluation of the present situation.

For each of a park characterizing criteria is prepared its own description, which is possible to use for getting and classifing the information, for example,

about the park landscape structure and visual esthetical quality. Park landscape evaluation, first of all, clearly shows what are Latvian cultural historical parks, how important they are for today's society, what is their current situation, and, secondly, it is used in the garden protection, reviving and maintaining processes, helps to study the optimal garden landscape resources.

Garden environment and structure characterization includes information about the park location in a geographical aspect, territory area, property rights, state status, geomorphological factor, and landscape mosaic.

Cultural historical elements in a particular landscape are historical environment objects that describe regional and district park forming and the total features of the planning and insight into the culture of that time. Particular historical elements and objects help solving the park planning sylistics, using way, and compositional connection. As a successful and sustainable today's cultural historical landscape reviving and development reason is historical heritage evidences.

Park landscape analyses mainly are the landscape visual characterizations. Those are the landscape visual criteria, landscape esthetical factors, quality, and landscape functionality. For a human landscape spaces are not so important as their fulfilment with landscape elements. Important is that the landscape visual features are especially detachable and terminated. The visual criteria with the above mentioned element description, with preservable, impertinent, obstructive or landscape degrading objects, the perspective development of the territory and the desirable, allowable or not allowable landscape (int.al.building) elements' characterization, emphasize the garden values and problems, which stimulates its successful development.

As a high value esthetical landscape is considered the landscape, in which there is a harmony between the landscape elements made by nature and human or there is a relatively big visual variety and harmony in a natural landscape (Nikodemus and Rasa, 2005). A serious meaning in a landscape evaluation is for the existing perspectives from different views or moving along the road or path. The character of the landscape: intelectual, emocional, esthetical, associative, scientific, is made by human thoughts, interpretations, and creative imagination. In general, cultural historical garden quality is defined by visible landscape environment relations, cultural environment richness, and biological variety. The landscape quality is a subjective indicator, though there are definite principles for their evaluation. Those are: the unity of the landscape, variety, scale and aura, which helps to define the level of landscape harmony, complicity and secretness.

The park landscape functionality depends on the existing infrastructure and proposals which a society gets from a visual esthetical part from a definite park.

After the garden existing situation functional zoning inventory, it is possible to evaluate the park resource availability and the using way. Every park is special, making unique environment, space, landscape element composition, which influences the functionality of the particular territory. Functional zonings might be different and each park owner realized ideas according to a successful society, tourism involvement in the park development, is an addition in the functional zoning elements in the cultural environment optimal using (Feliu, 1996).

Cultural heritage expierence in Europe

Looking at this situation in general it is clear that the last 10 years outside Latvia cultural heritage protection and development planning has more and more attention from interstate society, as well as at individual state level. During the research, considered European cultural historical gardens were chosen with the historical value, territorial location, stylistics, esthetical landscape value and problems similar to those of the chosen Latvian cultural heritage parks. It is worth mentioning that the park dendrological value both according to species variety and the impact of climatic conditions may seriously differ from the dendrology in Latvian parks, which, for sure, affects the care, maintaining, and value of these parks. European expierence in conservation and nowadays use of cultural historical landscapes, is viewed in several aspects:

- park use directions (recreational, presentational, educational, research);
- development features of park spatial concept (conservation, restoration, revitalization);
- protection of dendrological and biological diversity (exotic and protected plants, secular trees, dead trees, protected species);
- public integration (infrastructure, communication, services. Load influence and threats);
- historical and modern elements interaction (improvement and art elements, expositions. Buildings. Planning principles).

These aspects will be used in future research of Latvian cultural historical parks and will be important to protect, conserve and make sustainable development models of the Latvian cultural historical parks.

Although, in general, development features of European cultural heritage park spatial concept is a base of Latvian cultural environment.

The exsistance of historical and modern art elements and their mutual interaction was examined as an idividual criteria in European cultural heritage garden territories. The exsistance of the modern art elements in a historical environment mark out and increase its values.

Evaluating the European chosen projects and different points of view, which are used for achieving the cultural heritage protection purposes, demonstrates wide creative possibilities for bonding the area with other spheres. Different aspects of the European cultural heritage protection such as political, investigative, planning, and management, are becoming more important both in their volume and content.

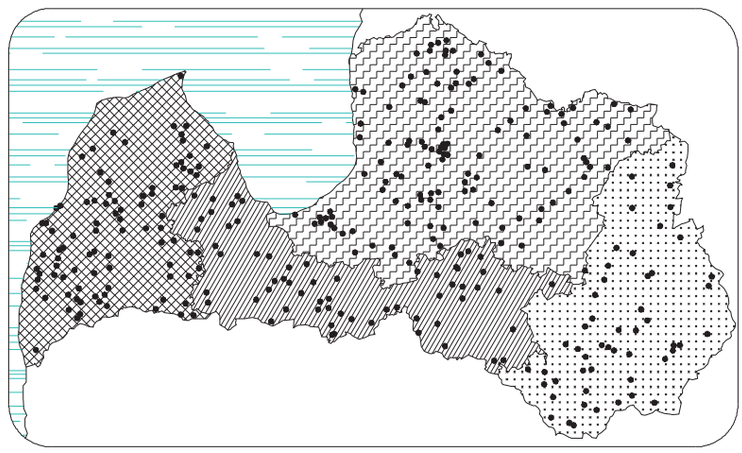
Results and Discussion

The possibility of maintaining and developing cultural historical parks was evaluated according to the previously done researches and summaries about Latvian gardens and parks as their integral part in palace and manor complexes. In literature descriptions, a garden as an idividual cultural environment is analysed after evaluating its historical development that discovers garden heritage, but an evaluation of the landscape as Latvian nature treasure in nowadays point of view with a purpose to revive and develop its resource using and applying in social processes, is only in some special cases.

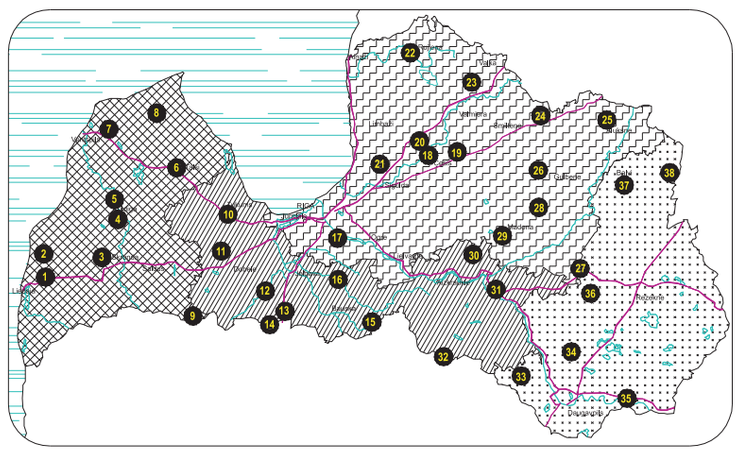
In the result of landscape qualification from 321 Latvian palace and manor parks were selected 38 culturally historically, esthetically, and territorially most important Latvian historical parks, which during the research were classified according to different criteria, making new groups with a possibility to work out sustainable development models in future research.

Cultural historical objects (palaces, manors) were studied, evaluated and maped after summaraizing and evaluating the information according to the presently and in future culturally and historically important landscapes, realizing the landscape esthetical evaluation of the territories, defining esthetically important landscapes. In Map 1 all Latvian palaces and manors are mentioned. Using a selective check, culturally most interesting, most notable, most unique and richest parks of Latvian palaces and manors with a different present situation were chosen (Map 2).

Map 1



Map 2



1. Tasu manor
2. Vergale manor
3. Kalnamuiza manor
4. Pelcu manor
5. Padure manor
6. Vicezu manor
7. Pope manor
8. Dundaga palace manor
9. Vadakste manor
10. Durbe palace
11. Strutele manor
12. Zalenieku manor
13. Elejas manor
14. Blakenfelde manor
15. Skaistkalne manor
16. Dzimtmisa manor
17. Mercendarbe manor
18. Karla manor
19. Veselava manor
20. Ungurmuiza manor
21. Birinu palace
22. Valtenbergu manor
23. Jercenu manor
24. Gaujiena palace manor
25. Aluksnes manor
26. Lizuma manor
27. Varaklanu manor
28. Cesvaine palace manor
29. Marciena manor
30. Odziena manor
31. Krustpils palace
32. Nereta manor
33. Bebrene manor
34. Arendole manor
35. Kraslava manor
36. Galenu manor
37. Balvu manor
38. Vilaka manor

The landscape evaluation of historical parks provides information on visualy esthetical landscapes in Latvia, which draws the attention to the uniqueness of the environment, richness and the singularity of the historical heritage. Characterization of the landscape offers a chance to increase the social understanding about a cultural historical landscape in any environment, not only in the located places. This understanding is the first step to the cultural environment heritage, and, possibly, in this way the social perception about yesterday's world and future landscape is changing (Fairclought, 1996). Evaluating those particular landscapes it is possible to offer the most optimal ways of garden development, this way giving an investment in esthetical, social, and economical spheres. According to the done analyses, from different aspects and grouping the park landscapes with a similar character, planning development models are made, which makes easier to use park resources in the future processes.

In European countries, a landscape value involves use of a sustainable natural resource, virgin land biotopes, an open space and views, as well as culture elements in it (Nikodemus and Rasa, 2005). One of the solutions for a balanced development, which is popular in many countries, for example, USA, Canada, Great Britain, Finland and elsewhere, is an ecological landscape planning – an approach when the needs for territorial development and protection of natural and cultural historical values are considered at the same time. Unlike the European cultural historical object development, in Latvia, for the most part of cultural historical environment during its development, the interaction between the man and the nature has been totally lost or it has been negative, which has stimulated the degradation of cultural environment. European park development with a positive human interest has been more successful. A park is living if a man helps it to maintain, care and develop. Park maintaining is a complicated process, but it is less difficult if compared with a protection in other spheres (Goulty, 1993). Latvian cultural environment has survived through different times, in the result cultural historical objects and landscapes have been left in oblivion for more than half a century. That is the main problem – how to maintain by renewing and how to develop by protection. The landscapes, which during decennarys have got an image of a natural environment and humanity untouched corner, are interesting and unique with a different bitope complex not only in Europe, but also in the whole world. The regular French and Italian style parks with a clear composition, lines and geometrical shapes have been made with a purpose to take care of them and maintain in regular shapes, while English free style parks, which already historically have been made according to naturalism and nature virginity principles, are turned to a nature variety in any sphere. In landscape parks that kind of natural untouched corner is interesting both dendrologicaly, ecologically and biologically, still in the parks with a regular planning with poorly visible composition traits, overgrown plantation and tumbledown historical objects, a regret and feeling of desertion appears. That is why according to the history of park landscape, character, stylistics and esthetics we should carefully evaluate and analyze the desirable park development model, which will be culturally and historically revealing, sustainable and affecting the society. The places of cultural heritage must be actively and dynamically used, not forgetting about the impact of reactive load on territory nature values and possible danger, which might be involving unorganized holidaymakers, tourists and noisiness, as well as an insufficient tourism infrastructure. The visible expression of too excessive tourism load is topsoil laying, stimulating of erosion processes, as well as littering the territory with household waste. Planned and arranged tourism resources in park territories would only enable a profitable culture tourism development and popularization of the cultural historical heritage.

Europen expierence in cultural historical park development is tested and advised bearing in mind the cultural historical heritage, landscape uniqueness, and identity evaluations. Uniting Latvian historic park landscape evaluation and European expierence in a successful development of those parks, Latvian cultural historical garden development tendencies are worked out.

Conclusions

1. As a direct interaction between the civilization and the nature, a park gets global meaning and is a culture style, age and proof. During Latvian landscape development, the city and rural environment have become rich in historic parks. In their maintaining, the most important is the value realization and a continuous professional care. A historical park base is an architectonic plant composition which lives, dies, and gets renewed. Historic gardens, parks, parts of park cities are significant Latvian culture heritage elements, their maintaining for the next generations satisfies Latvian and European society interests. Envolving the models of park development in future research, we can get:
   - park development guide for the owners of cultural historical parks;
   - cultural historical park cleaning and conservation of degraded landscapes, preservation and revival;
   - public education and involvment in environmental problems;
   - a potential use of Latvian landscape resources for various purposes.
2. Unfortunately, due to the economical crisis, the visions of the cultural historical park development will come true in a longer time period. Although, right now, when the world economics is having hard times and the development of tourism market has decreased, a flexible reaction to the soling amount in the changing economical situation is

specially needed. Especially it regards to a rural tourism in Latvia. The cultural heritage enables a sustainable development, that is why a serious meaning is for raising the competitiveness and development of rural territories. Renewing and maintaining historical parks define the quality of the cultural environment and sustainability, which stimulates the tourism.

3. Understanding the regenerated, cultivated, and declined landscapes and educating the society in environment issues is the main solution of those problems that could be attained only by exchange of information. The more there will be cultivated landscapes, the greater will be the possibility for the society of becoming educated in the cultivated environment sphere.

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LANDSCAPE CLASSIFICATION OF THE LIELUPE RIVER VALLEY – HUMANS' USE OF RIVER LANDSCAPE AND LANDSCAPE ELEMENTS

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Abstract. Civilization has historically flourished around rivers. There exists invisible and visible social activity system in the river landscape. With the world's economical, technological and social development, a focus on meeting human needs is vital. There is a need of a reinterpretation of landscapes' functions and revision of archetypes. The proposed approach is search for design of lifestyle versus design for territory. The research is based on the Lielupe river case study. The aim of the on-going research is search for approach to solve individuals' role of the river landscape. The task of this paper is to identify types of individuals' use of river landscape. Data collection was performed both from individuals' prospectus of use of landscape and from the functional use of river as a landscape object supplementing data both ways. I investigated it by analyzing intuitive images, making of an observation of people's habits, behaviours and occupations, and by cartographic analysis. At this stage of research there were observed seventeen groups of functions in the landscape of the Lielupe river valley, characterized by wide range of actions, described by landscape elements, and organised in social groups. These data are assessed by grading of their influence on landscape and its participants. Sixteen marginal grades were detected. This highlights a high potential for development of river landscape with an individual's participation in it. The further investigation is to develop ergonomic and functional planning principles for each type of interest group to compromise the individuals' needs.
Key words: river landscape, use of landscape, landscape functions, grade of influence, lifestyle.

Introduction

Rivers have played an important role in human societies for thousands of years. There exists invisible and visible activity system in the river landscape, signs which have a meaning only for specific groups of individuals. The different cultural layers overlay the territory. Landscapes are dynamic – they change in time scale, by seasonality, rhythms of day and individuals in landscape. The changes are at different rates. In respect of time scale, the changes are driven by climate change, demographic processes, economic and technologic development, and by changes in man's lifestyle. All these forces affect also the river's landscape. River itself is a dynamic landscape element. A combination of environmental and cultural factors led to a rich diversity of landscapes in the Lielupe river valley, ranging from the nearly untouched landscapes of bogs to the artificially constructed landscapes of cities. River landscape is an asset that has not used for full its potential the landscape offers.

The latest investigations on landscape planning and landscape classification concluded with an approach of landscape as symbiosis of abiotic, biotic and anthropogenic landscape elements and planning for landscape using ecological principles (Makhzoumi and Pungetti, 1999). Also the European landscape classification has been developed and a European Landscape Map has been produced. The theoretical approach is driven from assumption – landscape as a function of the following factors: climate, geology and geomorphology, hydrology, soils, vegetation, fauna, land use, landscape structure, and time. However, the European Landscape Map is limited to a biophysical approach, since there is a lack of consistent and European-wide data about landscape history, visual, cultural and aesthetic factors (Mucher et al., 2010).

These approaches suit for global planning, which leads to national, regional. But such methodological approach does not solve individuals' role of river landscape. The human scale does not appear. As a result, bottom up methodological approach should be developed to plan individualized river landscapes. As far as the investigations reach the human, there is no comprehensive system developed. Humanscale solutions respecting the cultural and social fabric of river landscapes are precondition of the individual's participation in it.

The aim of the on-going research is search for approach to solve individuals' role of the river landscape. The task of this paper is to identify types of individuals' use of river landscape.

The data of this paper will further be applied for a case study data set in the landscape of the Lielupe river valley. The outcome of this application and the wider implication of this methodology and potential variations will finally be discussed. The part of investigation results were presented in the 68th Scientific Conference of the University of Latvia in Landscape research section (Purs, 2010).

Materials and Methods

The research is based on the Lielupe river case study. The Lielupe river is situated on latitude – N 57°0′, longitude – E 23°56′ (rivers' mouth in the Baltic Sea). This paper is part of preliminary investigations to find out research focus area to be more detailed examined further. The Lielupe valley for this paper is set as a river and its affected territory – how far the

individual feels presence and influence of the river, and individuals' possibility to use river as an asset. In further research, the rivers' affected territory will be the object of investigation.

At the first stage of research, roots of existing and historical humans' use of the river landscape were searched for. Investigation was performed both from individuals' prospectus of use of landscape and from the functional use of river as a landscape object supplementing data both ways. I investigated it by analyzing intuitive images, rethinking functionality, making of an observation of people's habits, behaviours and occupations, reviewing archetypes. The data were obtained by observing and analysing territory and individuals' behaviour, traditions and their use of the Lielupe river landscape. Also cartographic analysis and assessment of historical use were performed analysing land use, identifying actions in landscape affected by river or landscapes being close to river. Data sources used for this paper are Google Earth maps and images, the Lielupe Basin Management Plan (2009), literature and museum collections, overall field observation, visiting the territory and discussing with locals.

Further purpose is by identification of individuals' actions in landscape to find overlapping needs to merge them in social interest groups. The next stage of investigations will be by interviews of involved and affected people representing different interest groups with an aim to reconsider the completeness of data.

Results and Discussion

Search for approach

The landscape has and integrative potential, because it ties and combines different social activities in a specific area (Bartol, 2006). The global approach to human issue is set in several political documents. The Universal Declaration of Human Rights (1948) points importance of freedom of independent of others' viewpoint and the right of equal access to public service in their country. The Kyoto Design Declaration 2008 (2008) states the importance of human-centred design thinking rooted in universal and sustainable principles. The European Landscape Convention (2000) defines landscape as an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors making a focus on human and nature. Also the convention states that it applies to the entire territory and covers natural, rural, urban and peri-urban areas, including land, inland water and marine areas. It concerns landscapes that might be considered outstanding as well as everyday or degraded landscapes. The European Landscape Convention focuses on democracy: community participation and involvement. It also recognises landscapes as an essential component of people's surroundings, an expression of the diversity of their shared cultural and natural heritage, and a foundation of their identity.

European landscape convention defines landscape quality as the goal of human and societal activities, which derives from the characteristics of individual landscape areas and is directed to desired quality in the future at the same time. The landscape is an integral category in which the societal development and state of the spirit are mirrored; at the same time, the sectors, public, professionals, politicians, and inhabitants are contributing to its state and to its future.

Search for lifestyle

N. Bučar-Draksler (2006) expressed approach that 'we live as individuals. The voice of a single person is hard to hear. That is why we are looking for a group, which we can relate to and which can express our opinion, too. Each society has rules. When they become too restrictive for us or they don't fulfil us – the rules may be too general or not concrete enough – then this society does not suit us anymore. We want changes.' All this led to the need of a reinterpretation of landscapes' functions and revision of archetypes. For developing the new system, the emphasis is on identification of ergonomic and functional requirements for the each type of interest group.

The proposed approach is start for design of lifestyle versus design for territory. The approach proposes to revise existing assets – traditions, physical space and elements on the base of the existing capacity of users. It proposes to revise functionality to its core. To reach this principle, the research begins with identification of historical and nowadays lifestyle in river landscape.

The Lielupe river landscape is a stage and an asset for different activities. The landscape archives are a visual reflection of historical use of river landscape. Through the time the river landscape fulfils the different functions for individuals and social groups (Table 1). The identified uses of landscape define potential landscape elements which help to realise the needs. The result of brainstorming was set in the Table 1 grouping of items representing functionality, activity and landscape elements involved in activities. Functions, landscape elements and activities in river landscape are interrelating elements. Behind the each type of usage of the river landscape there are interest groups and to be in compliance with principles of democracy no weights are used at this stage of research. At this stage there is observed seventeen groups of functions in the landscape of the Lielupe river valley, characterized by wide range of actions, described by landscape elements and organised in social groups.

Table 1

Use of river landscape and landscape elements in the Lielupe river valley

No	Function of river landscape	Action in river landscape	Sample landscape element to organize the action	Social or interest groups
1.	Source of water	Garden watering, animal watering, bathing, irrigation	Pump, beach	Gardener, dweller, animal owner
2.	Source of food and food production	Fishing, fish farming, agriculture, land fertiliser (by flood), land amelioration	Pier, path, board, plank, pasturage, dike, polder, drainage, ditch, pipe	Fisherman, farmer, gardener
3.	Transportation	Floating of production (logs, bricks), barge, carrying by inland waterway, flying, air ballooning	Dock, pontoon, barge, boat, magazine, granary, passengers' train station, public house, landmark, air balloon, air plane	Carrier, passenger, traveller
4.	Navigation	Shipping, canalization	Channel, canal, waterway, dike, barge, boat	Carrier, passenger, traveller
5.	Mining industry	Gravel, sand, clay, dolomite or peat extraction	Pit, lake	Producer
6.	Dwelling	Greening	House, manor, farmland, city, village	Family, local municipality
7.	Social contact	Promenading, socialising, picnicking	Market, promenade, riverwalk, embankment	Dweller
8.	Aesthetic and sensual	Contemplation, meditation, touching water, fresh air breathing, sightseeing	View, invisible	Human
9.	Cognition and research	Nature observation, conservation, education, fish feeding, flower, herbal tea picking, bird watching, bird of passage	Wild fauna and flora, pathway, hide or observation tower, meadow	Tourist, visitor, researcher, children, pupil
10.	Recreation and rehabilitation	Swimming, sunbathing, cruise, boating, walking, yachting, water walking, water playing, scuba diving, travelling, celebration	Green strand, beach, cruise ship, boat, boardwalk, riverwalk, steps, ramps, traditions, salute	Human
11.	Production	Producing	Market, production site	Producer, employee
12.	Source of danger	Safeguarding, flooding, drowning	Dam, polder	Dweller, visitor
13.	Source of power	Windpower, hydropower	Windmills, watermills, hydroelectric stations	Producer
14.	Defence	Fortification	Water barrier	Owner
15.	Dispose of waste	Disposing of wastewater, rainwater	Drain, agricultural land	Dweller, producer, municipality
16.	Bordering	Defining border, visiting the neighbourhood	Landmark, invisible	Municipality, neighbour
17.	Brakeage of territory	Crossing, linkage, intertwining, transition	Bridge, boat, ferry	Neighbour, visitor

The data of individuals' use of river landscape and landscape elements (Table 1) collected are assessed by grading of its influence on landscape and its participants (Table 2). There are sixteen marginal grades detected. The grades are organised assessing characters in high and low influence.

Table 2

Grade of influence of use of the Lielupe river landscape characters

Grade	
High	Low
dynamic	calm
intervening	insensible
eternal, long-term	temporary
group	individual
age specific	all age
gender specific	gender neutral
mercantile	mental, unworldly
conflicting	complementary
interrelating	independent
seasonal	year round
dependent on day, week rhythms	timeless
site specific	infinite
mentality specific	mentality neutral
cultural specific	cultural neutral
danger	safe
inaccessible	approachable

The wide range of functions and activities, also of landscape elements and social and interest groups, shows a potential for development of the Lielupe river landscape with an individual's participation in it. The grades could be used as a base for development of the landscape design and planning principles. Also the data could be used to develop targets for development of a sustainable river landscape policy. Based on interrelation and grade of influence of each type of usage of the river landscape, the further investigation is to develop ergonomic and functional planning principles for the each type of interest group to compromise the individuals' needs.

The question rises how different groups value their river landscape to satisfy the groups' specific needs. If there are no solutions and offers, the humans are not in landscape (does not use it, and landscape becomes an unused asset or is used in improper way). Historically, the landscape of the river Lielupe is a cultural landscape, and if there is no human, the territory loses its cultural landscape's value.

By the investigation of functions and use of the river landscape (Table 1) it is complicated to define fixed social groups and find a complete range of them. The social groups are dynamic, and changes in use of river landscape are affected by economical, technological, ecological and seasonal factors, by changes in timescale, and by social fashion.

Conclusions

1. With the world's economical, technological and social development, a focus on meeting human needs is vital. Several political documents emphasize the need for use of democracy principles and human-centred design thinking. The proposed approach is to solve individuals' role of river landscape. It could be used as a starting point for design of lifestyle versus design for territory. The approach proposes to revise the existing assets – traditions, physical space and landscape elements on the base of the capacity of landscape. It proposes to revise functionality to its core. To reach this principle it is important to begin with the identification of historical and nowadays lifestyle in river landscape. The themes that emerge from this analysis provide important mandates for city planning, landscape design, and environmental decision making.
2. Through research of factors, the potential solutions to increase comfortable and safe humans contact with nature will be developed. The grades can help for development of the landscape design and planning principles with individuals' participation. The data could be used to develop targets for development of a sustainable river landscape policy.

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DEVELOPMENT OF PUBLIC ART IN THE URBAN SPACE: EXPRESSIONS AND POTENTIAL

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Abstract. The research deals with public art, and its related discourses. The particular focus of the paper is on investigating how public art can be a resistant or controversial part of the urban space. The first part of the paper describes the historic development of public art through time. Subsequently, the discussion goes on to the main aspects which dominate art in the public, urban space. We focus on the site-specificity realm, sculpture and installation, the role of public art in urban regeneration as well as influences in society. Today, it is argued that public art shifts its focus from object to process, from artist to audience, and that the artwork becomes part of city development policies, approaches to people's everyday life. Currently the quest of contemporary public art becomes one of the main subjects to explore and find definitions for. The methodology used in this paper is descriptive, based in a historical point of view. The aim of this research is to find out the main development lines of public art, trying to answer questions such as: how is public art expressed in the urban space realm? What is its potential?
Key words: public art, urban space, urban regeneration, site-specific, cross disciplines.

Introduction

The research presented in this work, focuses on ongoing processes in contemporary public art discourse, its relations and influences. The aim is to explore how public art intersects with multiple disciplines, how it expands its boundaries through time, and how it works as a contributor or an antidote to public engagement in urban space.

The paper is divided into five sections with related sub-sections that point out the explored themes. The paper tries examining the main problematic features in public art discourse and entity in urban space. First, it tries to find the beginning of public art discourse; second, it discusses site-specificity within public art development that made changes to the understanding of the environmental context of the artwork. Next is debated the formation of new art forms that bring essential changes in public art and explores the connections between art and the public. Discussion goes further through attempting to understand the role of sculpture and installation in urban regeneration processes. Finally, it concludes with an open discussion on contemporary public art that governs multiple disciplines, where perceived complexity of public art is in the twenty-first century.

Public art is seen as an interrelation between art and its public, where these both concepts are diverse. This causes several questions when we speak about public art: What art is public? What makes this art public? What is its public? What makes the space public? What is the relationship between 'public' and 'art'?

As Cameron Cartiere (2008) outlines, public art is a complex, multifaceted discipline, and its definition is still not clearly defined in any art history text. In many formulations public art means works of art that are located in public places and that are therefore easily viewed and available. Public art is not simply art placed outside; it's rather the desire to engage with its audience and created space (Sharp et al., 2005). Public art has, as well, to deal with interrelationships between art, architecture, and urban design (Cartiere, 2008).

Looking for the beginning of public art

Going through the historical context there are considerable changes in understanding and expressing public art. Cameron Cartiere (2008) points out how some historians mark the beginning of public art already at the cave paintings in Lascaux. She explains however how other scholars argue that this beginning was located in the United States of America in 1935, in the context of the Great Depression, when the Works Progress Administration was created. The Federal Art Project was one of the divisions of the Works Progress Administration created under Federal Project One. But some historians mark that public art was recognized within Art in Public Places program of the National Endowment for the Arts in 1967.

Arlene Raven (Raven, 1989; Krese, 2007) points out the importance of monuments casted in bronze, as the best known public art form in the nineteenth century. She also marks how these were later replaced by the gigantic abstract sculptures, which filled city public spaces in the 1960s.

In the mid to late 1960s, minimalism established a new art phenomenon, in which artists were working in three dimensions rather than in two. One of the ways to public art was to promote a site-specific approach which emerged in this time. There is no doubt about the inovation brought by the minimalist site-specific art way of working (Lucie-Smith, 2000; Vaz-Pinheiro, 2005). In the United States, these projects roughly coincided with the inception of the Art-in-Architecture Program of the General Services Administration in 1963, the Art-in-Public-Places Program of the National Endowment for the Arts in 1967, and numerous local and state Percent for Art programs throughout the 1960s (Kwon, 2002). Miwon Kwon (2002) marks out how three paradigms emerged within the modern public art movement in the United States:

- the art-in-public-places model, as Alexander Calder's 'La Grande Vitesse' in Grand Rapids, Michigan (1967), carried out with the Art-in-Public-Places Program of the National Endowment for the Arts;
- the art-as-public-spaces approach, for example, design-oriented urban sculptures of Scott Burton, Siah Armajani, Mary Miss, Nancy Holt, and others, which function as street furniture, architectural constructions, or landscaped environments; and
- the art-in-the-public-interest model, how it is identified by critic Arlene Raven (1989) and artist Suzanne Lacy under the heading of 'new genre public art'. Artists seek to integrate more social issues and political activism, engaging 'community' collaborations.

In the mid-1960s to mid-1970s, the term 'public art' denoted modernist abstract sculptures that emerged outside of the museums, galleries, collections and were either sitting outdoors or in open locations, with unrestricted physical access in the urban environment. Generally they were enlarged models of works found in the museum and galleries, which have been integrated in the city environment and had a decorative function. This is the art-in-public-places model. Previously adduced examples, in the city environment, mainly had an aesthetic task. In the United States and Europe, authors of this kind of public art are often well known artists such as Pablo Picasso, Henry Moore, Isamu Noguchi, Alexander Calder (Kwon, 2002; Krese, 2007).

By the end of the 1960s, began the growth of environmental art (earth art) as well. Artists like Robert Smithson, Walter de Maria, Michael Heizer and Richard Long started to create works in remote landscape sites (Lucie-Smith, 2000; Senie, 2002).

Materials and Methods

The following research is based largely on published accounts of public projects and concepts that examine several aspects of public art, such as the model of site-specificity, the formation of new genre and community-based public art and the contribution to the regeneration of urban spaces/communities.

The methodology we use for discussing the development of public art takes into account the historical perspective within an empirical and qualitative approach. This will be discussed through following determined questions: What is understood as 'public art' in urban spaces and with what it relates? What are its peculiarities today? Why art matters in urban space? What is the economic impact of public artworks? Is this the only impact? What does public art embrace? Where is the focus going?

This paper concentrates on the main aspects of public art discourse and what has influenced its interdependent development in the twentieth and twenty-first centuries. Other aspect that we investigate and emphasize in this research is related to interdisciplinary practice.

Results and Discussion

In this paper we focus directly on the creation of artworks for an urban environment. What do we mean when we speak about public art in the urban space? What is the potential of public art's forms today?

The importance of site-specificity

The developments of art in the public space come to bring forth the problem of site-specificity. In the twentieth century artists started to refer their artworks as site-specific, mainly implying something grounded (Morris and Cant, 2006). Site-specific works reversed the modernist paradigm as these works first emerged in the wake of minimalism in the late 1960s and early 1970s (Kwon, 2002). Environmental context (the natural landscape or ordinary spaces of the everyday) become important.

The dominant definition of site-specificity is 'one of unified and useful urban design, imagined as a model for social harmony and unity' (Kwon, 2002). Richard Serra's came against this definition, with his 'Tilted Arc' — a massive sculpture which was located in the Federal Plaza in New York. 'Tilted Arc' has been the focus of much controversy and it caused big discussions between the artist, government officials, and people (mainly workers in the adjacent federal building), as it was considered to be threatening. The sculpture was removed from the Federal Plaza in 1989. According to what Serra said: 'to remove the work is to destroy the work' (Kwon, 2002). The removal of 'Tilted Arc' revealed the political specificity of the site. The Minimalist approach (like 'Tilted Arc') has become the centre of the famous polemics by art critic Michael Fried. E. Crow (2004) writes what M. Fried criticized large scale minimalist art and 'in the journal 'Artforum', he declared that these large, simple shapes were not properly art at all, but belonged to the realm of theater'. M. Fried characterized minimalist sculptures as theatricality (Fried, 1998), which, by definition, is not art. For M. Fried, art is removed from real time, inhabiting an ideal space and frozen time that radically distinguish it from 'everyday life'. 'Tilted Arc' is an example of a work that is not anymore a modernist passive object on a pedestal, but the space of art now should entail real form in real space and in real time. The work rather invited to consider the economic and political forces that construct the instrumental cityscape in which people live, work, and form their conception of reality (Cooper, 2009).

Today, the Federal Plaza is transformed by landscape architect's Martha Schwartz designed project. It is an abstract composition – the maze of green benches circling the green mounds of grass that are traditional design elements of urban parks, a decorative mix of street furniture and natural materials (Kwon, 2002; Senie, 2002). Her redesigned project is recalled by M. Kwon (2002) and many people as 'full of dynamic colours and user-friendly forms'. Although it is occupying more space, pedestrians cannot cross the plaza directly and it cannot be used for concerts, so far there has been no protest (Senie, 2002). This

outlook of Federal Plaza project has erased all physical and historical traces of 'Tilted Arc'.

Going forward site-specific art changed the relationship between the art works, the place and the audience. As N. J. Morris and S. G. Cant (2006) described, the artwork was no longer autonomous, it 'gave itself up to its environmental context' and acknowledged the multiple relationships that might exist between artwork, artist, site, exhibition and context. The related formulations of site-specificity that have appeared in recent years are 'community-specific', 'context-specific', 'issue-specific', 'audience-specific', and 'new-genre public art' (Morris and Cant, 2006).

Formation of a social context

The explosion of the new art forms in the public space during the 1980s brought sweeping changes in contemporary art history (Raven, 1989; Sharp et al., 2005). Public art started to establish the relationship between art and society, what Suzanne Lacy (1995) called 'new genre of public art' and community-based public art. She writes that the discursive emergence of new genre public art coincides with the removal of 'Tilted Arc' in 1989. This tendency corresponds also to what critic Arlene Raven named 'art in the public interest'. According to Raven, art in the public interest incorporates intersections with social issues (Raven, 1989; Kwon, 2002).

The engagement of the public becomes a key concept in new genre public art. According to S. Lacy, public art shifts the focus from artist to audience, from object to process, from production to reception, and emphasizes the importance of a direct, apparently unmediated engagement with particular audience groups. Within new genre public art, artists choose to work with 'real' places and 'real' people, within 'every day' issues (Lacy, 1995). In this way, artists seek to engage with non-art issues of 'the average man on the street' by involving him/her in the making of the art work, either as subjects or as producers themselves (Kwon, 2002). S. Lacy (1995) in her book 'Mapping the Terrain: New Genre Public Art' stated what Mary Jane Jacob explored other questions: what if the audience for art were considered as the goal at the centre of art production? And what if the location of art was determined to reach and engage that audience most effectively?

The program 'Culture in Action', which took place in Chicago in 1993, was aimed at giving a community a voice and overcoming preconceptions. The project was sponsored by the non-profit public art organization Sculpture Chicago and directed by curator Mary Jane Jacob (Sharp et al., 2005; Kwon, 2002). The project was related to enlarge artists' role to have a part in social transformation and to change the role of the audience from spectator to participant. 'Culture in Action' included seven projects located throughout the city at various neighbourhood locations, where most of them were event-oriented.

According to M. J. Jacob, the modern public art movement introduced an exceptional rethinking of public art practices. She wrote: 'as public art shifted from large-scale objects, to physically or conceptually site-specific projects, to audience-specific concerns (work made in response to those who occupy a given site), it moved from an aesthetic function, to a design function, to a social function. Rather than serving to promote the economic development of American cities, as did public art beginning in the late 1960s, it is now being viewed as a means of stabilizing community development throughout urban centers. In the 1990s, the role of public art has shifted from that of renewing the physical environment to that of improving society, from promoting aesthetic quality to contributing to the quality of life, from enriching lives to saving lives' (Jacob, 1995; Kwon, 2002).

Public art's ability to transform urban public space becomes an issue regarding the public, instead of simply a matter of design, architecture or sculpture. This direction of public art is a process of required reconciliation and dialogue between aesthetic judgement of a designed object and community need. According to M. J. Jacob the move away from site-specificity is a logical step towards a meaningful relationship between artists and audience. The artworks are not anymore addressed to a physical site, but are engaging the concerns of 'those who occupy a given site'. The sites of community need are linked with the place of living. This is a new formulation of community-based public art, where the dialogue that matters is between an artist and a community or audience group (Kwon, 2002). However, the model of site-specificity also slides to issue-specific oriented public art, where the concept of site has moved away from physical location. The accent of it is on process, participation, inclusiveness, and auto organization.

This tendency today we can see also in the Latvian public space realm. An example could be seen in the exhibition 'Ventspils. Transit. Terminal' that was organized by the Soros Centre for Contemporary Arts - Riga (now The Latvian Centre for Contemporary Art) during 1998 - 1999 in the Ventspils city environment (Krese, 2007). The concept of the exhibition had the will to provoke a new type of public art that would not only be based on the adaptation of space and materials. Curator Kristap Gelzis sought to integrate the artworks of Latvian and international artists, into the city environment and everyday life inconspicuously. Artworks were made to interact with spectators directly or indirectly, the installations worked as one of components and the spectators reactions became a complement to the works. S. Krese (2007) explores that artworks presented in this exhibition should be characterised from the relational aesthetics theory point of view. Relational aesthetics art concentrates on the creation of a situation. French art critic Nicolas Bourriaud (2009) described relational aesthetics art and defined it as 'relational art'. In relational art practice, artist's role has shifted from producer of an object to service provider. Relational art is based on people's interface and its social context. Although, works that are based on relational aesthetics theory can

be described as installations, artists are inclined less into object making and more into creating situations (Krese, 2007; Bourriaud, 2009).

A related form to community-based art is participation art, and this form can be illustrated with the project 'republic' which took place in Riga, Latvia in 2003. This project was organized by the Latvian Centre for Contemporary Art. The idea was to incorporate the inhabitants of suburbia and neighbourhoods in Riga. The projects tried to make art interact with people's everyday life. In Latvia, this project was a step forward towards the involvement of the public. The project was directed to the public and situation, in both a socioeconomic and a cultural politics area in Latvia, as well as in the relationship between centre and periphery. In several events, the public were the producers themselves, and in others audience became actors in situations staged by the artists (Krese, 2007).

Public art in urban regeneration realm

Recently, public art is linked with urban politics and policies, not just with civic service and pride (Norman and Norman, 2000). Public art now mainly contributes to the meaning of the term 'urban regeneration' (Hall and Robertson, 2001; Hall and Smith, 2005). It becomes linked with the recovery of cities, aesthetically enriched urban environments, as well as promoting people's quality of life. In many contemporary Western countries, public art has an increasingly prominent role in urban design. The meaning of art as a route to urban regeneration can be exemplified by policy in the UK, where it first appeared with the 1988's Action for Cities programme (Hall and Robertson, 2001). The contemporary public art history in the UK is linked with the Percent-for-Art policies. Moreover, the Percent-for-Art initiative already exists in several states in the United States, Australia (Stein, 2010) as well as in a number of European countries such as France, Germany, Italy, and the Netherlands (Lydiate et al., 1992). In this policy, a part (often 1%) of the cost of new building projects is dedicated to art. The contribution of public art regarding the Policy Studies Institute's, described by T. Hall and I. Robertson (2001) can be summarize as: contributing to local distinctiveness, attracting companies and investment, having a role in cultural tourism, adding to land values, creating employment, increasing the use of open spaces, reducing wear and tear on buildings, and lowering levels of vandalism. T. Hall and I. Robertson continue to underline that for its advocates, public art can play in culture-led urban regeneration, in the economic realm, but also in terms of culture and community. T. Hall and I. Robertson (2001) identified seven claims of public art that contribute to the regeneration of urban communities: developing a sense of community, developing a sense of place, developing civic identity, addressing community needs, tackling social exclusion, having educational value, and promoting social change.

But what about the role of public art in urban regeneration? According to J. Sharp et al. (2005) it has contributed not only to urban economic growth, but also to that of social inclusion. It can be explained by two interrelated factors: the contribution of public art is often deliberately symbolic which brings methodological problems in evaluating the impact of public art. The outcomes of social inclusion generally are more appealing in material terms. That comes out of urban policies and is mainly aimed at reducing material inequalities. As society/audience sees more public art in symbolic terms, this increases the conflict regarding its use, which respectively increases the difficulties in measuring its benefits (Sharp et al., 2005). One of the examples to contradict this is what B. Plaza (2000) identified as the 'Guggenheim effect', that represents the approach to the Guggenheim Museum in the Bilbao, in the north of Spain. The Museum iconic architecture caused an up-growth of urban tourism and the overall regeneration of the city. However, generally public art intervenes in smaller scale and its economic contribution is indirect.

Approximately 40 per cent of local authorities in the UK had adopted a public art policy of some sorts in 1993 (Miles, 1997; Sharp et al., 2005). Like J. Sharp et al. (2005) say, in the UK, Newcastle, Glasgow, Birmingham and Gateshead are examples of the incorporation of public art in their city regeneration schemes. An icon of public art's power is Anthony Gormley's work the 'Angel of the North' at Gateshead, in the north of England. It helped to change Gateshead from 'post-industrial' to 'cultural' city. E. H. Norman and J. M. Norman (2000) wrote that the 'Angel of the North' 'was welcomed when it was installed, although it had been the object of much criticism before. Perhaps if their city fathers had been bolder, Gormley's enormous standing steel man would have been welcomed in Leeds or Sheffield, both of whom rejected it.' This shows that public opinion can affect change and this links to C. Cartiere's (2008) point of view that the artwork needs a time to adapt to the site, to settle into the landscape and to survive the often reactionary emotional response. In Gateshead, as J. Sharp et al. (2005) remarked, 'many of the artworks are concentrated in areas of social deprivation and this highlights how public art has been used as a tool to reaestheticise areas within a city as well as the city at large. Implicit in this is the notion that public art can bring economic and social benefits alongside the aesthetic.' Malcolm Miles (1997) states that 'since this advocacy [art as part of the regeneration process] has been unquestioning of the intentions of development and its impact on communities, art has perhaps been complicit in the abjection that increasingly follows development and the extension of privatisation and surveillance.'

Critics started to view public art as a commercial practice (as it is linked with policies) or develop a variety of terms such as interventions, political activism, service art, site-specific work, community-produced projects, spatial practice, interdisciplinary activism, contextual activism, social practice art. It seems that the term 'public art' was simplified for use

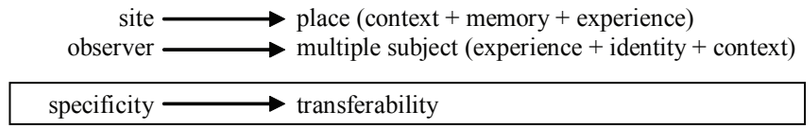

Figure 1. From the concept of specificity to the idea of transferability by G. Vaz-Pinheiro (2005).

by administrators and officials. Public art can now be found in multiple ways as permanent work, temporary work, political activism, service art, performance, earthworks, community projects, street furniture, monuments, and memorials (Cartiere, 2008).

The roots of historical development change from outcome to process and from object to event. It is seen a strong accent on process based public art. According to G. Vaz-Pinheiro (2005), process identifies the artwork more than outcome. Outcomes can also create, what she called, 'temporary closures of meaning', in which 'they instigate moments in which the audience comes into contact with them but are then carried through to another stage/space' (Vaz-Pinheiro, 2005).

The role of sculpture and installation

A significant issue is that, in order to see the development process of public art, we need to take into consideration the evolution of sculpture and installation. Sculpture and art outside the gallery 'continues to focus on urban and often monumental artworks, their socio-spatial and historical functionality and their position within shifting systems of exchange and power, the problematic nature of 'public art' and its role in urban regeneration', explored by N. J. Morris and S. G. Cant (2006). E. Rankin (1996) explains that outdoor sculpture is traditionally linked with the promotion of civic, political or religious agendas and represents a dominant ideology.

There are debates to define diversified genres of what has been termed 'sculpture'. From minimal sculptures and happenings in the 1960s, we can trace the roots of installation, earthworks, and interventions. There are still expanded borders to define the term 'installation' that generally is understood as three dimensional sculptures that either created an environment (mostly in the galleries), or large-scale works that interacted with the environment (Christo and Jeanne-Claude's work is an example) (Cartiere, 2008). This has been leading to a hybrid discipline, linking varied historically shaped branches, including architecture and performance art. Contemporary installation can incorporate video, performance, and viewer participation as an exhibition strategy. As installation and environment works have increased in their complexity in the 1990s, the importance and use of the term 'site-specificity' continue to grow.

Obviously, some artists still develop their pieces in traditional spaces such as galleries and museums, but others tend to look outside the traditional spaces and work with messages within a political and social context and/or are connected to specific locations or settings (Cartiere, 2008).

The postmodern sculpture shift during the 1960s and 1970s is clearly characterised by Rosalynd Krauss' model. She adopted the term 'expanded field' from Robert Morris as 'an extended physical and mental terrain for understanding 'sculpture'' (Rendell, 2006). R. Krauss argues that, historically, modern sculptures had lost their relation to site (where it was defined as not-architecture and not-landscape). With the term 'expanded field' artworks are understood as having moved beyond the historically known definitions of modern sculpture. She marks three sculptural conventions: 'site construction' (exemplified by C. Cartiere (2008) as large scale constructions which were landscape and architecture), 'marked sites' (earthworks or temporary works which were landscape and not-landscape), and 'axiomatic structures' (interventions into architectural space which were architecture and not-architecture). Boundaries of 'expanded field' had developed and extended during the 1980s and 1990s. Artists continued to move into the public realm, earthworks were moving out of originally remote locations into cities and public parks. Installation and public art had moved even beyond the expanded field (Rendell, 2006; Cartiere, 2008).

C. Cartiere (2008) develops the notion of the 'further-expanded field' which does not incorporate the discussion on place-specificity. This model was presented by G. Vaz-Pinheiro (2005) where she talked about the word 'site' as specific itself and where she draws the concept of specificity into the idea of transferability. Her idea is represented in Figure 1.

Contemporary public art forms

Further contemporary public art tends to move beyond its boundaries and cross into multiple disciplines through the time. According to C. Cartiere (2008), public art incorporates fine arts, and other disciplines, such as design and crafts that branch out into other academic arenas. Public art exists in city planning, architecture, landscape architecture, cultural studies, political science, urban design, urban studies, social science, public policy, environmental studies, history, feminist studies, geography, ethnography, and anthropology. Public art can be implemented in urban centres, suburbia, as well as rural regions.

In order to draw the genealogy of public art, we have to put into context that in the last decades there have been radical changes within the history of public art (Figure 2). Public art as it was known in the 1960s was traditionally understood as sculptures placed in the outdoors. Through time, public art was replaced with new public art forms that integrate a wide range of disciplines and made public art branch out into new terms and models; this radical explosion took place in the 1980s.

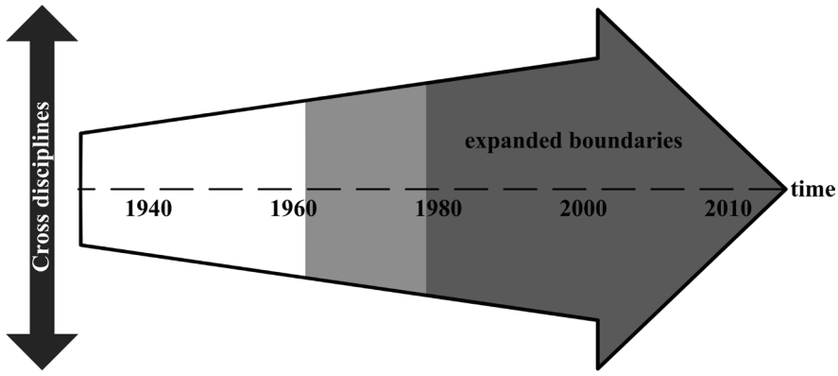

Figure 2. Changes of public art through time during twenty and twenty-first centuries.

Contemporary public art at the beginning of the twenty-first century is a complex discipline. Since there are multiple recognized directions within public art practice, Cameron Cartiere and Shelly Willis suggested the following definition that ‘’public art’ is art outside of museums and galleries and must fit within at least one of the following categories: first, be in a place accessible or visible to the public: ‘in public’; second, be concerned with or affecting the community or individuals: ‘public interest’; third, be maintained for or used by the community or individuals: ‘public place’; and forth, be paid for by the public: ‘publicly founded’’ (Cartiere, 2008). As we find the vast spectrum of current discourse, this definition could help to clarify the terminology.

Conclusions

1. Public art can make a contribution for enabling change in a wide range of urban, environmental, aesthetic, economic, social and psychological fields. The term ‘public art’ includes complex issues between artwork, site, where it is located, and audience. Generally we speak about public art being posted in the public space that is free to access. Today we see that large scale objects have shifted to process oriented public art practices that deal with social issues. Public art with its complexity became a wide subject of discussion in the twenty-first century.
2. This paper tries to show that, from a historical point of view, public art comprises a wide range of issues, through several public art expressions such as sculpture, installation, site-specific art, linking to community/ audience, meaning of place, political and social issues.
3. Today, artists tend to move away from a traditional approach and are trying to expand the boundaries to more socially based works. Taking this in consideration, the artworks based on the concept of site-specificity brings further to new genre and community based public art. Community-based art project ‘Culture in Action’ aimed to bring art to urban communities and enlarge artists’ role as a part in social transformation. The exhibition ‘Ventspils. Transit. Terminal’ and the project ‘republic’ in Latvia show the importance of social practice in trying to make art interact with people’s everyday life.
4. This research has attempted to provide an insight into how contemporary public art today is characterized as a social practice and how it contributes to economic growth besides aesthetically enhancing environments. Urban regeneration has become one of the main subjects in public art. Contemporary public art has grown with the Percent-for-Art policies that allow to bring art closer to people’s everyday life and, for example, this policy helped to change Gateshead from ‘post-industrial’ to ‘cultural’ city in the UK. The so called ‘Guggenheim effect’ clearly demonstrates the economic impact and growth of urban tourism in Bilbao. However, public art can also bring controversy, Richard Serra’s ‘Tilted Arc’ can characterise political power over art.
5. Contemporary public art has become a platform for interdisciplinary collaboration, it has increased and changed the role of the spectator, it has become social practice based art, it becomes an object that attracts people and emerges in people’s everyday life.
6. Analyzing this theme opens more questions than it closes. It is a complex issue that requires further debates, taking into consideration the empirical questions on landscape, culture, politics, socio-economy and perception in public art analysis within urban space.
7. The research of public art in urban space, through understanding the contributions and controversy can be used a basis to analyze contemporary public art in cities in Latvia. Regarding this, there is the need to characterize the current situation in Latvian cities exemplifying aesthetical, economic and social practice. Which brings forward the questions: How is the potential of public art used in Latvian urban spaces? Do local authorities try to adopt some sort of a model of public art policy in Latvia? And what is the result? All these are questions that we hope to address in further developments of this work.

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MODELING OF UNIDIRECTIONAL SHORT-FIBER REINFORCED CONCRETE

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Abstract. The interaction between short fibers and concrete in the post-cracking phase influences crack spacing and width in the composite. In order to perform analysis of deformation of a composite and the fiber displacement at the crack, single fiber was examined. A two-fiber model considering the distribution of fiber length and incomplete bonding was developed. Numerical analysis reveals that two-fiber model analysis is believed to be more accurate than that obtained from the single-fiber analysis. Comparing the solution of the single-fiber and two-fiber system shows that the latter gives a greater fiber displacement at the crack. The study was performed in the Department of Structural Engineering, year 2009/2010.
Key words: stress distribution, incomplete bonding, equilibrium, strain difference.

Introduction

In short-fiber reinforced concrete, the fibers are effective in the post-cracking case. The cracking mode of the composite under tensile forces depends on whether the fibers at the crack can transfer the total load needed for crack formation. In the case of short fibers, the multiple cracking can be achieved if the fiber volume content is sufficiently high. In a multiple cracking stage, the concrete is divided into segments of similar length. The force transferring mechanism from the fiber to the concrete and from the concrete to the other fiber has a considerable influence on crack spacing and width.

In general case, fiber may cover two or more cracks if the crack spacing is sufficiently low. Because the matrix stress is zero at the crack, the shear stress between the fiber and concrete is not uniformly distributed across the crack. Therefore the boundary conditions must be stated for the segment between the cracks. With short fibers the fiber's shorter embedded length at the crack may be too small to transfer the load equal to that at the adjacent crack. Thus, the fiber forces at the two cracks are not in balance. It is assumed that at the adjacent crack there is another fiber located symmetrically with respect to the fiber being analysed. The forces in the two-fiber system at the cracks satisfy the equilibrium condition.

In this study by using experimental bond stress-slip relationships (Tepfers, 1973), the stress state in straight short-fiber reinforcement is examined. The reinforcing fibers are interconnected with concrete not through their entire side surfaces. The incomplete bonding can be formed as a result of corrosion of components of the composite or micro voids formed in casting process, etc. In the calculation model it is assumed that the composite consists of two unidirectionally oriented fibers.

The aims of the study are to analyze stress state and deformations of orientated short-fibre reinforced concrete using the proposed single-fibre model, consider incomplete bonding between fibre and concrete, due to various imperfections, develop a model that takes into account stress distribution to an adjacent fibre, and to compare the solutions of single-fibre and two-fibre models.

Materials and Methods

The study was performed in the Department of Structural Engineering, Latvia University of Agriculture, year 2009/2010, supported by ESF, contract No. 2009/0180/1DP/1.1.2.1.2/09/IPIA/VIAA/017.

Single fiber model

In the model it is assumed that the calculation element consists of a fiber with length l_f, crack spacing or embedded length $l_{crc} = l_f/2$, and cross-sectional area A_f included in a concrete (matrix). Here and below, the index *f* refers to fiber, and index *m* – to matrix. It is assumed that in the fiber at the crack act forces P_1 and P_2 (Fig. 1). As the basis of the calculation model of the material, the model given by Cox (Cox, 1952) is used. According to this model, the following linear inhomogeneous differential equation can be written for the action of a tensile force *F* on a particular fiber:

$$\frac{d^2F(x)}{dx^2} = C\left[\frac{F(x)}{E_f A_f} - \varepsilon_m\right], \qquad (1)$$

where *x* is the coordinate in the direction of the fiber; E_f and ε_m are the modulus of elasticity of the fiber and deformation of the matrix, respectively. The constant *C* is determined approximately by using matrix shear modulus G_m and fiber diameter d_f:

$$C = \frac{\pi d_f G_m}{R}, \qquad (2)$$

where 2*R* is medium distance between axes of adjacent fibers.

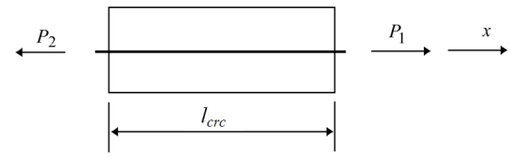

Figure 1. Single-fiber model.

The solution of equation (1) can be written in the form:

$$F(x) = C_1 e^{Bx} + C_2 e^{-Bx} + E_f A_f \varepsilon_m , \quad (3)$$

where $B = \sqrt{\dfrac{C}{E_f A_f}}$.

Assuming that $P_2 = 0$, the unknown constants C_i can be determined from the following boundary conditions:

$$F(0) = 0; \quad F(l_f / 2) = F .$$

In the case of ideal bond between fiber and matrix, the stress distribution through the length of a fiber, when (3) is taken into account, is:

$$\sigma_f(x) = E_f \varepsilon_m \left[1 + \frac{e^{B(x-l_f/2)} - e^{-B(x-l_f/2)}}{e^{Bl_f/2} - e^{-Bl_f/2}} \right] =$$

$$= E_f \varepsilon_m \left[1 + \frac{\mathrm{sh}B(x - l_f/2)}{\mathrm{sh}Bl_f/2} \right] . \quad (4)$$

The length-averaged stress in the fiber is found by integrating (4):

$$< \sigma_f >= \int_0^{l_f/2} \frac{\sigma_f(x)}{l_f} dx = E_f \varepsilon_m \left(1 - \frac{\mathrm{th}Bl_f/4}{Bl_f/2} \right) . \quad (5)$$

By using the rule of mixtures, the modulus of elasticity of a unidirectional reinforced element (composite) in direction *x* can be written as

$$E_x^c = \hat{E}_f \qquad V_f + E_m(1 - V_f) , \quad (6)$$

where V_f and E_m are the volume content of reinforcement and the modulus of elasticity of the matrix, respectively. The effective value of modulus $\hat{E}_f$ can be found by using the deformation in the middle of the fiber, and it takes into account the finite length of fiber (or embedded length):

$$\hat{E}_f \asymp \ < \sigma_f > / \varepsilon_m . \quad (7)$$

The results of studies of the bond properties are presented by F. H. Rabinovich (Рабинович, 2004). On the basis of the mentioned experimental relationships for variation of shear (bond) modulus versus deformation is fixed.

The model developed has been used to study the effect of the finite element length on the modulus of elasticity in fiber direction of themonotropic element. Note that the effect is negligible when $l_f / d_f > 100$, but in the case of a small length ($l_f / d_f < 20$) the difference in magnitudes of the modulus of the monotropic element with continuous fiber and fiber of finite length is significant (Clyne, 2000).

In order to perform analysis of deformation of a composite at the crack, the stress-strain relationship in the case of a single fiber is examined. The shear stress between the fiber and the matrix is expressed as

$$\tau(x) = \frac{1}{\pi d_f} \frac{dF(x)}{dx} \quad (8)$$

and the local strain difference between the fiber and the matrix can be written as:

$$\varepsilon_m(x) - \varepsilon_f(x) = \frac{r}{\pi d_f G_m} \frac{d^2 F(x)}{dx^2} . \quad (9)$$

The fiber displacement at the crack can be derived using (8) in the following way:

$$\Delta = \frac{r}{\pi d_f G_m} \frac{dF(x)}{dx}\Big|_{x=l} = \frac{r P_1 B}{\pi d_f G_m} \left(C_1 e^{Bl} - C_2 e^{-Bl} \right) . \quad (10)$$

Incomplete bond model

The reinforcing fibers are interconnected not through their entire side surfaces. The incomplete bonding is formed as a result of corrosion of composite components or under other conditions (Cabrera, 1996; Schiessl and Reuter, 1992).

Examining the stress distribution mode through the length of a fiber in the case of partial bond, the fiber is arbitrarily divided into sections in which an ideal bond exists between fibers and the ones without bonding. Thus, the regions with ideal contact are concentrated in annular volumes covering the reinforcing fiber (Fig. 2). Curve 1 in Fig. 2 shows the variation of stress in the case of ideal bond σ_f ; curve 2, obtained as a result of geometric construction, shows the variation of the stress $\tilde{\sigma}_f$, i.e., the stress that arises in the case of alternating regions with and without ideal bond. In Fig. 3 the ratio $\tilde{\sigma}_{f\max} / \sigma_{f\max}$ as a function of crack length l_{crc} is shown.

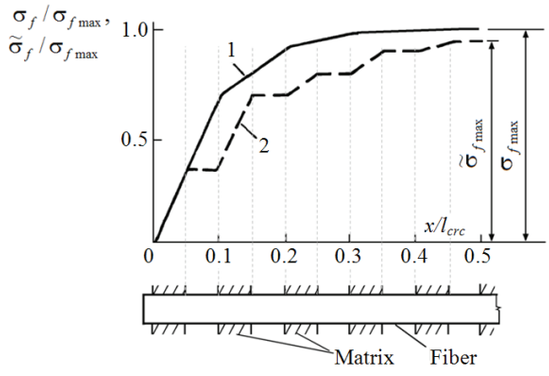

Figure 2. Stress distribution in fiber (l_f = 30 mm) with ideal (1) and incomplete (2) bonding, and the diagram of arbitrary distributed matrix sections with complete bonding.

On the basis of equation (4), the variation of stress $\tilde{\sigma}_f$ along the particle can be expressed as

$$\tilde{\sigma}_f(x) = E_f \varepsilon_m \left[\frac{\tilde{\sigma}_f}{\sigma_f}(l_f) + \frac{\mathrm{sh}B\,(x - l_f/2)}{\mathrm{sh}(B l_f/2)} \right]. \qquad (11)$$

After averaging of stress $\tilde{\sigma}_f$ and considering that effective stiffness of fiber depends on relation $<\tilde{\sigma}_f>/\varepsilon_m$, the reduction factor ψ which takes into account the influence of fiber length l_f and incomplete bonding on the modulus of a composite can be determined by using expression

$$\psi = \frac{\int_{l_{f\min}}^{l_{f\max}} \left[\frac{\tilde{\sigma}_f}{\sigma_f}(l_f) - \frac{\mathrm{tg}(Bl_f/4)}{Bl_f/2} \right] \varphi(l_f)\,dl_f}{\int_{l_{f\min}}^{l_{f\max}} \varphi(l_f)\,dl_f}. \qquad (12)$$

Here function $\varphi(l_f)$ shows distribution of the relative content of fibers as a function of the fiber length.

Assuming the incomplete bonding and distribution of fibers with respect to crack spacing (or embedded length), the modulus of elasticity of a unidirectional reinforced composite E_x^c can be expressed as

$$E_x{}^c = \hat{E}_f \psi V_f + E_m (1 - V_f). \qquad (13)$$

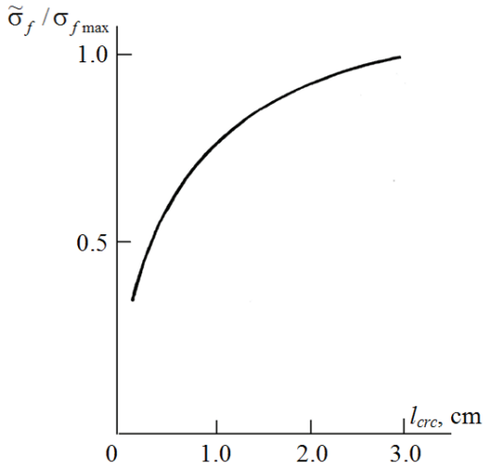

Figure 3. Relationship of relative stress in the fiber of incomplete bonding versus fiber length.

Interaction model of two-fiber system

In the case of two adjacent fibers that are symmetrically located so that the force balance is satisfied at the crack (Fig. 4), the equilibrium condition of the composite in the cross-section is:

$$P = \sum_{i=1}^{2} F_i + \sum_{i=1}^{2} T_i = \sum_{i=1}^{2} \left(A_f \hat{E}_f \psi \varepsilon_f \right)_i + \sum_{i=1}^{2} \left(A_m E_m \varepsilon_m \right)_i =$$

$$= A_f \hat{E}_f \psi \sum_{i=1}^{2} (\varepsilon_f)_i + A_m E_m \sum_{i=1}^{2} (\varepsilon_m)_i, \qquad (14)$$

where $P = P_1 + P_2$, F_i and T_i are the tensile forces in the fiber and matrix, respectively. In the two-fiber system the geometry of matrix area A_m is never axisymmetric with respect to the fibers axis and therefore it is difficult to determine exact value of the area (Рабинович, 2004).

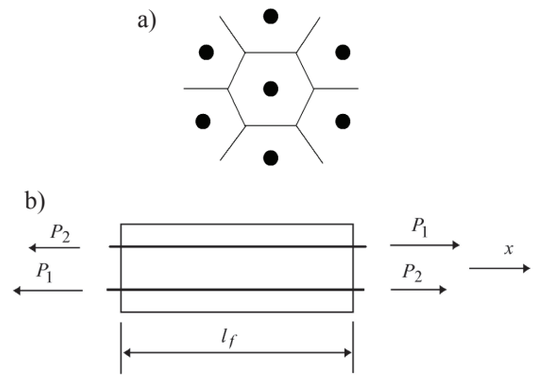

Figure 4. Hexagonal fiber arrangement a) and two-fiber system model b).

Assuming that ε_m is defined as the average of the matrix strain around the two fibers and taking into account the expression (14) it follows that

$$\varepsilon_m = \frac{1}{2A_m E_m} \left[P - A_f \hat{E}_f \psi (\varepsilon_{f1} + \varepsilon_{f2}) \right]. \qquad (15)$$

The local strain difference between, for example, the first fiber and the matrix is:

$$\varepsilon_f(x) - \varepsilon_m(x) =$$

$$= \frac{r}{2A_m E_m} \left[\left(\frac{2A_m E_m}{A_f \hat{E}_f \psi} + 1 \right) F_1(x) - P + F_2(x) \right]. \qquad (16)$$

Combining (9) and (16), the differential equation for $F_1(x)$ can be written

$$\frac{d^2 F_1(x)}{dx^2} = -S\,P + S\,R\,F_1(x) + S\,F_2(x)\ , \qquad (17)$$

where

$$S = \frac{\pi d_f G_m}{2A_m E_m};\ R = \frac{2A_m E_m}{A_f E_f \psi}.$$

Deriving the differential equation for $F_2(x)$ and replacing $F_2(x)$ by its value from the equation (17) we obtain a differential equation of order four for $F_1(x)$:

$$\frac{d^4F_1(x)}{dx^4} - 2S\,R\frac{d^2F_1(x)}{dx^2} + (R^2-1)S^2F_1(x) = \\ = S^2(R-1)P. \quad (18)$$

The solution of equation (18) can be written in the following form:

$$F_1(x) = C_1e^{-B_1x} + C_2e^{B_1x} + C_3e^{-B_2x} + C_4e^{B_2x} + \frac{P}{R+1}, \quad (19)$$

where

$$B_1 = \sqrt{S(R-1)}\,; \quad B_2 = \sqrt{S(R+1)}\,.$$

The force $F_2(x)$ can be obtained from equation (17) as

$$F_2(x) = -C_1e^{-B_1x} - C_2e^{B_1x} + C_3e^{-B_2x} + C_4e^{B_2x} + \frac{P}{R+1}. \quad (20)$$

The unknown constant C_i in expression (20) can be found from boundary conditions

$$F_1(0) = P_1; \quad F_1(l) = P_2; \quad F_2(0) = P_2; \quad F_2(l) = P_1 \quad (21)$$

and taking into account values for $P_i, B_i, R,$ and S. Because of the size of the expressions they are not given here. The fiber displacement at the crack in the case of the two-fiber model is:

$$\Delta = \frac{r}{\pi d_f G_m}\frac{dF_2(x)}{dx}\Big|_{x=l} = \\ = \frac{r}{\pi d_f G_m}\left(B_1C_1e^{-B_1l} - B_1C_2e^{B_1l} - B_2C_3e^{-B_2l} + B_2C_4e^{B_2l}\right). \quad (22)$$

Results and Discussion

In order to compare the results in the case of a single-fiber and two-fiber system, some numerical analyses were performed. The following material parameters were chosen: $d_f = 0.5$ mm, V_f = 4%, E_f = 210000 MPa, E_m = 50000 MPa, G_m = 20000 MPa. The segment length between two cracks (embedded length) is chosen 60 mm, and the fiber forces at the cracks – P_1 = 0.1 kN and P_2 = 0.

The distribution of the fiber force $F(x)$ is shown in Fig. 5. The solid lines represent the two-fiber system and the dashed ones – the single-fiber system. It is seen from Fig. 6 that the fiber force in the single-fiber analysis is twice as that obtained in the two-fiber analysis.

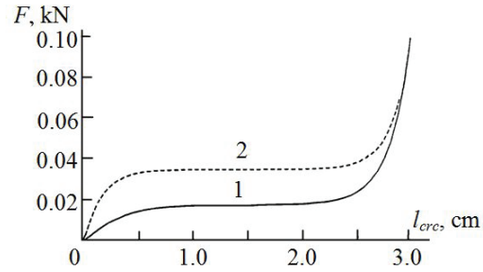

Figure 5. Distribution of fiber (l_{crc} = 30 mm) force: 1 two-fiber system, 2 single-fiber system.

On the basis of the two cases analysed separately (Figs 6 and 7) with P_1 = 0.1 kN, P_2 = 0, and P_1 = 0, P_2 = 0.1 kN it is determined that the total matrix force distributions are equal. The matrix force was derived by expression $T(x) = P - F_1(x) - F_2(x)$.

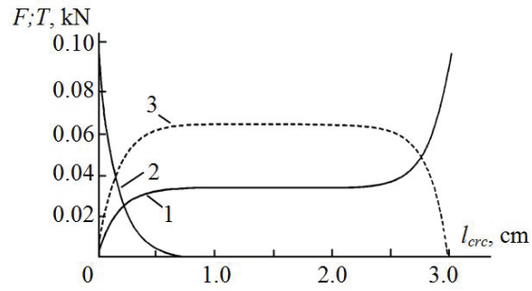

Figure 6. Distribution of fiber force (1, 2) and matrix force (3) in the single-fiber system (l_{crc} = 30 mm, P_1 = 0.1 kN, P_2 = 0).

In the two-fiber system, the fiber force distribution is symmetrical while in a single-fiber analysis it is not symmetrical due to the exceeded boundary conditions (Fig. 6). Line 2 in Fig. 7 shows the distribution of compensation force needed to balance the system. Note that for the single-fiber system the fiber displacement at the crack is Δ = 1.032 x 10^{-3} mm, and for the two-fiber system it is Δ = 1.155 x 10^{-3}, where the relative difference is approximately 12%. Obviously, the two-fiber system analysis gives more accurate results for the fiber displacement at the crack.

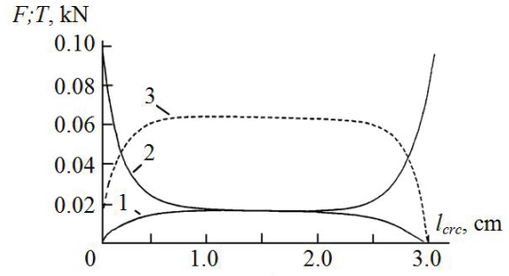

Figure 7. Distribution of fiber force (1, 2) and matrix force (3) in the two-fiber system (l_{crc} = 30 mm, P_1 = 0.1 kN, P_2 = 0, P_1 = 0, P_2 = 0.1 kN).

Conclusions

By using the proposed model, the stress state and deformation caused by axial force in the calculation element with oriented short-fiber reinforcement were studied.

To satisfy the equilibrium conditions at the crack in the case of cracked concrete a two-fiber model is developed.

The model takes into account distribution of fiber length (embedded length) considering incomplete bonding.

The fiber displacement at the crack derived from the two-fiber model analysis is predicted to be more accurate than that obtained from the single-fiber analysis. Comparison of the solutions of the single-fiber and two-fiber systems (with l_f = 60 mm and V_f = 4%) shows that the latter gives a greater fiber displacement at the crack.

In order to apply the proposed model to real cement composites, the fiber forces at the cracks should be derived considering the crack width, and a theory in the multiple cracking cases is still to be developed.

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ROLE OF WEB BROWSING LAYOUT ENGINE EVALUATION IN DEVELOPMENT PROCESS OF MORE USABLE WEB INFORMATION SYSTEM

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Abstract. This paper focuses on evaluation of Web browsing layout engines used as a backbone in Web browsing software. Study of commonly used Web browsers and Web information system developing languages has been performed. The role of Web browsing layout engine evaluation in Web information system development process is identified as a critical matter for bringing business processes online in a form of usable and accessible information system. By analyzing Web browsing layout engines as a tool that renders elements on a particular Web page of Web information system, key tendencies and emphasis for Web information system developers are revealed and discussed.
Key words: Web browser, Web browsing layout engine, Hyper Text Markup Language, Web information system.

Introduction

Bringing everyday business processes online has become a consistently growing tendency that goes side by side with developing possibilities of the Web (Lane et al., 2008). A key tool to carry out business process online is to develop information systems that are able to work online serving large number of users. Web users typically are not restricted by geographic location and specific accessibility environments (Taniar and Rahayu, 2004).

One of the key software solutions for accessing Web services, including Web information systems, are Web browsers. Web browser is a software application for retrieving, presenting, and traversing information resources on the World Wide Web (William, 2009). When users read a specific page on Web information system, it means, they use some type of Web browser. Most browsers that are available on the market have a common nuance: browsers read Hypertext Markup Language, HTML and Cascading Style Sheets, CSS codes and interpret them to data which are more understandable to users in a form of visual layout. HTML, CSS and other commonly met Web page development languages, such as JavaScript, are client-side languages (Scott, 2006). It means in a client – server architecture, which is a core architecture in the Web, most of operations are processed in the client - user side (see Figure 1.).

In the client side information processing model, for example, if a mathematics statement such as 1+1 is made, the server will not perform the calculation. In such a model, the server does not interact with data. The server's main function is to send data to the client side. The main interaction, in Figure 1 example is made on a client computer. In such interaction Web browser has a huge impact on how the server sent information is processed. The browser receives data then performs operation taking into account the client hardware and software environment and displays the result.

Opposite to the client-side information processing, server-side processing is performed on the server. Data are processed and then the result is sent to the client.

In such a model, the client does not know how the data, which are sent by the server, are processed. In this model, the main task for the client is to receive and display data.

Each model with according languages has its main targeted tasks in the Web information system development. Sometimes the tasks can overlap, which requires developer skills to choose the solution for specific problems. One of the key factors in information system accessibility and usability is the designed presentation of information. System users usually are not interested how the information is processed or by which algorithm the task is completed. Most attention is paid on how the information system can be used in

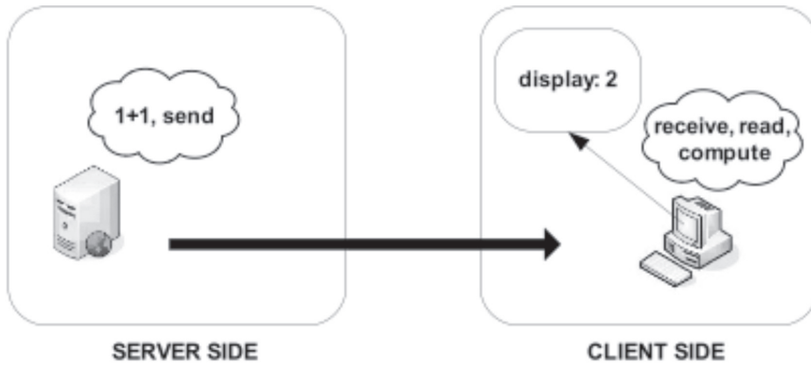

Figure 1. Client side information processing in the client-server architecture.

an effective, easy and beneficial way. It is seen that in order to meet such demands, focus on the client side information processing process examination has to be put.

The aim of this paper is to evaluate commonly used Web browsing layout engines and bring forward tendencies for more accessible and usable Web information system design. To reach the aim the following tasks have been brought forward:

1. Determine Web browsing layout engine diversity in various Web browsers.
2. Evaluate commonly used Web browsing layout engine similarities and differences regarding processing Hypertext Markup Language tags.
3. Identify tendencies and factors in Web browsers for information system developers that could allow creating more accessible and usable Web information systems.

Materials and Methods

When the analysis and summary of the leading Web standardization organization W3C provided browser usage statistics are made, it is seen, that in the year 2009, three leading Web browsers were Mozilla Firefox 3.x (46.94%), Microsoft Internet Explorer 6-8.x (40.52%) and Google Chrome 3-4.x (6.28%) which all together make 93.74% from all browser usage. In the beginning of the year 2010, tendencies remain the same and companies Mozilla, Microsoft and Google are developing and own most widely used Web browsers. According to published data (World Wide Web Consortium, 2010), there is an obvious tendency that popularity of Google Chrome and Mozilla Firefox has slightly increased, while Microsoft Internet Explorer has lost its stable position in the market. For example, Google browser popularity has increased for more than 5% in January 2010 compared with December 2009 (World Wide Web Consortium, 2010).

Next in a queue for the three most used Web browsers is Apple owned Web browser Safari, whose popularity increases with its integration into company manufactured, popularity gaining products, such as iPod portable music player and iPhone model mobile phones.

Web browser market consists of more than 10 universal, widely known Web browsers, not including many locally known or existing in developmental stage. For this research three named Web browsers with corresponding layout engines were chosen: Microsoft Internet Explorer 6.0, Mozilla Firefox 3.5 and Google Chrome 4.0.

To examine the role of Web browser layout engine in development of accessible and usable Web information system, one of the backbone client side languages of the Web - Hypertext Markup Language was chosen. Since creation of HTML, this language has been updated to various versions. In the year 2000, HTML language version 4.01 specification (World Wide Web Consortium, 2009) was published as an ISO/IEC international standard ISO/IEC 15445:2000(E) with a title 'Information technology — Document description and processing languages — Hyper Text Markup Language' (International Standards for Business, Government and Society, 2006). This is the latest approved version of HTML, (Johansson, 2010) however, there is an intense work at HTML 5.0 version development which specification still, until February 2010 appears to be in a draft version, and possibly will be released during the year 2010 or 2011 (Johansson, 2010).

When using HTML 4.01, there is a need to define the format subtypes of a language usage or more precisely DOCTYPEs, such as Strict and Transitional. Usage of document types relates to the Web browser rendering methods. If the Strict is used, rendering will be more precise and close to the language fundamental aim. If Transitional is chosen, exceptions in HTML document formatting are allowed. (Johansson, 2005) As the Strict document type promotes, a Web page separation in structure and presentation, which makes more usable and easier accessible Web page (Johansson, 2005) to design, the document type 'Strict' is used for research published in this paper.

The test of HTML 4.01 Strict specification tag usage possibilities and Web browsers layout engine rendering have been performed. A sample page of Web information system containing each of elements across chosen browsers has been created and tested.

Browsers use the following Web layout engines: Microsoft Internet Explorer 6.0 use Trident unversioned, Mozilla Firefox 3.5 use Gecko 1.9.3 and Google Chrome 4.0 use WebKit unversioned.

There are 91 markup tags named in HTML 4.01 specification (Holzsschlag, 2004; World Wide Web Consortium, 2009). As the Trident layout engine is fully available only in Microsoft Windows operation system (Lane et al., 2008), an operation system for testing Web browsers, Windows family operating system version XP SP2 were chosen. Rendering results on chosen Web browsers are ordered in a HTML tag functional groups.

Results and Discussion

HTML top level elements can be described by tags - body, frameset, head and html. Execution and rendering examination results show that each top level element is supported by all three analyzed Web layout engines.

HTML head elements can be described by tags – base, isindex, link, meta, script, style and title. Execution and rendering examination results show that only isindex element is not supported by any of three analyzed Web layout engines. Unsupported isindex element relates to the chosen document type Strict. Specification of Strict describes this element as deprecated or not supported by document type specification. Therefore, Web developers should avoid using isindex element.

HTML generic block-level elements execution results are summarized in Table 1.

Table 1

Layout engine evaluation based on block-level elements rendering examination on various Web browsers

Tag name	Commentary	Trident	Gecko	WebKit
address	Contact information for a document	+	+	+
blockquote	Quotations	+	+	+
center	Center alignment	-*	-*	-*
del	Defines text that has been deleted from a document	+	+	+
div	Generic language container	+	+	+
h1	Used to define HTML headings, largest size	+	+	+
h2	Used to define HTML headings, size 2	+	+	+
h3	Used to define HTML headings, size 3	+	+	+
h4	Used to define HTML headings, size 4	+	+	+
h5	Used to define HTML headings, size 5	+	+	+
h6	Used to define HTML headings, smallest size	+	+	+
hr	Horizontal rule	+	+	+
ins	Defines the text that has been inserted into a document	+	+	+
isindex	Creates a single-line text input control	-*	-*	-*
noscript	Alternate content container for non script rendering	+	+	+
p	Paragraph	+	+	+
pre	Pre-formatted text	+	+	+

From the results included in Table 1 is seen, that from HTML block-level elements, only center and isindex are not supported. Mark '+' shows that the browser layout engine supports element rendering, but the mark '-*' means that the element rendering in document type Strict, is deprecated. Deprecated elements may become obsolete in the future, but browsers continue to support deprecated elements for backward compatibility. (World Wide Web Consortium, 2009) HTML list elements execution results are summarized in Table 2.

Mark '+' shows that the browser layout engine supports element rendering, but mark '-*' means that element rendering in document type Strict, is deprecated. Deprecated elements may become obsolete in the future, but browsers continue to support deprecated elements for backward compatibility (World Wide Web Consortium, 2009). HTML table elements execution results are summarized in Table 3.

Table 2

Layout engine evaluation based on list elements rendering examination on various Web browsers

Tag name	Commentary	Trident	Gecko	WebKit
dd	Description of items in a definition list	+	+	+
dir	List directory titles	-*	-*	-*
dl	Defines definition list	+	+	+
dt	Definition term	+	+	+
li	List item	+	+	+
menu	Menu list	-*	-*	-*
ol	Ordered list	+	+	+
ul	Unordered list	+	+	+

Table 3

Layout engine evaluation based on table elements rendering examination on various Web browsers

Tag name	Commentary	Trident	Gecko	WebKit
caption	Table caption	+	+	+
col	Table column for formatting	+	-	-
colgroup	Table column group for formatting	+	-	-
table	Table definition	+	+	+
tbody	Table body definition	+	+	+
td	Table cell	+	+	+
tfoot	Table footer	+	+	+
th	Table header cell	+	+	+
thead	Table header	+	+	+
tr	Table row	+	+	+

Mark '+' shows that the browser layout engine supports element rendering, but mark '–' shows that a tag is neither supported nor rendered. From the rendering results in Table 3, it is seen that Web information system developers should avoid using col and colgroup tags, as they are only supported by Trident layout engine and can lead to distortion of the whole rendered table on Mozilla Firefox and Google Chrome family Web browsers.

HTML form elements execution was successful for all analyzed Web layout engines. All HTML form elements, including a button, fieldset, form, input, label, legend, optgroup, option, select and textarea, are supported by all three analyzed Web layout engines. HTML special inline elements execution results are summarized in Table 4.

Mark '+' shows that the browser layout engine supports element rendering, but mark '–' shows that the tag is neither supported nor rendered. Mark '-*' means that the element rendering in document type Strict, is deprecated. A deprecated element is one that has been outdated. Deprecated elements may become obsolete in future, but browsers continue to support deprecated elements for backward compatibility (World Wide Web Consortium, 2009).

Table 4

Layout engine evaluation based on special inline elements rendering examination on various Web browsers

Tag name	Commentary	Trident	Gecko	WebKit
a	Anchor	+	+	+
applet	Allows designers to embed a Java applet	-*	-*	-*
basefont	Specifies a default font attributes for text in a document	-*	-*	-*
bdo	Specifies text direction, overriding the bidirectional algorithm	+	+	+
br	Line break	+	+	+
font	Specifies the font attributes	-*	-*	-*
iframe	Defines inline frame	-*	-*	-*
img	Embedded image	+	+	+
map	Defines image map	+	+	+
object	Generic embedded object	-	+	+
param	Named property value	+	-	+
q	Defines a short quotation	-	+	+
script	Defines a client-side script	+	+	+
span	Generic language container	+	+	+
sub	Subscript	+	+	+
sup	Superscript	+	+	+

Table 5

Layout engine evaluation based on phrase elements rendering examination on various Web browsers

Tag name	Commentary	Trident	Gecko	WebKit
abbr	Abbreviation	-	+	+
acronym	Acronym	+	+	+
cite	Defines a citation	+	+	+
code	Computer code fragment	+	+	+
del	Defines the text that has been deleted from a document	+	+	+
dfn	Defines a definition term	+	+	-
em	Emphasis	+	+	+
ins	Defines the text that has been inserted into a document	+	+	+
kbd	Defines keyboard text	+	+	+
samp	Defines sample computer code	+	+	+
strong	Strong emphasis	+	+	+
var	Defines a variable part of a text	+	+	+

From the rendering results in Table 4, it is seen that inline elements support varies from used Web layout engines. Trident shows the poorest performance by not supporting quotation and object elements, unlike Google Chrome Webkit can render all non deprecated special inline elements. Web developers should pay attention to widely used elements, such as iframe and font. These elements are deprecated and should be avoided.

HTML phrase elements execution results are summarized in Table 5.

Mark '+' shows that the browser layout engine supports element rendering, but mark '–' shows that tag is neither supported nor rendered. From the rendering results in Table 5, it is seen that Web developers should be aware of using abbreviation and definition tags in developing projects as they are only partly supported by analyzed Web layout engines. Gecko shows the best performance in phrase element execution as it supports all phrase tags.

HTML font style elements execution results are summarized in Table 6.

Mark '+' shows that the browser layout engine supports element rendering. Mark '-*' means that the element rendering in document type Strict, is deprecated. A deprecated element is one that has been outdated. Deprecated elements may become obsolete in the future, but browsers continue to support deprecated elements for backward compatibility (World Wide Web Consortium, 2009). From the rendering results in Table 6, it is seen that Web developers should avoid using strike-through and underlined text elements as they are deprecated. As an alternative Cascade Style Sheet font styles could be used.

HTML frame elements execution was successful for all analyzed Web Layout engines. All HTML frame elements, including frame, frameset, noframes, are supported.

Even if Web developers follow mentioned analysis of HTML element rendering, there can still be some sort of distortions that relate Web layout engine tag attribute rendering or specific non-HTML element rendering, so in the project development stage it is useful to test Web page on different browsers. Besides installing different Web browsers on a system, there are also other possibilities to test Web page against various Web layout engines.

Table 6

Layout engine evaluation based on font style elements rendering examination on various Web browsers

Tag name	Commentary	Trident	Gecko	WebKit
b	Bold text	+	+	+
big	Larger text size	+	+	+
i	Italic text style	+	+	+
s	Strike-through text	-*	-*	-*
small	Small text	+	+	+
strike	Strike-though text	-*	-*	-*
tt	Teletype text	+	+	+
u	Underlined text	-*	-*	-*

In the Web browser market, a research for solutions to make more universal Web browser that could work with multiple layout engines is in progress. There are solutions named Hybrid Web browsers. These browsers include multiple layout engines in one software product. For example, Lunascape Orion that includes triple Web layout engine support – Trident, Gecko and Webkit (Lunascape Author Group, 2009). But until 2010, hybrid Web browsers are still in developmental stage. Also hybrid Web browsers face serious problems. It is known that parts of Web layout engine family are proprietary and owned by specific company which means that a hybrid Web browser cannot implement such layout engines without a license from its owners. For example, Opera and Microsoft Internet Explorer owns its own Web layout engines. So the fact that, for example, Lunascape Orion operational requirements are Windows operation system and Internet Explorer 6 or later (Lunascape Author Group, 2009) clearly shows that in order to support Trident in Lunascape, a user should have Internet Explorer installed on their devices.

Evaluation also can be done by using some virtualization service that is provided on Web. Adobe BrowserLab (Adobe BrowserLab Author Group, 2009) is one of examples. This service allows testing Web pages in various browsers on different operation systems using one Web page opened in Web browser. Although testing service is limited by amount of browsers and operation systems, there are few options that can be helpful for Web developers. For example, Adobe Browser lab supports the so called Onion skinning (Adobe BrowserLab Author Group, 2009) feature that allows to overlay two different browser rendering results, identifies faults and evaluates offsets. These types of services usually require Flash technologies support and at least one particular version Web browser that is already functioning on a system (Adobe BrowserLab Author Group, 2009).

Conclusions

1. Layout engines that are analyzed in this paper are not the only existing ones, but as the data by World Wide Web Consortium shows these are mostly used in the year 2009. From the layout engine analysis summarized in result tables, it is seen that two layout engines - Gecko and Webkit perform with similar results. Trident HTML tag rendering possibilities are more limited, although the main HTML elements can be executed and rendered properly. According to the information by Microsoft (Lane et al., 2008), Trident Web layout engine has been dramatically improved in future versions; unfortunately statistics and practices still show that Internet Explorer 6 with its corresponding layout engine is still widespread in use.
2. The fact that one has to take into consideration when designing Web information system and facing layout engine rendering testing, is that the creation of draft specifications of HTML 5 is also in progress. There is a need for Web developers to take into account and be aware of new possibilities which will be available by release of HTML 5.0 specification. There will be also a need to analyze and evaluate HTML 5.0 elements rendering on various layout engines in the nearest future.
3. Analysis in this research is not complete as it only covers HTML main element rendering results, not including, for example, attribute rendering evaluation.
4. Web developers should consider testing developing project on various browsers as a critical matter. For testing, the most stable method is installation of various browsers on a system, but alternatives as hybrid Web browsers and virtualization services can be considered. The tendency for hybrid Web layout engine development is still under a question mark and shows that market will remain scattered with existence of various stand-alone layout engines, but virtualization services such as Adobe BrowserLab, can be a good option for evaluation of Web layout engine performance.
5. In conclusion, it can be seen that Web browsing layout engine evaluation against programming language element execution has a serious role in Web information system development process. Web developers should practice testing Web pages of Web information system on various browsers, follow guidelines and published practices, as it directly addresses developed system accessibility and usability problems.

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MOODLE IMPLEMENTATION AT THE LATVIA UNIVERSITY OF AGRICULTURE INFORMATION TECHNOLOGY SYSTEM ARCHITECTURE

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Abstract. One of key elements when implementing e-learning system is integration in already existing system. System implementation begins with a planning process and ends with installation and maintenance. First of all, it is necessary to determine project team and set responsibilities, collect all information about current situation and possible changes. Latvia University of Agriculture has just started to plan implementation of Moodle system, as its e-learning environment. This article attempts to provide answers on some implementation questions during the system development lifecycle process.
Key words: e-learning, distributed systems, information system architecture.

Introduction

One of the European Union's 'Education and Training Work Program Strategic Framework' identified objectives is turning lifelong learning and mobility into reality, one of chances to realize it is e-learning. These platforms help to attract more students from wide area, learners are not required to sit in classrooms on a regular basis. Almost all contacts between teacher and students are organized by web based technologies. Latvia University of Agriculture (LUA) plans to implement Moodle learning management system as an e-learning course system. Moodle is full-featured open source course management system, which is used in 206 countries, with about 33 412 708 users. This system has become very popular because of its ease of use and rich set of resource and activity creation tools. It is a modular object –oriented and dynamic system meaning that an instructor can customize his courses by selecting several modules, such as discussion forum, chat, calendar and more. C.-J. Hung has pointed out some features that describe Moodle's advantages (Huang, 2005):

- It is suitable for 100% online classes as well as supplement to face to face learning;
- It supports simple, lightweight, efficient, compatible, low – tech browser interface;
- Most text entry areas, such as resources, forum posting, etc, can be edited using an embedded WYSIWYG (What You See Is What You Get) HTML (HyperText Markup Language) editor;
- It allows flexible array of course activities – Forums, Quizzes, Resources, Choices, Surveys, Assignments, Chats, and Workshops;
- The teachers can define their own scales to be used for grading forums and assignments;
- It is effortless to proceed with further study and analysis on the learners profiles as they are comprehensively established.

Latvia University of Agriculture provides education, research, extension and continuing studies in agriculture, food industry and forestry. The number of students is about 6450 and the number of lecturers and researchers more than 500 who carry out significant research for Latvia as well as research concerning actual issues in the Baltic Sea Region. The lecturers are involved in various study and research programs of the European Union. E-learning system can help to keep together these experts and students even if they are far away from each other. However, e-learning implementation in LUA deals with all aspects of the University's operations. Such important changes demand deep understanding, strategic plan containing specific recommendations. During e-learning system implementation it has to integrate with LUA environment that, means that before a system design there is a need to understand local rules, network requirements, current data storage and access control structures used standards, security requirements and more. These characteristics make implementation process quite challenging.

The purpose of this paper is to give an in-depth understanding of most important LUA information and communication technologies structure requirements for an e-learning system implementation.

Materials and Methods

A key characteristic of successful e-learning environment implementation is the need for high integration, availability, security, scalability and reliability. These processes should be provided during the whole system life cycle. Information system lifecycle processes introduced in IEEE/EIA 12207 standard. This standard supersedes both the previous military standard MIL-STD-498 and the industry standard ISO/IEC 12207 (Lee et al., 2002). Software development life cycle generally can be described in five steps; relationship of these steps can be described by a waterfall model (Fig.1).

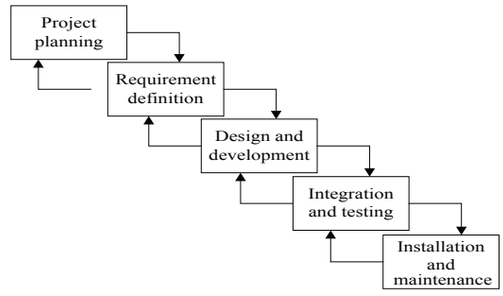

Figure 1. Waterfall model of software development life cycle.

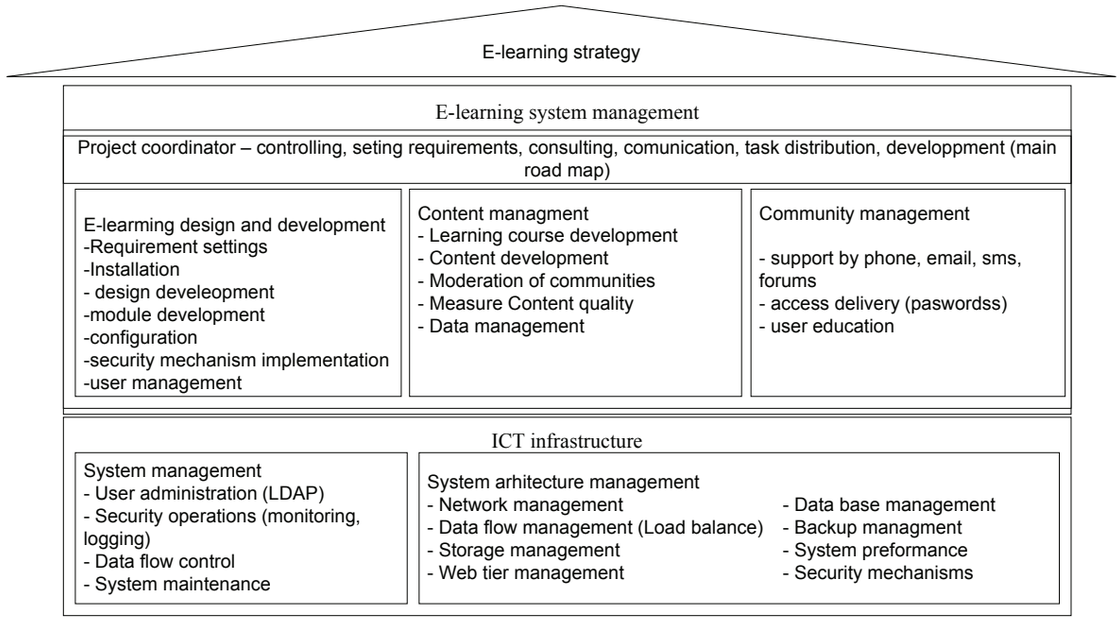

Figure 2. E-learning management realization process.

These processes also can be grouped into three broad classes: primary; supporting and organizational. Primary processes are the prime movers in the life cycle; they are acquisition, supply, development, operation and maintenance. Supporting processes are documentation, configuration management, quality assurance, joint review, audit, verification, validation and problem resolution. A supporting process supports another process in performing a specialized function. Organizational processes are management, infrastructure, improvement and training. An organization may employ an organizational process to establish, control and improve a life cycle process. During each step not only information for the next level is gathered or developed, but also previous information can be changed during the project development. It should be pointed out that all processes should have a top management support, it has been considered important in the adoption of strategic systems to ensure a long-term business vision, top-level interaction among users, and information system department to facilitate successful implementation. To obtain top management support of a new IS (information system), a product or technology champion is necessary to educate the relevant parties about the new technology and promote its adoption (Lee and Kim, 2005).

In the research LUA information and communication technology (ICT) infrastructure has been analyzed. During the study process three main forms of information gathering have been used-initially: a review of research literature, an interview with a senior 'Information System Department' system and network administrator at LUA and research of LUA requirements in e-learning policy realization. The following specific aspects where highlighted:

- LUA ICT structure and information system relationship and dependency
- LUA Moodle implementation work processes and necessary project team;
- Necessary system modifications for project realization and optimization;
- System quality measurement methods during development process.

This research concentrates on technical and organizational project processes; pedagogical and didactic questions are not included here.

Results and Discussion

LUA in its strategy has included e-learning and distance learning activities, but still hasn't defined real steps and actions that are needed to be taken at LUA in order to implement an e-learning system. The most important thing that has to be done is to set work activities and project realization team. Realization process can be split in three main activities – project management, e-learning system management and ICT infrastructure management (Fig.2).

LUA has about 7000 potential e-learning system users with a growing tendency, which means that system must be designed for high availability, using clustering technologies, load balancing across servers, multi-path routing strategies and backup solutions. The LUA territorial network consists of 10 main buildings, where historically main communication point is a central university building (Fig.3).

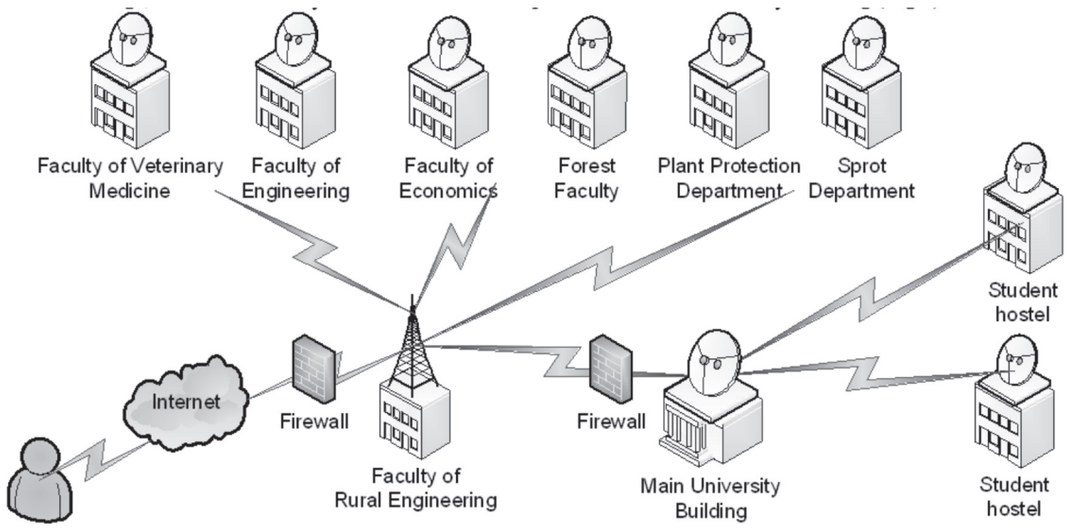

Figure 3. LUA territorial network in 2009.

A problem is that all data flow goes through one line, because connection to internet is going through the Faculty of Rural Engineering. It is necessary to move the main communication point to the Faculty of Rural Engineering for necessary system availability and performance. That will split data flow between several university buildings and will make possible to creat multi-path network between the university main building and the Faculty of Rural Engineering. Multipath-networks and load balancing will provide a better performance than a single-path routing. Such a scheme is introduced in several publications (Pham and Perreau, 2004; Wang et al., 2002).

LUA ICT infrastructure includes 7 information systems:

- LUA portal – University portal delivers a core set of information about the university for students and workers.
- LAIS – a Web based information system, which is used for a learning process support in LUA. This system includes information about all students, orders, and study payments, stuff registration, study course registration, study plans, student study success and more. This system is also used for other system information source;
- Horizon – an accounting system;
- Computer resource information system – a web based system, which includes information about all LUA computers, connected devices, and used software;
- Library system Aleph 500 – library resource system. A web based system with oracle data base.
- Student Scholarship calculation system – a local system that uses LAIS as an information source.
- Internet user tracking system – local system connected with LAIS and e-mail system.

The University portal is traditionally content delivery portal for current systems, which makes it strategically very important component of the system. Best practice from other universities has shown that main services should be integrated in portal, thus giving several benefits: single interface for several systems, single log-on and more. At the moment LUA doesn't have singe log-on authentication solution, such a system can provide several benefits: ability to enforce uniform enterprise authentication and/or authorization policies across the enterprise; end to end user audit sessions to improve security reporting and auditing; removes application developers from having to understand and implement identity security in their applications. One of most popular systems for single log-on is The Lightweight Directory Access Protocol (LDAP).

LDAP is an application protocol for querying and modifying data using directory services running over TCP/IP. Such a system will provide integration of current systems in one scheme that can be realized through a university portal (Fig. 4).

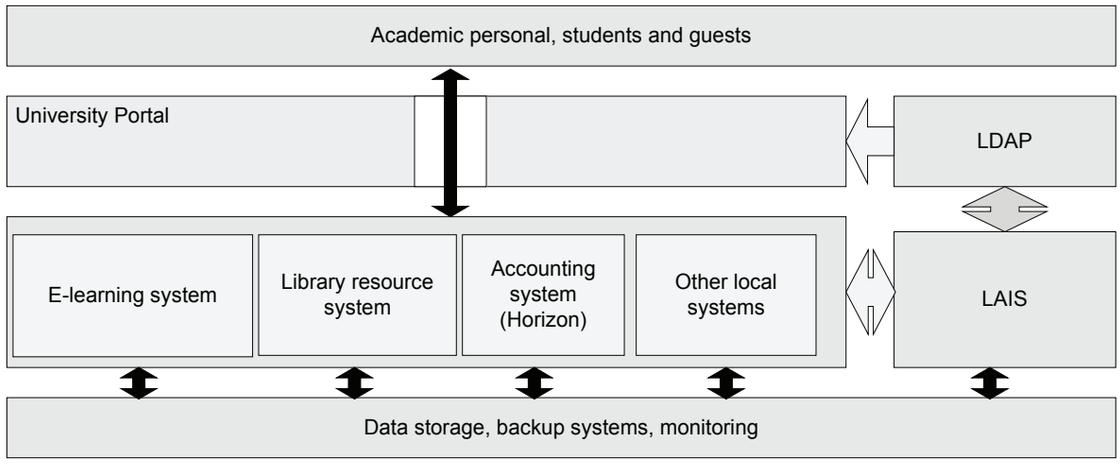

Figure 4. LUA information system integration.

Conclusions

Research shows that it is necessary to make several organizational and technical tasks and modifications before and during e-learning system implementation at LUA:

- Create an e-learning strategy where all goals, priorities and organize e-learning development project team is organized. E-learning strategy must be implemented in the main university strategy.
- Create strategic IT plan for an e-learning system implementation, and reorganize current IT infrastructure for maximal information flow performance;
- Create a single log-in authentication, and integrate it with current LUA systems;
- Reorganize a university portal and integrate mechanisms for other information system implementation in LUA Portal.

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TECHNOLOGIES SELECTION FOR VR/AR SYSTEMS DEVELOPMENT

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Abstract. Today e-learning is a term which is commonly used, but does not have a universally accepted definition, but it can be considered as technology-enhanced learning, where all types of digital technologies are used to support the learning process. Over the years some new functionality has appeared as mobile and wireless technologies (m-learning) and digital television provided possibilities for interactive study materials management (tv-learning). Latest options for training process acceleration are offered by virtual and augmented reality (VR/AR) technologies. The aim of this paper is to find solution for appropriate hardware selection before constructing VR/AR system for training needs focusing on platforms used for operators preparation to work with industrial equipment. In the beginning of the paper all hardware devices for such systems are summarized and explained. Then by using set theory and combinatorics all possible sets of input/output devices are described and calculated. Next dynamic modelling is used to create deterministic, static simulation model with an aim to ease the process of hardware selection for VR/AR training systems development. Simulation model is used for development of two pilot projects.
Key words: virtual and augmented reality (VR/AR), input-output devices, dynamic modelling, industrial training.

Introduction

Training is an important aspect of any industry as it is necessary that employees are equipped with the skills and knowledge required for their work, but also in order to maintain some competitive advantage. Investment in training can be costly and, therefore, it is important to consider solutions which are appropriate and flexible to change. In pressure to minimise e these costs and improve upon the training provided. VR/AR has the potential to address this need and these technologies have attracted a lot of attention due to its potential to improve training programs and provide additional benefits to the learning process while minimising the overheads. And due to increasing complexity of rapidly changing technologies, it is important to maintain competent labour. To achieve this, existing training methods can be improved in terms of cost, effectiveness, time consumption and quality, through the use of VR/AR training systems (Cobb et al., 2008).

The variety of benefits that VR/AR can provide to industrial training applications is wide. Firstly, the use of VR/AR training system can be designed in order to recreate a scenario that otherwise cannot be recreated in a real life situation whether this is due to cost, risk or the task in hand being destructive or the availability of resources. The scenarios can represent real and abstract three dimensional environments which enable training familiarisation without a risk to the trainee and at minimum expense. It can, in principle, engage the trainee's different senses and, therefore, essentially afford the experience of the learning environment similar to the real working environment. Virtual objects can be capable of behaving as they would in the real world; the trainee can activate them accordingly and can virtually practise the desired skill and receive instant feedback on the consequences of their actions, serving reinforcing the training without anxiety or injury.

VR/AR training systems have the potential to provide additional information that other more traditional training tools may not. It can support learning at different levels (novice to expert) by providing a number of virtual environments with varying degrees of complexity based on the trainee's level of understanding. Importantly, VR/AR training systems are not constrained in a pre-defined form as video or animations; the trainee can try out different methods to reproduce the same outcomes. Progress can be tracked, and automatic records may be generated to monitor progress and system can be designed to provide feedback to the user during interaction (Cobb et al., 2008).

The aim of this paper is to find solution for appropriate hardware selection before constructing VR/AR system for training needs focusing on platforms used for operators preparation to work with industrial equipment. To achieve this authors use analysis of literature, classification of VR/AR devices and sets, and simulation modelling.

Potential of VR/AR technologies is huge; there are lots of way to interact with virtual environment. These categories of interaction, although implemented in widely different ways and perceived by different senses, still incorporate most of the basic features of VR/AR: interaction, immersion, group work and scenario.

Table 1

VR/AR Input Devices

Active, A	Passive		
Buttons	Position tracking, B	Tracking body parts, C	Transducers, D
Switches			
Sliders	Optical*	Head*	Electromagnetic
Dials	Videometric*	Hand*	Electrochemical
Valuators	Electromagnetic*	Fingers*	Electromechanical
Keyboards*	Ultrasonic*	Torso	Electroacoustic
Joysticks*	Inertial	Feet	Photoelectric
Wands*	Neural	Eyes	Electrostatic
Mouses*	GPS	Whole body*	Thermoelectric
3D mouses*	WiFi		Radioacoustic
Digitizers*			
Data gloves*			
Props			
Microphones*			
Panels			
Platforms			

* Chosen input devices for VR/AR system development

As the definition of VR states, physical immersion and highly interactive simulations are key components of the medium. Thus, the VR system needs hardware devices that of a monitor the user in order to provide the user information necessary to make a display physically immersive (Sherman and Craig, 2003).

To provide interactivity, there are many possibilities of input devices (Table 1) for users real time monitoring. There are active devices, which allow the user to tell the system they want doing and passive input devices, which track at least some part of the user's body (Cirulis et al., 2009). Different combinations of input devices are available, and they must support monitoring process of a user, which is a continuous tracking of both user movements and user-initiated actions, such as pressing a button or issuing a voice command to the system.

To support next key feature of VR/AR system there is also a need for output devices (Table 2), which prescribe how the user perceives the environment (Cirulis et al., 2009). These hardware devices present information to one or more of the user's senses through the human perceptual system (visual, auditory, haptic and vestibular).

Table 2

VR/AR Output Devices

Visual, E	Auditory, F	Haptic, G	Vestibular, H
Monitors*	Headphones*	Ground referenced	Motion base systems
Surround screens*	Externals speakers*	Body referenced	Motion platforms
Workbenches		Tactile	
Hemispherical displays*		Hybrid	
AR head mounted displays*		Passive	
VR head mounted displays*			
Arm mounted displays*			
Virtual retinal displays*			
Autosterioscopic displays*			

* Chosen output devices for VR/AR system development

Materials and Methods

Appropriate and right selection of devices used in VR/AR system is not a simple task, that is why the general architecture of such systems must be considered.

The architecture of e-learning system can be described as A = (L, F), where:

L – logical structure (rules, algorithms, methods, approaches, instructions, directives etc.) – the essence of the system;

F – physical structure (software, hardware (data processing and visualisation equipment, communication subsystem, measurement and control equipment)) – the environment for (L) deployment.

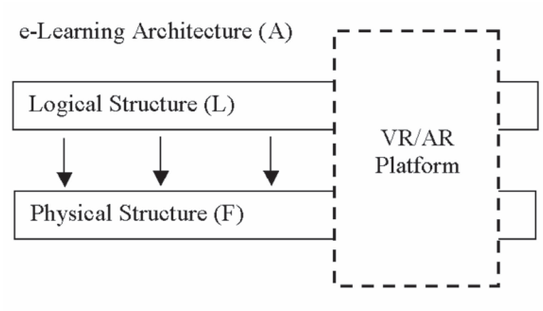

Figure1. E-learning structural model.

The first step in modern e-learning development was LMS deployment on the Internet, which was typical for beginning of XXI century. Imaging on the screen the information stored in databases replaced reading the lectures and training books (Bluemel et al., 2006). Sometimes the material was supplemented with audio and video clips improving perceptibility of the information (see Fig.1). Nowadays VR/AR tools have become integral part of advanced e-learning systems architecture (VR/AR) ∈ (A), but the platforms are getting various and heterogeneous (Cirulis et al., 2009).

In present situation it is important to deal with physical structure. Taking into account that so many input-output devices (see Fig. 1) can confuse and encumber appropriate device choice to construct VR/AR system for prescribed training needs, there is a need for solution how to predict a set of equipment to satisfy training systems' needs.

By using set theory (Wikipedia, Set mathematics, 2010) and combinatorics (Wikipedia, Combination, 2010), it is possible to describe and calculate all possible sets of input/output devices. To minimise set count, such devices are removed (devices without asterisk *) from Table 1 and Table 2:

1. out-of-date devices;
2. devices which are not used for industrial training;
3. devices with compatibility problems.

The following sets are formed:

Set A, will be used for active input devices, where maximum element count is 16, but elements which are used, will be 8, so n=8 or |A|=8. A= {Keyboard, Joystick, Wand, Mouse, 3D mouse, Digitizer, Data glove, Microphone}

Set B, will be used for position tracking technologies, where maximum element count is 8, but elements which are used, will be 4, so n=4 or |B|=4. B= {Optical, Videometric, Electromagnetic, Ultrasonic}

Set C, will be used for position tracking devices, where maximum element count is 7, but elements which are used, will be 4, so n=4 or |C|=4. C= {Head, Hand, Fingers, Whole body}

Set D, will be used for transducers, where maximum element count is 8, but no elements will be used from this device type, so D=∅

Set E, will be used for visual output devices, where maximum element count is 9, but elements which are used, will be 8, so n=8 or |E|=8. E= {Monitor, Surround screen, Hemispherical display, AR head mounted display, VR head mounted display, Arm mounted display, Virtual retinal display, Autosterioscopic display}

Set F, will be used for audio output devices, where maximum element count is 2 and both devices will be used, so n=2 or |F|=2. F= {Headphones, Externals speakers}

Set G, will be used for haptics devices, where maximum element count is 5, but no elements will be used from this device type, so G=∅

Set H, will be used for vestibular devices, where maximum element count is 2, but no elements will be used from this device type, so H=∅

Set J will be used for all suited input devices, so |J|=16

Set K will be used for all suited output devices, so |K|=10

Input and output devices will be calculated separately, removing such sets, which contain too many elements from one type and are not used in one VR/AR system; for example, no more than 3 active input devices can be in one power set. Also empty sets will be ignored.

Valid power sets (Wikipedia, Power set, 2010) from set A, $\left|P(A)\right| = C_n^1 + C_n^2 + C_n^3, n = 8$ (1)

Valid power sets from set B, $\left|P(B)\right| = C_n^1 + C_n^2 + \ldots + C_n^n, n = 4$ (2)

Valid power sets from set C, $\left|P(C)\right| = C_n^1 + C_n^2 + \ldots + C_n^n, n = 4$ (3)

Combination count is estimated by $C_n^k = \frac{n!}{k!(n-k)!}$ (4), where n is complete elements count in set and k is chosen elements count from set, elements order in set is not important.

Valid sets count from input devices power sets equals $|P(J)| = |P(A)| \times |P(B)| \times |P(C)| = 20{,}700$ (5)

Valid power sets from set E, $|P(E)| = C_n^1 + C_n^2, n = 8$ (6)

Valid power sets from set F, $|P(F)| = C_n^1 + C_n^2, n = 2$ (7)

Valid sets count from output devices power sets equals $|P(K)| = |P(E)| \times |P(F)| = 208$ (8)

Finally all possible valid sets from input and output devices equals

$$|P(L)| = |P(J)| \times |P(K)| = 4{,}305{,}600 \quad (9)$$

If there is a situation, when any of elements change in Table 1 or Table 2, set count should be recalculated by formulas above.

In the next step dynamic modelling (Hannon and Ruth, 2007) will be used. Appropriate criteria and parameters must be selected, to create working base model. Criteria are chosen by analysing several well used VR/AR systems for industrial training (Cirulis et al., 2009), which have confirmed that the hardware choice for solution is correct. VR/AR devices sets count and sets by themselves are important to predict at some level how complicated imitation model could be and how many results it is possible to get.

STELLA as modelling language is a powerful tool to model dynamic systems. Its functionality is simple and interface is user - friendly. There is a possibility to create convenient and functionally complete simulation models. This dynamic system simulation model development software was chosen, to begin a process of deterministic, static simulation model's development, with an aim to ease the process of hardware selection for VR/AR training systems by creators (Hannon and Ruth, 2007). By using this model, specialists get appropriate suggestions for technologies to use in VR/AR system they are developing.

Results and Discussion

The simulation model authors created gets input data from user, by using user interface of simulation model and choosing different values of parameters, which are demands for VR/AR components and devices.

At this time simulation model consists of general parameters, which are acquired from visual and auditory devices (Fig. 2), for example, VR/AR system portability, training system users' mobility, number of active users, the level of immersion and the session duration. Each parameter is weighted and it has intensity level, which determines how much particular technology is suitable for demands satisfaction and accomplishment. The result is data, which identify how suitable are visual and auditory devices, depending on VR/AR training systems demands.

The user interface is presented in Figure 2. In the first step, potential VR/AR systems developer must choose type of senses that will be used, type of system (virtual or augmented) and active users count. In next steps it is possible, by changing values of scroll bars, to choose appropriate level and weight for portability, user mobility, system immersion and session duration. The last one is important for optimal environment, considering needs of training scenarios and ergonomics and safety in operation process of VR/AR equipment.

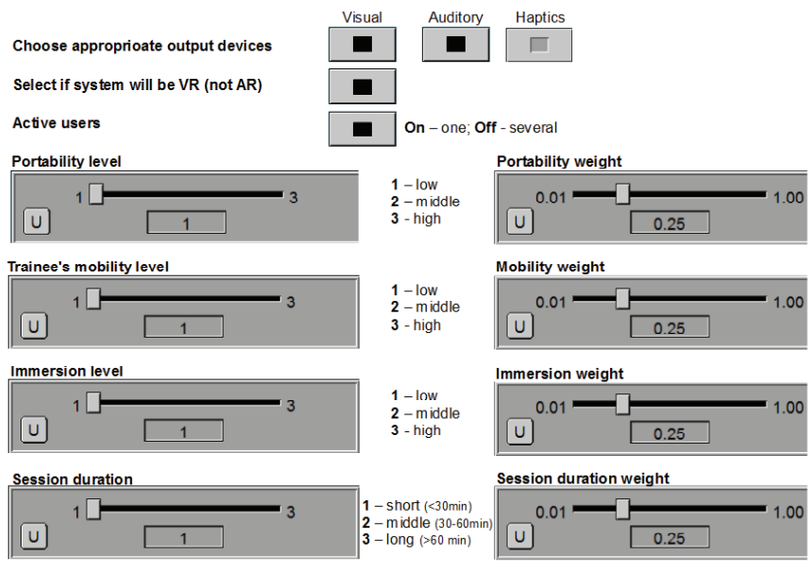

Figure 2. Simulation model user interface.

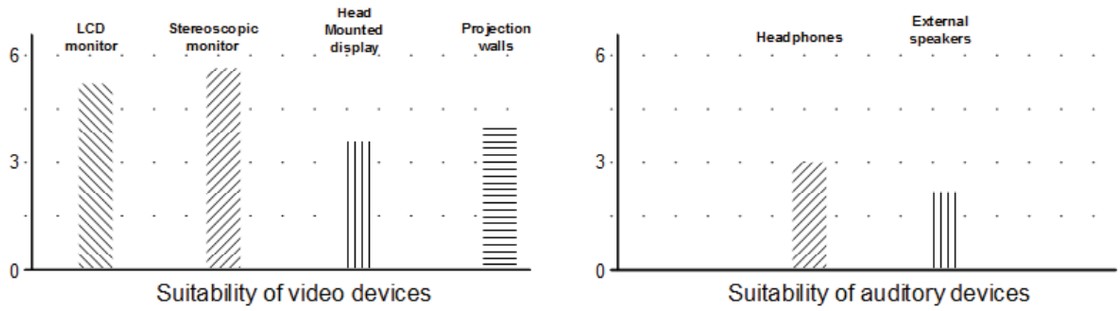

Figure 3. Suggestions for virtual reality system.

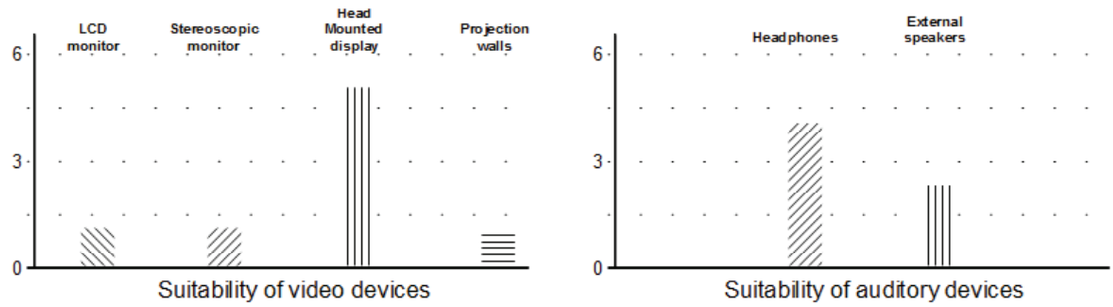

Figure 4. Suggestions for augmented reality system.

In this paper a simulation model is created and used for two pilot projects in food processing industry, which are developed by Sociotechnical Systems Engineering Institute in Vidzeme University of Applied Sciences. One project is 'Meat Grinders Assembling Scenarios' and the main task for this project is to prepare food production specialists to assemble, disassemble and maintain meat grinders. Such equipment usually consists of approximately fourteen parts, which must be correctly set together. Assembling scenario depends on for what type of meal meat should be minced. Structure of minced meat depends on what type of strainer is used. There is one basic scenario for complete assemblage, and about three sub scenarios for the right choice of strainers. This system can be accomplished in virtual reality; there is one user and its mobility, but system portability is not an important issue. Session duration is under 30 minutes and level of immersion is also set to low. And as depicted in Figure 3, the results of simulation show, that the most appropriate video output device is stereoscopic monitor, but LCD (liquid crystal display) monitor is very close, because the immersion level was set to low. As least appropriate device for this system is head mounted display and external speakers from auditory devices.

In case of augmented reality, which will be used for the second pilot project 'Accuracy Improvement for Splitting and Deboning Process of Pig Carcass', training session takes place in real working environment, because portability and mobility are important, also training scenarios are more complicated and take more time. Figure 4 clearly presents the results of simulation model that in such situations a leader is head mounted display among visual output devices.

Conclusions

All possible sets of VR/AR devices were calculated and summarized by using combinatorics and set theory. Simulation model was created and used for two pilot projects, to ease hardware selection for virtual and augmented reality systems. This model can be used for any other project where VR/AR technologies are planned to use. Developed simulation model will be also a base for future research, including in it not only more detailed selection of video and audio output devices, but also haptic devices, active and passive output devices to determine suitability in wider range. Benefits of using this model are obvious, like VR/AR systems save training time, this model saves VR/AR system development time. In addition, an important task for future is model validation when it is more completed.

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MATHEMATICAL MODEL OF GLYCEROL CYCLE IN BAKER'S YEAST

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Abstract. Approach of white box mathematical modelling was used to develop dynamic mathematical model of glycerol cycle in baker's yeast *Saccharomyces cerevisiae* and by deterministic simulations explore an interaction between glycerol cycle and glycolysis. The key process in research was reaction of artificially expressed glycerol-2-dehydrogenase (Gld2) which catalyses glycerol transition into dihydroxyacetone and reduced nicotinamide adenine dinucleotide phosphate (NADPH). We put forward hypothesis that expression of Gld2 in *S. cerevisiae* could increase concentration of reduced cytosolic NADPH. Michaelis-Menten equation was used to describe a rate law of reactions of the model of glycerol cycle. Kinetic parameters K_m (Michaelis - Menten constant) and V_{max} (maximal velocity of reaction) were taken from BRENDA database and publications. To perform deterministic simulations of the model of glycerol cycle and glycolysis, an accomplished model of glycerol cycle was introduced into the mathematical model of glycolysis of Nielsen et al. (1998). Results suggested that Gld2 reaction could run even without glycolysis as long as glycerol and oxidized nicotinamide adenine dinucleotide phosphate ($NADP^+$) was present in the system. Intracellular concentration of glycerol had a direct impact on formation and acumulation of dihydroxyacetone. Reduced nicotinamide adenine dinucleotide (NADH) concentration decreased significantly and rapidly when glycerol cycle was switched on suggesting that it could be a limiting factor of the system.
Key words: dynamic modelling, NADPH, glycerol metabolism, glycolysis.

Introduction

In a wild type of yeast the first two reactions of pentose phosphate pathway are major sources of cytosolic cofactor reduced nicotinamide adenine dinucleotide phosphate (NADPH) (Kletzien et al., 1994, cited by Schenton and Grant, 2003; Minard and McAlister-Henn, 2005). KEGG database suggests that glucose-6-phosphate dehydrogenase (G6PD) and phosphogluconate dehydrogenase (PGD) catalyse first two steps of pentose phosphate pathway. Both enzymes are specific for oxidized nicotinamide adenine dinucleotide phosphate ($NADP^+$) resulting in a production of reduced NADPH.

Reduced NADPH in a cell is required for numerous biosynthetic enzymatic reactions (Minard and McAlister-Henn, 2005) although it has even higher importance during exposure to oxidants since it provides the reducing power for antioxidant enzymes, including the glutathione, glutaredoxin and thioredoxin systems (Holmgren, 1989, cited by Schenton and Grant, 2003).

Several metabolic engineering methods to increase concentration of reduced NADPH in a system have already been mentioned. For example, it has been proposed previously that blocking glycolysis could be beneficial during conditions of oxidative stress since it would result in an increased flux of glucose equivalents through the pentose phosphate pathway leading to the generation of NADPH (Holmgren, 1989, cited by Schenton and Grant, 2003). J. Liepins et al. (2006) demonstrate reduced NADPH production possibility by expression of glycerol-2-dehydrogenase (Gld2) in yeast.

Modified yeast Gld2 expression extends pathway of glycolysis and metabolism of glycerol (Glyc). Gld2 reaction use Glyc as a substrate to produce reduced NADPH and dihydroxyacetone (DHA). Though DHA is not typical for yeast metabolism, nonetheless, there is no direct toxicity to intact yeast. H. Nguyen and E. Nevoigt (2009) research demonstrates a successful production of DHA in yeast *Hansenula polymorpha*. Comparing to wild type engineered strains, the *Hansenula polymorpha* glycerol dehydrogenase (Gdh) overexpression led to DHA production, reaching about 100 $mg \cdot L^{-1}$, which is 60 times the wild type level under comparable growth conditions (Nguyen and Nevoigt, 2009). However, it has also been shown that high concentrations of both glycerol and DHA (substrate and product, respectively) inhibit growth and negatively affect the specific DHA production rate (Claret et al., 1992; cited by Nguyen and Nevoigt, 2009).

As far as DHA is not assumed as a target product, it can be enzymatically phosphorylated to dihydroxyacetone phosphate (DHAP) in an adenosine triphosphate (ATP) - dependent manner by DHA kinase encoded by the *S. cerevisiae* genes Dak1 and Dak2 (Molin et al., 2003).

Several quantitative kinetic models of glycolysis of yeast have been published by BioModels database. Nevertheless none of these models describe kinetics of pathway of glycerol in depth. Neither dynamics of Gld2 reaction is described in yeast previously. Therefore aim of our research is to develop quantitative kinetic model of glycerol cycle and perform deterministic simulations to predict possible behaviour of the system in pre-experiment stage.

Materials and Methods

The structural model of glycerol cycle (see Fig. 1.) consists of five reactions and twelve species. The First reaction describes glyceraldehyde-3-phosphate (GAP)

transition into dihydroxyacetone phosphate (DHAP). In the mathematical model reaction is described as reversible. The second reaction is catalyzed by enzyme glycerol–3–phosphate-dehydrogenase which is coded by gene Gpd1 (Albertyn et al., 1992), and it is reduced nicotinamide adenine dinucleotide (NADH) specific. It describes DHAP transition into glycerol-3-phosphate (Glyc3P). In the mathematical model reaction is described as irreversible. The third reaction is catalyzed by enzyme glycerol-1-phosphotase which is coded by gene Gpp1 (Norbeck et al., 1996). It describes Glyc3P transition into Glyc. In the model reaction is described as irreversible. The fourth reaction is catalyzed by enzyme Gld2. It describes production of DHA from Glyc. Reaction is $NADP^+$ dependent and in the mathematical model it is described as irreversible. Finally, the fifth reaction is catalyzed by enzyme glycerone kinase which is coded by gene Dak1 (Molin et al., 2003). It describes DHA transition into DHAP. Reaction is ATP dependent and in the model it is described as irreversible.

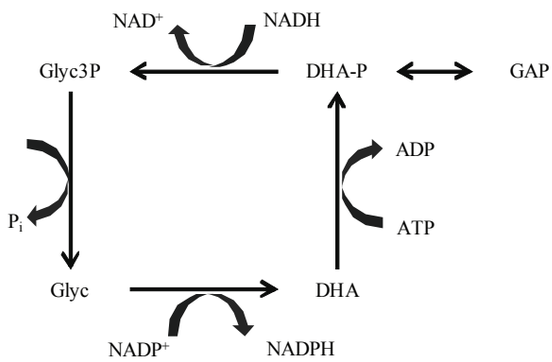


Figure 1. Structural model of glycerol cycle: ADP – adenosine-5-diphosphate; ATP - adenosine triphosphate; DHA – dihydroxyacetone; DHAP – dihydroxyacetone phosphate; GAP – glyceraldehyde-3-phosphate; Glyc – glycerol; Glyc3P – glycerol-3-phosphate; NAD^+ - oxidized form of nicotinamide adenine dinucleotide; NADH – reduced form of nicotinamide adenine dinucleotide; $NADP^+$ - oxidized form of nicotinamide adenine dinucleotide phosphate; NADPH – reduced form of nicotinamide adenine dinucleotide phosphate; Pi – inorganic phosphate.

Kinetic parameters to describe rate of reactions are taken from BRENDA database and publications. If a measurement unit of constant of maximal velocity V_{max} in a publication or database is expressed as $U \cdot mg^{-1}$ protein or $kat \cdot mg^{-1}$ protein, it is changed and the value calculated to $mM \cdot min^{-1}$ by using methodology described by Denim and Goryanin (2009). To perform calculations we also assume that 1 g of protein corresponds to 3.7 mL (Richard et al., 1996) of volume of cytosol.

In the first reaction Michaelis – Menten constat K_m for DHAP is 1.23 *mM* and for GAP it is 1.27 *mM*. Maximal velocity for forward reaction is 116.36 $mM \cdot min^{-1}$ and for reversible reaction it is 116.36 $mM \cdot min^{-1}$. For the first reaction both K_m constant and V_{max} are taken from F. Hynne et al. (2001). The Michaelis – Menten equation for reversible reaction (Klipp et al., 2005) is used to describe the rate law (equation 1) of the first reaction of the model.

$$v = \frac{\frac{V_{max}^{for}}{K_{mS}} \times [S] - \frac{V_{max}^{back}}{K_{mP}} \times [P]}{1 + \frac{[S]}{K_{mS}} + \frac{[P]}{K_{mP}}}, \quad (1)$$

where v – reaction rate;

V_{max}^{for} - maximal velocity of forward reaction;

V_{max}^{back} - maximal velocity of backward reaction;

K_m – Michaelis - Menten constant;

K_{mP} - Michaelis – Menten constant of product;

K_{mS}- Michaelis – Menten constant of substrate;

S – substrate;
P – product.

In the second reaction coded by Gpd1 Michaelis – Menten constat K_m for DHAP is 0.54 *mM* and for NADH it is 0.023 *mM*. Maximal velocity for the reaction is 864.86 $mM \cdot min^{-1}$. For the second reaction both K_m constant and V_{max} are taken from Albertyn et al. (1992). The Michaelis – Menten equation for irreversible reaction (Klipp et al., 2005) is used to describe the rate law (equation 2) of the second reaction of the model.

$$v = \frac{V_{max} \times [S]}{K_m + [S]}, \quad (2)$$

Where v - reaction rate;

V_{max} - maximal velocity of reaction;

K_m - Michaelis – Menten constant;
S – substrate.

In the third reaction coded by Gpp1 Michaelis – Menten constat K_m for Glyc3P is 3.10 *mM* and maximal velocity for the reaction is 6494.32 $mM \cdot min^{-1}$ (Norbeck et al., 1996). The equation 2 is used to describe rate law of the reaction.

In the forth reaction coded by Gld2 Michaelis – Menten constat K_m for Glyc is 350.00 *mM* and for NADPH it is 0.11 *mM*. Maximal velocity for the reaction is 19537.60 $mM \cdot min^{-1}$. For the forth reaction both K_m constant and V_{max} are taken from J. Liepins et al. (2006). The equation (2) was used to describe rate law of the reaction.

In the fifth reaction coded by Dak1 Michaelis – Menten constat K_m for DHA is 0.022 *mM* and for ATP it is 0.49 *mM*. Maximal velocity for the reaction is 251.35 $mM \cdot min^{-1}$. For the fifth reaction both K_m constant and V_{max} are taken from M. Molin et al.

(2003). The equation (2) is used to describe rate law of the reaction.

Initial concentrations of species of the model of glycerol cycle are set to the following values – 1.50 *mM* ADP, 2.10 *mM* ATP, 0.00 *mM* DHA, 2.95 *mM* DHAP, 0.11 *mM* GAP, 4.16 *mM* Glyc, 0.10 *mM* Glyc3P, 0.65 *mM* NAD^+, 0.33 *mM* NADH, 0.01 *mM* $NADP^+$, 0.05 *mM* NADPH and 0.10 *mM* inorganic phosphate (Pi). In order to perform simulation of the model of glycerol cycle initial concentration of NADPH and ATP is fixed.

Mathematical model of glycerol cycle is described by ordinary differential equations. The structural model of glycerol cycle is produced in CellDesigner software although dynamic mathematical model and deterministic simulations are developed and performed in Copasi software.

To explore impact of glycerol cycle on glycolysis an accomplished mathematical model of glycerol cycle is introduced into the mathematical model of glycolysis developed by K. Nielsen et al. (1998). To achieve successful introduction the third reaction of the mathematical model of glycolysis (Nielsen at al., 1998) which describes fructose-1.6-bisphosphate (FBP) transition into GAP is modified. Consequently reaction is changed so that substrate FBP by reversible reaction produces two products GAP and DHAP. Michaelis – Menten constat K_m for FBP is 0.30 *mM*, for GAP it is 4.00 *mM* and for DHAP it is 2.00 *mM*. Maximal velocity for forward reaction is 2207.82 $mM \cdot min^{-1}$ and for reversible reaction it is 11039.10 $mM \cdot min^{-1}$. For the reaction both K_m constant and V_{max} are taken from F. Hynne et al. (2001). Rate law of the reaction is described by equation (1).

As the model doesn't produce $NADP^+$, then concentration of reduced cofactor $NADP^+$ is fixed without a possibility to change it. In the model minutes are used as time and *mM* as a concentration unit. Specific flow rate is set to 0.66 % of volume per min (see model of Nielsen et al., 1998).

Results and Discussion

Simulation results suggested that $NADP^+$, ATP and NADH could be key parameters which can limit functionality of the cycle. Results also suggested that Gld2 reaction can function even without glycerol cycle. That is possible because concentrations of Glyc and $NADP^+$ in the system are affected by extracellular glycerol (Hynne et al., 2001) and by first two reactions of pentose phosphate pathway (Schenton and Grant, 2003). Glycerol cycle doesn't function if Gld2 reaction runs out of $NADP^+$. ATP also has an important role in a functionality of glycerol cycle. If the system lacks ATP, then it starts accumulate DHA. Simulations with various concentrations of Glyc also resulted in accrue of DHA. If the concentration of Glyc is higher than 49.01 *mM*, then DHA accumulates rapidly (see Fig. 2.). Accumulation of DHA decreases rapidly if the concentration of Glyc decreases below 49.01 *mM*, e.g., the concentration of DHA is down to 0.01 *mM* if the concentration of Glyc is 15.75 *mM*.

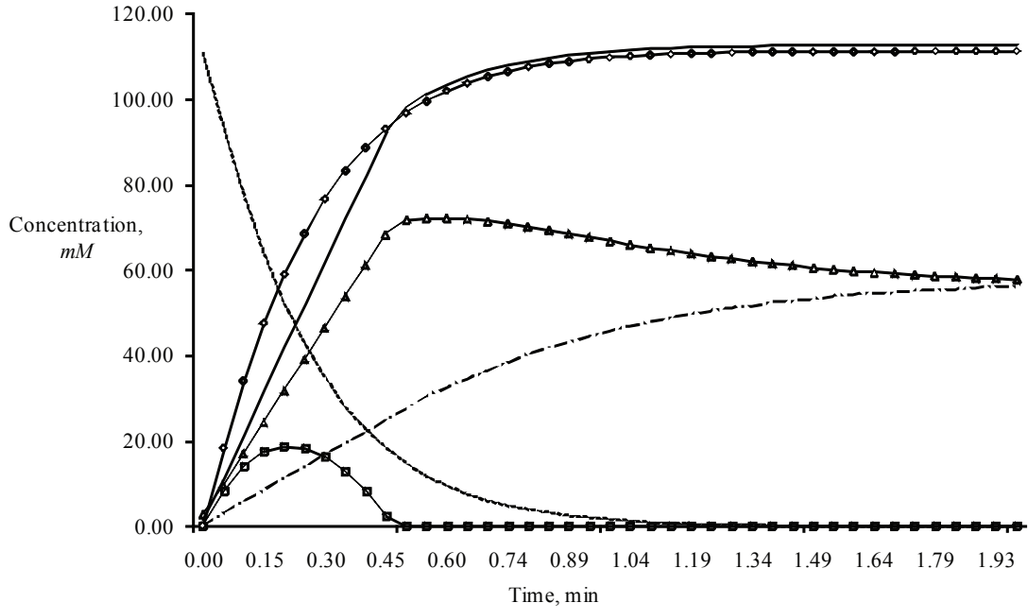
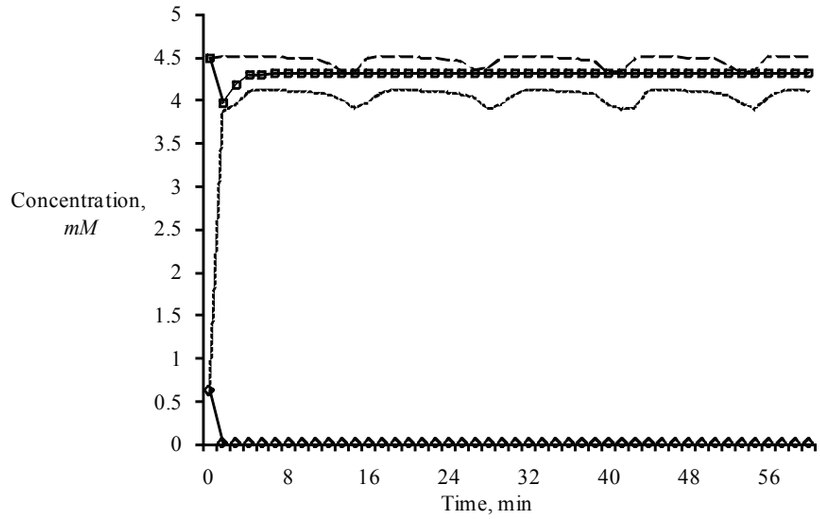


Figure 2. Deterministic simulation of dynamic mathematical model of glycerol cycle:
—△— DHAP; – · – · – GAP; ····· Glyc; —□— DHA; —◇— NADPH; ——— ADP.



Figue 3. Impact of glycerol cycle on NADH and ATP concentration changes during glycolysis: —□— ATP concentration changes when glycerol cycle is switched on; —◇— NADH concentration changes when the glycerol cycle is switched on; – – – ATP concentration changes when glycerol cycle is not switched on; --------- NADH concentration changes when the glycerol cycle is not switched on.

Gpd1 reaction which is NADH specific has an impact on formation of Glyc but as Glyc can be transported from an extracellular space into cytosol (Hynne et al., 2001) it does not have a direct impact on Gld2 and Dak1 reactions.

Deterministic simulations of the model of glycerol cycle and glycolysis show a rapid decrease of concentration of NADH (see Fig. 3.) reaching concentration 0.002 *mM* compared to average 4.0 *mM* (Nielsen et al., 1998) when a glycerol cycle is not switched on. Decrease is up to 2000 fold and suggests that the rate of Gpd1 reaction which is NADH specific is higher than the rate by which glycolysis produce reduced NADH.

A significant decrease of ATP is not observed during simulations. In a steady state the concentration of ATP is 4.31 *mM* compared to average 4.41 *mM* (Nielsen et al., 1998) when the glycerol cycle is not switched on. Although sustained, stable oscillations of ATP are lost (see Fig. 3.).

Reduced NADH decrease has also a direct impact on glycolysis. One of glycolysis target product ethanol (EtOH) shows significant decrease reaching 12.46 *mM* (see Fig. 4.) in a steady state of the model compared to average 36.89 *mM* (Nielsen et al., 1998) when glycerol cycle is not switched on. Decrease up to three fold can be explained by the fact that acetaldehyde (ACA) transition into ethanol is NADH specific.

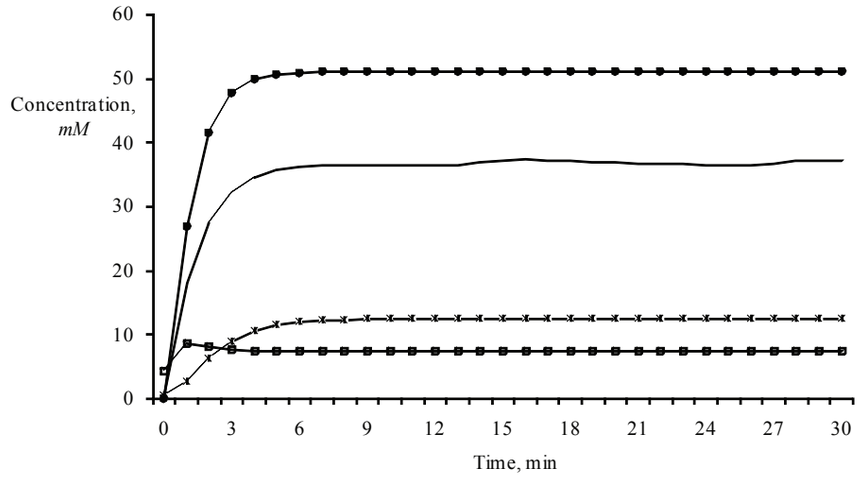


Figure 4. Impact of glycerol cycle on EtOH, Glyc and NADPH, and concentration changes during glycolysis: —— EtOH concentration changes when the glycerol cycle is not switched on; —✳— EtOH concentration changes when glycerol cycle is switched on; —□— Glyc concentration changes when the glycerol cycle is switched on; —●— NADPH concentration changes when the glycerol cycle is switched on.

A decrease of reduced NADH can be explained by a decrease of concentration of GAP in the system. Concentration of GAP reaches 0.10 *mM* during a steady state compared to average 0.40 *mM* (Nielsen et al., 1998) when the glycerol cycle is not switched on. GAP transition into 1.3-bisphosphoglycerate (DPG) is oxidized NAD^+ specific. Concentration of NAD^+ increases up to 18 fold during a steady state reaching 4.23 *mM* compared to average 0.23 *mM* (Nielsen et al., 1998) when the glycerol cycle is not switched on. An increase of oxidized NAD^+ in the system suggests that it can not be a limiting factor of decrease of reduced NADH in the system.

Nevertheless, the reduced NADH concentration is low in the system and the glycerol cycle is functioning. The main criteria to postulate that the model continuously runs the glycerol cycle are a fact that the model reaches a steady state. We would like to emphasize that the model by outflow continuously loses certain amount of concentration of species (see model of Nielsen et al., 1998). In the steady state concentration of species is produced in an equal amount as lost by outflow.

The concentration of Glyc which is a substrate of Gld2 reaction reaches 7.39 *mM* during the steady state. It shows that the reaction of Gpd1 can produce enough Glyc for Gld2 reaction. As substrate doesn't limit Gld2 reaction, the reduced NADPH is successfully produced. Concentration of reduced NADPH reaches 51.05 *mM* (see Fig. 4.) during the steady state of the model. NADPH concentration is reasonably high because none of processes or reactions consumes it as a substrate.

Conclusions

1. Results suggested that the Gld2 reaction could run even without glycolysis as long as Glyc and $NADP^+$ were present in the system. Intracellular concentration of Glyc had a direct impact on formation and accumulation of DHA. If concentration of intracellular Glyc was as high as 49.01 *mM*, then the reaction rate of Gld2 was higher than the rate of Dak1 resulting in an accumulation of DHA.
2. Deterministic simulations of glycolysis and glycerol cycle also showed significant and rapid decrease of concentration of reduced NADH in the system suggesting that it could be a limiting factor of the system. Glycolysis couldn't support enough production of reduced NADH and that also resulted in decrease of the concentration of ethanol which is one of the main products of glycolysis.
3. During simulations of the model of glycolysis and glycerol cycle concentration of reduced NADPH increased, and in a steady state concentration of NADPH reached 51.1 *mM*. This did not change over the time anymore. NADPH concentration was reasonably high because none of the processes or reactions consumed it as a substrate.
4. Nonetheless, mathematical model was built to predict possible and unknown behaviour of the glycerol cycle. Since we lacked experimental data, we did not perform validation of the mathematical model. Therefore, further research to develop mathematical model of better prediction should be carried out.

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INTERCULTURAL COMMUNICATIVE COMPETENCE

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Abstract. The aim of the study is to investigate and analyse the Model of Intercultural Communicative Competence in the Primary Schools. The investigation is based on the theoretical approach – scientific literature analysis of Intercultural Communicative Competence is done. According to that the Model of Intercultural Communicative Competence and the Competence assessment in the Primary Schools` Foreign Language (English) Lessons (for students aged 12-14) has been made. The Model of Intercultural Communicative Competence comprises Linguistic competence, Sociolinguistic competence, Discourse competence, and Intercultural competence. The developmental model of intercultural sensitivity consists of Ethnocentric stage (denial, defence, minimization), and Ethnorelative stage (acceptance, adaptation, integration). Intercultural methodology for teaching foreign languages includes Intercultural comparison, Intercultural didactics, and Intercultural Language awareness. Assessment of Intercultural communication competence shows culture understanding: empathy toward other (target) culture, ability to observe and analyse a culture, ability to communicate in the foreign (target) language.
Key words: culture, communicative competence, intercultural competence.

Introduction

In our polarized world intercultural communication takes a decisive role, and nowadays the foreign language teachers have also become teachers of culture. As the oft-quoted saying goes, the person who learns language without learning culture risk is becoming a fluent fool (Bennett et al., 2003). Culture includes the ideas, customs, skills, arts, and tools that characterize a certain group of people in a certain period of time. Intercultural competence means to overcome ethnocentrism, recognize other cultures, and provide adequate behaviour in one or more different cultures. Intercultural communicative competence means qualitative and successful communication, which takes place between two or more persons from different cultures. The role of the model of intercultural communicative competence is to acquire foreign language skills 'lack of oral proficiency may lead to a feeling of 'reduced personality'' (Harder, 1980) and provide factual knowledge as well as to enhance an awareness of cultural values and interpretations and the way they influence intercultural interaction (Jensen, 1995).

Many scientists from all over the world like M. Byram, J.A. Van Ek, J.M. Bennett, M.J. Bennett, D.L. Lange, B.D. Müller, A.A. Jensen, P. Harder, have done investigations proving the fact that acquiring intercultural communicative competence significantly improves mediating between cultures. Accordingly, the investigation described in the article is based on the theoretical approach, and scientific literature has been investigated and analysed. The results show the Model of Intercultural Communicative Competence and Competence assessment in the Primary Schools` Foreign Language (English) Lessons for students' aged 12-14. The aim is to make the model of intercultural communicative competence in the primary schools and its assessment.

Materials and Methods

A theoretical research has been done, and scientific literature has been analysed. The aim of the investigation was to analyse the scientists' researches and acknowledgements. According to that the Model of Intercultural Communicative Competence and Competence assessment in the Primary Schools` Foreign Language (English) Lessons for students' aged 12-14 is made. The model is based on understanding culture differences. The investigation was made during PhD studies at University of Aalborg (Denmark) from 28/08/2009 to 15/11/2009.

Results and Discussion

Figure 1 shows intercultural communicative competence, which includes linguistic competence (ability to produce and interpret meaningful utterances formed in accordance with the rules of the language concerned and bear their conventional meaning), sociolinguistic competence (the awareness of ways in which the choice of language forms is determined by following conditions: setting, relationship between communication partners, intention, etc., it covers the relation between linguistic signals and their contextual or situational meanings), and discourse competence (the ability to use appropriate strategies in the construction and interpretation of texts). Scientist Van Ek adds three more competences which are strategic competence (when communication is difficult we have to find ways of 'getting our meaning across' or of 'finding out what somebody means'), socio-cultural competence (every language is situated in a socio-cultural context and implies the use of a particular reference frame, socio-cultural competence presupposes a certain degree of familiarity with the context), and social competence (involves both the will and the skill to interact with others, involving motivation, attitude, self-confidence, empathy and the ability to handle social situations) (Van Ek, 1986).

The Model of Intercultural Communicative Competence

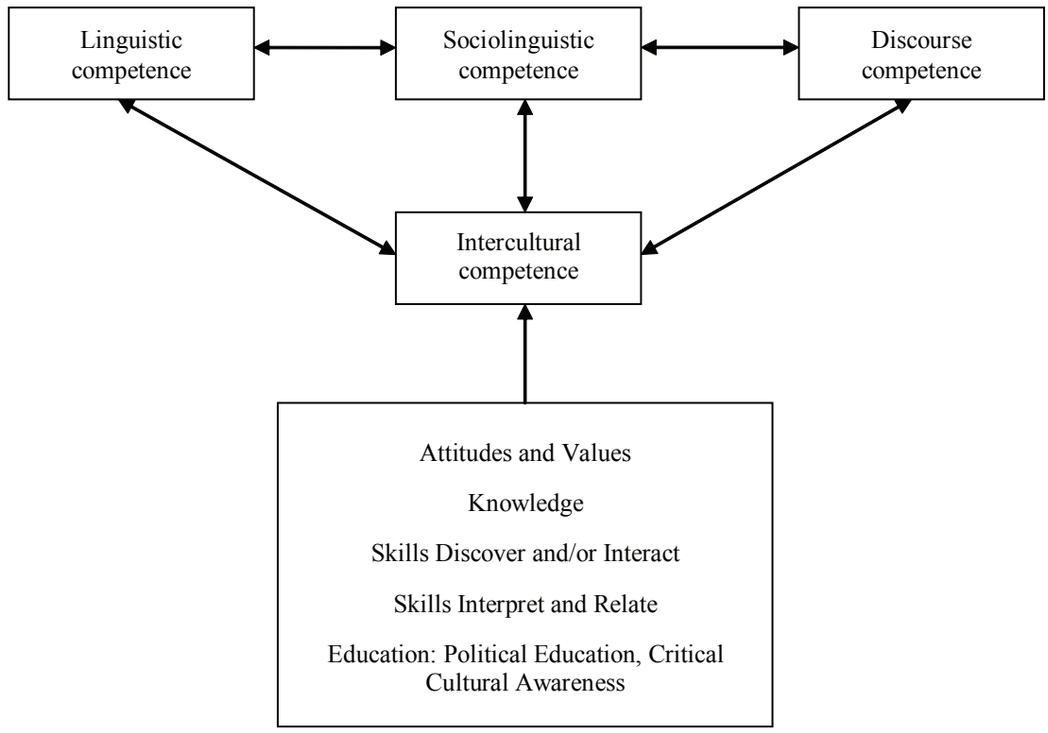

Figure 1. Intercultural Communicative Competence (adapted from Byram, 1995).

The developmental model of intercultural sensitivity leads to intercultural competence.

The developmental model of intercultural sensitivity consists of two stages: ethnocentric, and ethnorelative (Table 1). In the first stage – ethnocentric, people experience their own culture as central to reality. People avoid the idea of cultural difference as a real threat to the reality of their own cultural experience. In the second stage – ethnorelative, people recognize that all behaviour exists in cultural context, including their own. People seek out cultural differences as a way of enriching their own experience of reality and as a means to understand others.

Denial. People have not created the category of cultural difference. People from other cultures seem less human, lacking the real feelings and thoughts of one`s own kind. Cultural strangers exist as simpler forms in the environment to be tolerated, exploited, or eliminated as necessary.

Defence. People have become more adept at perceiving cultural difference while still people from other cultures still seam less human than one`s own kind. Dominates stereotypes.

Minimization. People recognize cultural variation in institutions and customs and may be interested in these differences. Still lacking cultural self-awareness, cannot see that their characterizations of similarity are usually based on their own culture.

Acceptance. People can accept the existence of different cultural contexts and can construct culture-general categories that allow them to generate a range of relevant cultural contrasts among many cultures. People respect behavioural differences; respect for value differences follows.

Adaptation. People are able to shift their cultural frames of reference, i.e., they look at the world through different eyes and intentionally change their behaviour to communicate more effectively in another culture. Appears intercultural empathy, and the result of employing empathy in an intercultural event is to generate natural behaviour that is appropriate to the target culture, i.e., adaptive behaviour emerges from successfully looking at the world from the other culture's perspective.

Integration. People extend their ability to perceive events in cultural context to include their own identity. This change in identity can be a profoundly alienating experience for people who have not been intentionally developing their intercultural sensitivity. Integration is not necessarily better than Adaptation in most situations demanding intercultural competence.

Table 1

The developmental model of intercultural sensitivity (adapted from Bennett, 1993)

Ethnocentric stages			Ethnorelative stages		
Denial	Defence	Minimization	Acceptance	Adaptation	Integration

Development of intercultural sensitivity in the language classroom.

Figure 2 illustrates the typical fit between language proficiency levels and developmental levels of intercultural sensitivity. This model of sequencing culture and language learning developmentally is for purposes of designing curriculum.

Intercultural Methodology for Teaching Foreign Languages comprises Intercultural Comparison, Intercultural Didactics, and Intercultural Language Awareness. Each of these stages includes various exercises (Table 3), which help students to acquire high level of intercultural communicative competence. An intercultural methodology for teaching foreign languages requires intercultural stance. Exercises should be interculturally oriented and make intercultural progression, i.e., it goes beyond purely linguistic goals and aims at imparting intercultural competence through foreign language teaching. Acquiring intercultural communicative competence demands new learning strategy, which makes foreign cultural meanings the object of study at all possible levels of learning, thus enabling the students to correlate constructively these meanings with their own culture specific frames of reference (Müller, 1995). Comparison is a rather elementary cognitive operation of analogy and opposition, which leads to new insights, new experiences and knowledge about one`s one and foreign (target) culture.

Intercultural Didactics is used in multi-cultural groups where specific bicultural situation comparing culture 1 (C1) with culture 2 (C2) cannot be taken as a basis without making a number of students feel left out. In this instance one can contrast a foreign

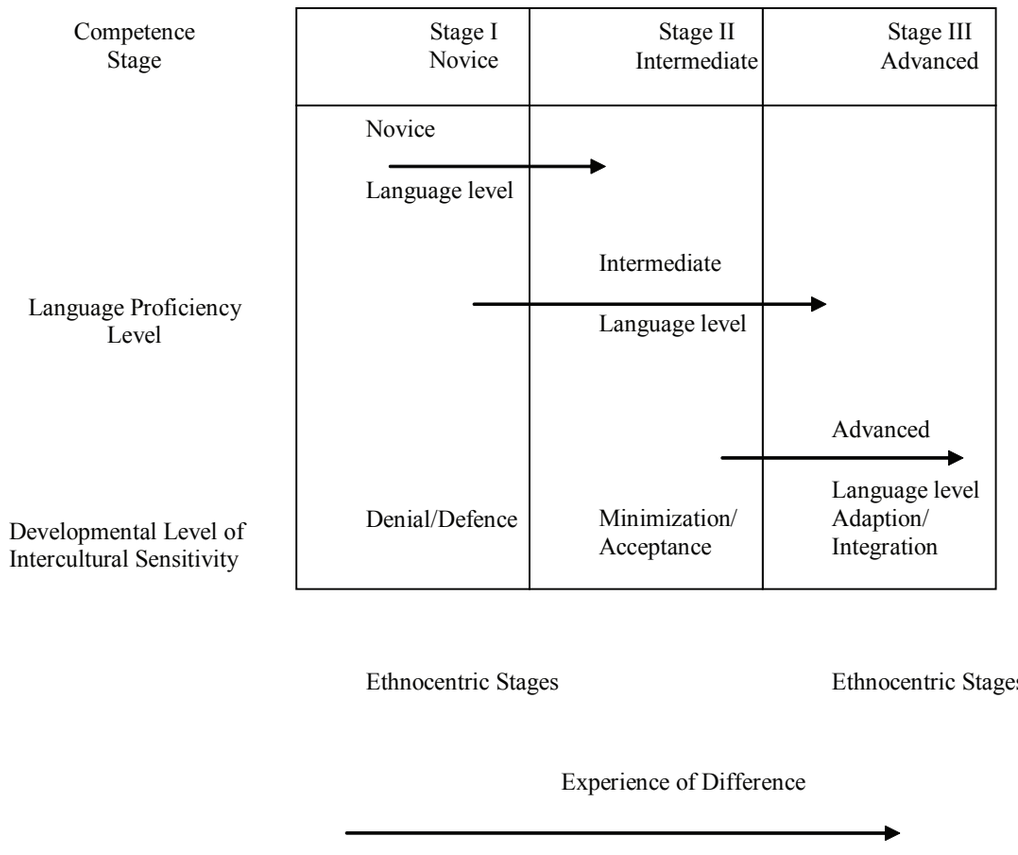

Figure 2. Development of Intercultural Sensitivity (Bennett et al., 2003).

Table 3

Intercultural Methodology for Teaching Foreign Languages (adapted from Müller, 1995)

Intercultural Comparison	Intercultural Didactics	Intercultural Language Awareness
Individual Comparisons: -semantic units; - features.	The Foreign Perspective.	Meanings.
Etiquette.	Fictitious Foreign Perspective.	Speech Acts.
Traditions and Customs.	Contrast Culture Approach.	Nonverbal Clues.
Anecdotes in Target Culture.		Registers.
Behavioural and Semantic Comparison.		Paraverbal Communication: - intonation (the melody of utterances); - volume and its variations; - modulation of pitch (high, low); - pauses.

culture C2 with another, fictitious foreign culture C3. Thus students can look at differences between their own culture C1 and C2 or C3. It is precisely the fictitious relationship between C3 and C2 which should encourage students to mull over how their own culture would look if contrasted with C2.

Intercultural Language Awareness. Exercises for intercultural foreign language teaching can be classified according to various criteria. One way is to order them in a scheme, which attracts teachers` attention to language and culture being interwoven. The scheme aims at promoting intercultural language awareness of cultures (LAC). In everyday situations where people with different cultural backgrounds interact, cultural differences are 'hidden' in linguistic manifestations. It comprises with Communicative style including rules of para-verbal, non-verbal and verbal expressions of meaning and intentions build, as a set of rules, communicative styles.

Assessment of Intercultural Communication Competence (Lange, 2003). To assess the Intercultural Communicative Competence you have to observe following steps (Figure 3): empathy toward other or target culture, ability to observe and analyse a culture, and ability to communicate in the foreign or target language. Besides, each of the areas of competence is locked into four levels:

- Stage 1: Elementary
- Stage 2: Basic Intercultural Skills
- Stage 3: Social Competence
- Stage 4: Socioprofessional Capability

Conclusions

1. Foreign language and culture studies are inseparable. Language cannot be taught without studying the culture.
2. Acquiring intercultural communicative competence requires profound knowledge of one`s own culture.
3. Different culture studies enrich student`s own perspectives.
4. Acquiring intercultural communicative competence demands new learning strategy.
5. Intercultural Communicative Competence involves knowledge, skills and abilities for qualitative and adequate behaviour in the Target Culture.

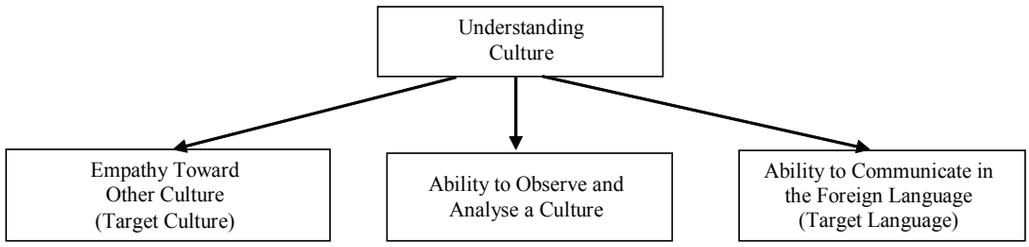

Figure 3. Culture and Language Assessment.

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THE SUBJECT OF INFORMATICS FOR PUPILS' UNDERSTANDING OF TASTE

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Abstract. Informatics is profoundly reshaping social relations and changing pupils' education. A goal was set to offer the pupils an integrated informatics learning content, orientated to develop an emotionally and intellectually equilibrated and harmonic personality. The aim of the paper is to characterize the integration in the content of the subject of informatics and research the realisation of integrated learning material in educational practice. Subjects in the school curricula provide concrete guidelines on knowledge, skills and attitudes that should be taught and what goals and purposes their education program follows. To establish the understanding of pupils on development of taste in integrated informatics subject, an educational experimentation was conducted. The data are obtained by using a pretest-post-test design and analysis of teaching-learning informatics in classroom. Pupils at Lielvarde secondary school were asked to involve for learning a new integrated informatics material for developing their understanding of taste. The method of analysis of aesthetic and pedagogical literature and data processing and analysis by Wilcoxon signed-rank Test and Chi-square test are used. Pupils undertook independent practical tasks at the computer with the aim of developing their knowledge and cognitive skills (understanding, selection, reflection). Learning integrated informatics material is a pedagogical condition for fostering the development of pupils' understanding of taste. Learning integrated informatics material executed diverse practical tasks with choice of color match, ethnographic characters and making a portfolio which enriched pupils' experience of taste and effectuated as acquisition of their cognitive skills.
Key words: taste, integrated approach, cognitive skills, understanding, selection, reflection.

Introduction

Informatics is profoundly reshaping social relations and changing pupils' education. The requirements of subjects in the school curricula are defined in educational standards and reflect the amount of study contents appropriate for the subject (Vispārējās izglītības likums, 1999). Informatics is a general study subject with the aim of conveying knowledge and skills for personal growth and development in mental, emotional and physical planes, as well as fostering the ability for independent learning (MK noteikumi Nr.715, 2008). The main task of informatics subject is to offer knowledge, develop skills of the pupil in use of the ICT, enhancing the awareness of cultural values and national identity. In Latvia there is no unified program of informatics study subject but guidelines for structure, formation and requirements' system exist.

The concept of informatics as digital environment describes the virtual educational space of the individual's relation to the information (Kopper, 2000). As the individual receives information the mind consisting of cognitive structures is unable to process the information into knowledge. Integrity of the cognitive and the affective in the system of counterbalancing mind and feelings is summed up in connection with developing pupils' personality in the frame of education (Vygotsky, 1978).

According to activity theory the individual's actions in the physical world both in social and practical situations are forming the basis of experience. 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 instrument for his/her object-orientated actions (Vygotsky, 1978). L. S. Vygotsky accented two aspects of experience as the factor of the formation of new knowledge and culture (Vygotsky, 1978).

W. Dilthey argued that experience is a starting point of cognition and demonstrates an attitude to the world. He suggested that all human experience divides naturally into two parts: that of the surrounding natural world, in which objective necessity rules, and that of inner experience, characterized by sovereignty of the will, responsibility for actions, a capacity to subject everything to thinking and to resist everything within the fortress of freedom of his/her own person (Dilthey, 2000).

Theorists argue that skills, values and understandings are best taught and assessed within meaningful, connected contexts (Čehlova and Grinpauks, 2003). Integrative approach to subject design planning is based on both philosophy and practicality. Integration is a philosophy of teaching in which content is drawn from several subject areas to focus on a particular topic or theme (McBrien and Brandt, 1997). Such approach purposefully draws together knowledge, skills, attitudes and values from within or across subject areas to develop a more powerful understanding of key ideas.

Subjects in the school curricula provide concrete guidelines on skills, knowledge and attitudes that should be taught and what goals and purposes their education program follows. A subject program includes description of the guidelines, methods and the required amount of study content. Pedagogy researcher R. Andersone argues that informatics as a subject is characterized by its integrity, which is an important factor for developing an educational content (Andersone, 2007). Observing the necessity for meeting the educational standards, a goal was set to offer the pupils the integrated informatics subject

content, orientated to develop an emotionally and intellectually equilibrated and harmonic personality connected with the pupils' understanding of taste.

Through integration teachers can plan for the development of key skills and understandings that transcend individual subjects. Themes are used based on interdependent knowledge and skills from more than one subject area. Choosing meaningful connections among subject areas helps pupils build on their knowledge and experience, supports their holistic view and ensures more meaningful learning and focus more clearly on conceptual understanding (Forbes, 2003). The education at school is structured as professionally orientated process with organisational, methodical and didactic system including selection of educational content. Latvia General Education Law in 19th paragraph states to create educational subject program by person employed to teach (Vispārējās izglītības likums, 1999). The pupils' personal meanings are enhanced by the integration of cognitive and affective domains with knowledge, skills and experience.

The aim of the paper is to characterize the integration in the content of the subject of informatics and research the realisation of integrated learning material in educational practice.

Materials and Methods

To establish the understanding of pupils on development of taste in integrated informatics subject, an educational experimentation was conducted. The essential feature of educational experiment is that investigators manipulate the conditions which determine the process of teaching-learning informatics in classroom. The researchers wished to find out whether the learning a new teaching material based on integrated approach for informatics they had designed would effect changes in the pupils' understanding of taste.

L. Cohen and L. Manion draw attention to the features of pre-experimental design in educational experimentation in classroom settings as the one group pretest-post-test design (Cohen and Manion, 1994). The data are obtained by using a pretest-post-test design and analysis of teaching-learning informatics in classroom. During 2009/2010 academic year, 46 pupils at Lielvarde secondary school were asked to involve in the use for learning a new integrated informatics material for developing their understanding of taste. The method of analysis of aesthetic and pedagogical literature and data processing and analysis by Wilcoxon signed-rank Test and Chi-square test are used.

Results and Discussion

The data on pupils' understanding of taste in teaching-learning experiment of integrated informatics subject are obtained before and after informatics lessons which integrated separate visual arts and history of culture themes. According to the requirements of the informatics standard, the pupils undertook independent practical tasks at the computer with the aim of developing their knowledge and cognitive skills. Simultaneously, to foster the aesthetic interest on learning a new integrated informatics material, ethnographic characters (history of culture) and rules of color match (visual arts) were used projecting the newly acquired knowledge onto the development of pupils' understanding of the meaning of taste.

The first part of educational experiment involved observing the effect of learning a new integrated informatics material for making a change in pupils' knowledge about:

- history of culture (ethnographic characters),
- visual arts (color match),
- logo,
- portfolio,
- meaning of taste.

A hypothesis was made that the pupils' knowledge in history of culture about ethnographic characters before the onset and after completion of learning integrated informatics material was different.

Table 1

Pupils' responses in the number of quality before and after learning experiment

	Grade 10	Grade 11
Large random number Z	-0.784[a]	-2.45[a]
Asymptotic Significance (2-tailed) p-value	0.433	0.006

As 10th grade p-value=0.433>0.05, then with probability of 95% hypothesis cannot be rejected. This means that 10th grade pupils' knowledge in history of culture about ethnographic characters before and after the learning experiment is the same. As 11th grade p-value=0.006<0.05, then with probability of 95% the hypothesis can be rejected. This means that 11th grade pupils' knowledge in history of culture about ethnographic characters before and after the learning experiment differs. The difference is to be explained with higher accomplishments of the 10th grade pupils in learning in general and with their interest in history of culture and Latvian ethnographic characters in particular.

Learning integrated informatics material offers to pupils to use the knowledge on color match, acquired in visual arts subject. A hypothesis was made that use of knowledge on color match, acquired in visual arts before the onset and after completion of learning integrated informatics material was different.

Table 2

Pupils' responses in the number of quality before and after learning experiment

	Grade 10	Grade 11
Large random number Z	-2.232[a]	-1.513[a]
Asymptotic Significance (2-tailed) p-value	0.026	0.130

As 10th grade p-value=0.026<0.05, then with probability of 95% hypothesis can be rejected. The

use of the knowledge acquired in the visual arts on color match in informatics subject before and after the learning experiment was different. As 11th grade p-value=0.130>0.05, then with probability of 95% hypothesis cannot be rejected. This indicates that use of the knowledge acquired in the visual arts on color match in informatics subject did not differ before and after the learning experiment. The 10th grade pupils are not, at the current moment, able to relocate their acquired knowledge in visual arts onto the acquisition of informatics. But for 11th grade pupils, the earlier acquired experience in informatics proved to be of use in applying the acquired knowledge on color match in order to complete the given practical tasks.

Learning integrated informatics material offers to pupils to use the knowledge about logo. A hypothesis was made that use of the knowledge of pupils about logo before and after learning integrated informatics material was different.

Table 3

Pupils' responses in the number of quality before and after learning experiment

	Grade 10	Grade 11
Large random number Z	-0.673[a]	-2.658[a]
Asymptotic Significance (2-tailed) p-value	0.501	0.008

As 10th grade p-value=0.501>0.05, then with probability of 95% hypothesis cannot be rejected. This indicates that 10th grade pupils' knowledge about logo before and after the learning experiment was the same. As 11th grade p-value=0.008<0.05, then with probability of 95% hypothesis can be rejected. This indicates that 11th grade pupils' knowledge about logo before and after the learning experiment differs. Pupils in 10th grade are well-read and had already earlier understood the meaning of a logo, but 11th grade pupils were surprised by the new knowledge; introduction of logo as a practical task in learning integrated informatics material was expressed as interest and satisfaction about acquisition of practical result.

Learning integrated informatics material offers to pupils to use the knowledge about portfolio. A hypothesis was made that the number of pupils' answers on portfolio before and after completion of learning integrated informatics material would be distributed evenly.

Table 4

Pupils' responses in the number of quality before and after learning experiment

	Before learning	After learning
Chi-Square[a]	6.333	5.333
Degrees of freedom	2	2
Asymptotic Significance p-value	0.042	0.069

As p-value=0.042<0.05, then with probability of 95% hypothesis can be rejected. This indicates that before the learning experiment the number of answers on portfolio was not evenly distributed and the answer 'no' prevails. As p-value=0.069>0.05, then with probability of 95% hypothesis cannot be rejected. This indicates that after the learning experiment the number of pupils' answers on portfolio is evenly distributed and answers 'yes' and 'partly' are shared. During lesson pupils showed joy and interest in the ongoing task. Research data allows to conclude that in learning informatics subject, pupils acquired new knowledge on portfolio and understood its personal importance (see Fig. 1).

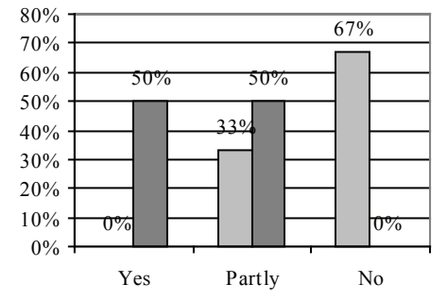

Figure 1. Pupils' knowledge on portfolio:

The learning integrated informatics material involved the changes on pupils' knowledge of the meaning of taste. At the end of educational experiment most pupils of 10th grade (64%) and 11th grade (72%) reported having accepted the meaning of taste and being able to verbalize the essence of this concept (see Fig. 2).

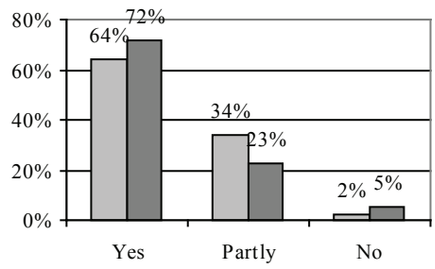

Figure 2. Pupils' knowledge of the meaning of taste:

The second part of educational experiment involved observing the effect of learning a new integrated informatics material for making a change in pupils' cognitive skills for:

- understanding,
- selection,
- reflection.

A hypothesis was made that pupils' understanding of ethnographic characters before and after completion of learning integrated informatics material was different.

Table 5

Pupils' responses in the number of quality before and after learning experiment

	Grade 10	Grade 11
Large random number Z	-2.058[a]	-2.372[a]
Asymptotic Significance (2-tailed) p-value	0.040	0.018

As 10th grade p-value=0.040<0.05 and 11th grade p-value=0.018<0.05, then with probability of 95% hypothesis can be rejected. This indicates that in both grades pupils' understanding on ethnographic characters before and after the learning experiment is different. 10th grade pupils as well as 11th grade pupils enjoyed Latvian ethnographic characters, a part of which had been introduced during the history of culture course, but had already been forgotten. The integration of ethnography in learning informatics material produced an activating effect in the lessons and deepened pupils' understanding on the values of Latvian national culture.

Pupils' skill to select ethnographic characters for a personal logo differs between the 10th grade and 11th grade pupils. At 10th grade only 36% of pupils report being able to select ethnographic characters for the personal logo, but at the 11th grade already 54% pupils report being able to do so. Pupils' skill to select is determined by their subjective interests, psychological state of being, amassed experience and joy about the practical task.

Pupils' skill to reflect on color match for using ethnographic characters for a personal logo differs between the 10th grade and 11th grade pupils. At 10th grade only 37% of pupils are reflecting and undertake the necessary corrections to match colors for presentation a personal logo. At 11th grade 55% of pupils make use of the skill to reflect on color match for such presentation. It was observed that pupils are not afraid to try out different color combinations too. Differences in the skill to reflect can be explained with insufficient use of integrated skills in the educational process.

Pupils' reflection on color match for making a tasteful portfolio before and after completion of learning integrated informatics material was evenly distributed.

Table 6

Pupils' responses in the number of quality before and after learning experiment

	Before learning	After learning
Chi-Square[a]	6.333	9.333
Degrees of freedom	2	2
Asymptotic Significance p-value	0.042	0.009

As p-value=0.042<0.05, then with probability 95% hypothesis can be rejected. This indicates that before the learning experiment pupils' reflection on color match for making a tasteful portfolio is not evenly distributed and answer 'no' predominates. As p-value=0.009<0.05, then with probability 95% hypothesis can be rejected. This indicates that after the learning experiment pupils' reflection on color match for making a tasteful portfolio is not evenly distributed and the answer 'yes' predominates. Data confirm that the learning integrated informatics material not only develops reflection skill but also enriches pupils' experience on taste by evaluating the aesthetic properties of the portfolio, finding structural coherences and realizing a tasteful design.

Research data allow to conclude that learning integrated informatics material developed pupils' reflection on creation of a tasteful portfolio (see Fig. 3).

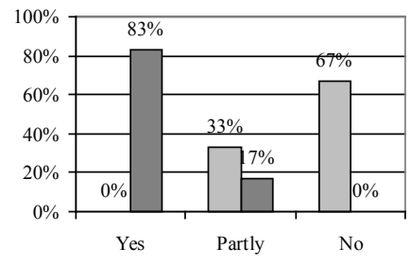

Figure 3. Pupils' reflection on creation of a tasteful portfolio:

Learning integrated informatics material included practical work with the computer with means that were though to evoke positive emotion in pupils – joy and elation, also surprise about the color match rules and explanation possibilities of ethnographic characters, hereby rendering the informatics learning content more interesting.

A matter of taste is subjective matter of experience lacking any claim to normative. This concept may refer merely to the preferences and experience of individuals. Taste as an aesthetic concept is the sense of what is appropriate, harmonious, or beautiful; taste as sociological concept refers to a cultural patterns of choice, preference and experience; aesthetic preferences to various cultural events are associated with education (Bourdieu, 1984). In 18th century, I. Kant developed a theory of taste which privileges the concept of beautiful. The four possible reflective judgments of taste (the agreeable, the beautiful, the sublime, the good) established the very basis of the Kantian theory as the systematic structure of aesthetic ideas in connection with artistic beauty, natural beauty, and morality (Kants, 2004). Contemporary theorist P. Bourdieu argued that an individual's notions of what is tasteful are determined more by social standing than any special ability to experience and appreciate the sensory, aesthetic, or social world (Bourdieu, 1984).

H. G. Gadamer pointed out that the taste was thought of as a special way of knowing. Moreover, taste was not a private but a social phenomenon and was not limited to the realm of the aesthetic, but also encompassed morality in which significance is thought to be grasped in an individual case (Gadamers, 1999). H. G. Gadamer took the experience of beautiful to be a central to an understanding of the nature of art. He argued that aesthetic judgment had become purely a matter of taste, but understanding is an event or experience that we undergo (Gadamers, 1999).

Color impact is being underlined in physiological and psychological, as well as aesthetic aspect, acquiring a visual, psychologically emotional and symbolical effect (Ozola, 2006). The photoreceptors' in human eye translate light waves of different lengths into colors in the human perception system, enabling the color vision which is essential for humans to perceive everyday objects as beautiful (Holtzschue, 2006). I. Kant wrote about color as the crucial element of the aesthetic perception (Kants, 2004); this view in 20th century was supported by Russian researcher J. Borev (Борев, 1988). N. Serov described color language as a language of symbols with many meanings which is not being used sufficiently (Серов, 2004), and in the field of art pedagogy, J. Anspaks noted that colors and shades reveal the hidden part of the life of mind – the world of emotion (Anspaks, 2004).

Psychology notes on the human subconscious that the primary form of perception is the one of color and form is secondary (Skinner, 2003). Choice of color is moderated by two factors, which are direct (objective factors) and associative (subjective factors) in their effect (Kraukle, 2006). Associative effect of colors is being used as an indicator to classify and evoke a wide spectrum of emotional responses (Kress and Leeuwen, 2002). In education, not always a fact is being acknowledged that the color perception between people is not the same. Almost 8% males and 0.5% females suffer from color vision deficiency (Forsyth, Ponce, 2002).

Two different emotions as joy and interest were chosen because both positive emotions appear to be distinct from one another, as well as recognizable. Joy is often used interchangeably with happiness and shares with other high-arousal positive emotions such as amusement, exhilaration, elation and gladness. Joy creates the urge for play and can have the incidental effect of building pupils' cognitive and social skills (Holland, 1982).

Interest is sometimes used interchangeably with curiosity, intrigue, excitement, or wonder. Interest arises in contexts appraised as safe and as offering novelty, change, and a sense of possibility. Interest is the primary instigator of personal growth, creative endeavor, and the development of intelligence. The momentary thought-action tendency sparked by interest is exploration and actively aimed at increasing knowledge of and experience with the target of interest (Ainley, 2007). Researcher A. Vorobjovs notes that a basis of sustained interest is a positive emotional state, which is effectuated by the satisfaction of important needs for a human being as well as success in one's activities (Vorobjovs, 1996).

Conclusions

1. Learning integrated informatics material is a pedagogical condition for fostering the development of pupils' understanding of taste.
2. Learning integrated informatics material executed diverse practical tasks with choice of color match, ethnographic characters and making a portfolio which enriched pupils' experience of taste and effectuated as acquisition of their cognitive skills (understanding, selection, reflection).
3. Learning integrated informatics material is characterized by pupils' interest and positive emotions (joy, elation, surprise).

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THE PRINCIPLE OF EXEMPLARITY AND ITS USAGE IN THE STUDIES OF GEODESY

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Abstract. The aim of the study: to analyse the principle of exemplarity, comprehend its features and their usage in university exact courses learning practice. The principle of exemplarity is a means of arranging the geodesy study course programme according to the most essential notions of the course and students abilities and knowledge level at the Latvia University of Agriculture. It is one of the cognitive learning didactical principles proponed by the German scientist Martin Wagenschein and recognised in a teaching/learning process particularly in natural sciences. The origination of the principle of exemplarity, its relevant features and experience of other countries are analysed in the article. The following notions of the principle are analysed in the article: coping with information quantity, comprehension of a course entity and epistemology, interdisciplinarity; usage of exemplar as a feature of entity criterion in obtaining particular knowledge and skills; traits of Socratic dialogue. The principle of exemplarity is combined with problem-based learning, project method and student-centred approach and is used and discussed particularly in Germany and Denmark. The principle features and the ideas of its usage are being assessed, worked in and implemented in the geodesy study course programme for the land survey speciality first year students. The programme is revised thematically determining the focal themes (exemplars) in laboratory works via which the principle of exemplarity can be the means of obtaining the course of geodesy successfully.
Key words: the principle of exemplarity, studies of geodesy, exemplars.

Introduction

The principle of exemplarity is of high importance in nowadays didactics because it is one of the means which helps to cope with large quantity of information, promotes critical thinking and understand totality in relevancies with the subject matter and science development of the age. The principle in several works introduced the German scientist, educator, mathematician, and physicist Martin Wagenschein (1896–1988). He started his publications on the notion of exemplarity as a way out of constantly growing quantity of information in school subjects and a curriculum load in general education in the 50s of the 20th century. It became impossible to teach qualitatively a mass of subject matter and M.Wagenschein proponed the ideas of restructuring teaching/learning themes in exemplars (Wagenschein, 1956). The idea of exemplarity proposes restructuring of the curriculum in a few basic structures which serve as bench-marks for other items of the curriculum.

His idea was that students get a conception of the subject and understand its structure as well studying deeply and widely several focal items (exemplars by Wagenschein) which represent the subject's essence. Subject knowledge and fundamental cultural values can be experienced and understood on the basis of the concentrated studies of an exemplar.

A teacher has to use the didactics so that the exemplars reflect the entity (the whole beyond a particular item/theme/case) of the subject. It is the main criterion for the exemplar.

Wagenschein's principle of exemplarity exceeds the borders of a particular study subject knowledge and skills because the principle promotes the development of critical thinking and this attribute has an important social value. Critical thinking is one of the features of democracy and a means of multisided valuation of phenomena.

His ideas opposed structuralism in curriculum building and promoted critical view on isolated subject teaching and learning. He defended the position of teaching/learning as a part of culture and as a part of socioeconomic and political processes.

M. Wagenschein's ideas developed in project works providing perspectives on the study of mathematics and natural sciences for the 21st century (International Handbook of Mathematics Education, 1997; Blomhøj and Kjeldsen, 2009; Vithal et al., 1995).

LLU geodesy study course programme themes have been revised according to the principle of exemplarity in a two-year period and are being developed considering the features of entity and interdisciplinary.

The aim of the study: to analyse the principle of exemplarity, comprehend its criteria and their usage in university exact courses learning practice.

Materials and Methods

The object of the study was the content of the course of geodesy. The objective of the study was to change the course according to the principle of exemplarity.Two main features of the principle were used simultaneously: entity and interdisciplinary.

The content of the course of geodesy considering the principle of exemplarity was designed according to the following steps:

1) to analyse the course choosing the focal themes (exemplars) considering entity, scientific coherencies, objectives of the course;
2) to group other themes around the focal themes;

3) to choose the range of the themes;
4) to find out themes which link other themes together;
5) to stress interdisciplinary aspect of the themes;
6) to choose the ways which promote students to investigate the theme historically.

The principle of exemplarity in geodesy course studies became topical mainly because of the discrepancies in time limit and quantity of the material which should be taught. The time limit created serious problems of the quality of the programme completion, and it is the first problem in the study process. Students do a lot of independent work in theory using various sources. As regards laboratory works, they have to do them in labs and they are planned paralelly to lectures.

The second problem in relation to the curriculum planning is the following: successful carrying out of laboratory works is based on theory which should be delivered and comprehended during lectures. The lectures are delivered for all the target student groups but laboratory works are organised in different times, which makes the sequence theory-practice more complicated.

Considering the author I. Bīmane's long years experience in geodesy course delivering it is possible to assert that one of the best problem solutions is the usage of the principle of exemplarity. It means focussing on particular exemplars versus traditional themes sequence in a text-book in laboratory works planning.

The study process of geodesy is organized traditionally: lectures, laboratory works, and two weeks practice in summer. Depending on an assignment, students carry out laboratory works in small groups or individually. Students accomplish individual graphical assignments, hereto each student has a distinctive version. The tasks of the laboratory works are prepared in order to accomplish them successively one after another, and the students comprehend the process of surveying, their coherence and necessary exactness. Needed theory and the process of the task accomplishing is talked and repeated before a running work, hereto the students are motivated to engage in a dialogue with a lecturer. It is very important to be a skilled assessor of the result, e.g. exactness of measuring or completion of necessary controls of analytical tasks. That is a way for students to develop their logical and critical thinking.

Works where geodesy instruments are used students accomplish in groups of three or four. The participants of the groups can be changed by the students' choice next time. Every student writes a report on the works accomplished and submits to a lecturer a completed calculation or graphic work which is also a basis of the work acceptance.

Students organize groups of five or six participants in each by their choice at the beginning of a practice. The students do not change the groups during the practice. A leader of each group is responsible for all the work organization and discipline during the practice. The accomplishment of the practice tasks is a collective

Table 1

The sequence of laboratory works according to the text-book (Helfriča et al., 2007) of geodesy

No.	Themes of laboratory works
1.	Transversal scale construction.
2.	Theodolite lymb reading instruments.
3.	Theodolite controls.
4.	Horizontal angle and magnetic azimuth measuring by theodolite.
5.	Vertical angle measuring.
6.	Levelling instrument control.
7.	Geometric levelling line.
8.	Conversion from point orthogonal coordinates to polar coordinates or reverse geodesic exercise.
9.	Calculation of polygon orthogonal coordinates.
10.	Polygon construction in a plan according to the calculated coordinates of a right angle.
11.	Calculation of theodolite line among coordinated points.
12.	Calculation of the point right angle coordinates with the direct intersection.
13.	Drawing of a situation plan by a sketch and its designing by topographic symbols.
14.	Mechanical fixation of land areas in a plan by a planimeter.
15.	Calculation of a route's profile lengthwise levelling field book.
16.	Drawing up and designing of a profile lengthwise.
17.	Calculation of an earth's surface levelling field book.
18.	Drawing up of a contour plan.
19.	Exercises in a contour plan.
20.	Fixation of tachymetric horizontal distances and elevations.
21.	Calculation of a tachymetry survey field book.
22.	Drawing up of a tachymetry plan.

business therefore the practice documentation is only one copy per group. All the group participants defend their practice simultaneously and the students assess their practice themselves. Actually the practice mark is get considering both the practice leader and the students' assessment.

Results and Discussion

The sequence of laboratory works according to the material thematic sequence in the text-book of geodesy (Helfriča et al., 2007) is given in Table 1

The sequence of laboratory works according to the principle of exemplarity considering the features of entity and interdisciplinary had been changed in study years 2008/2009 and 2009/2010 (Table 2).

The lowest geodesy quite often is called also as a practical geometry. Therefore for explanation and solving of geodesy exercises often is almost enough with knowledge of mathematics obtained at school, particularly in geometry and trigonometry. One of such type of exercises is "Calculation of polygon orthogonal coordinates" using the measured horizontal angles and side lengths. This exercise corresponds well to the principle of exemplarity because basing on students knowledge of mathematics it is possible to explain concepts on line orientation in geodesy, exactness of measurements, coordinate projections, point coordinates, etc., simultaneously. Hereto „Calculation of polygon orthogonal coordinates" is given simultaneously with "Calculation of theodolite line among coordinated points", because both exercises differ minimally.

One more theme in compliance with the principle of exemplarity is "Exercises in a contour plan". Students get a conception on a land surface conformation, its mapping in plans and on land elevations by means of the exercise. A line gradient is calculated on a topographic plan, composed profile lengthwise as well as completed other exercises.

During the process of comprehending and completing the above mentioned exercises, the interdisciplinary of geodesy is studied because it is related to mathematics, physics and other disciplines.

It is very important to understand the complexity of the course of geodesy in the process of its acquiring because the geodesy works is the whole complexity. Its peculiarity is in actions sequence, and the actions are not possible apart by themselves at the same time. Measuring is possible only by means of geodesy instruments therefore students learn their construction, testing, and history of production, as well as get to know about nowadays advanced instruments and technologies. Here arise the rest aspects of the principle of exemplarity: acquiring of the course getting knowledge also about the development of humanity and culture, holism and humanistic values. Students

Table 2

The sequence of laboratory works according to the principle of exemplarity considering the criteria of entity and interdisciplinary

No.	Themes of laboratory works
1.	***Calculation of polygon orthogonal coordinates*** **.***
2.	Calculation of theodolite line among coordinated points.
3.	Transversal scale construction.
4.	Theodolite lymb reading instruments.
5.	Polygon construction in a plan according to the calculated coordinates of a right angle.
6.	***Drawing of a situation plan by a sketch and its designing by topographic symbols .****
7.	Theodolite controls.
8.	Horizontal angle and magnetic azimuth measuring by theodolite.
9.	Drawing of a situation plan by a sketch and its designing by topographic symbols.
10.	***Mechanical fixation of land areas in a plan by a planimeter.****
11.	Conversion from point orthogonal coordinates to polar coordinates or reverse geodesic exercise.
12.	Calculation of the point right angle coordinates with the direct intersection.
13.	Calculation of a route's profile lengthwise levelling field book.
14.	Calculation of an earth's surface levelling field book.
15.	Drawing up and designing of a profile lengthwise.
16.	***Exercises in a contour plan.****
17.	Calculation of a tachymetry survey field book.
18.	Drawing up of a contour plan.
19.	Drawing up of a tachymetry plan.
20.	Fixation of tachymetric horizontal distances and elevations. Measuring of vertical angles.
21.	Levelling instrument control.
22.	Geometric levelling line.

* exemplars

comprehend that their knowledge will be a means for meeting both an individual and society needs. The students are motivated to think critically in the course of geodesy, to participate in a dialogue actively and find out solutions in the case of problems appearance. It approves the elements of Socratic learning as one part of the principle of exemplarity.

M. Wagenschein described the principle of exemplarity in several works. O. Skovsmose (1994) characterised his principle by means of epistemic approach using epistemic objects and subjects and their relations. „First, the epistemic object: a specific phenomenon can reflect a totality. This idea condenses a holism: a total complexity can be present in a single aspect of that complexity. M. Wagenschein examplifies this in different ways: a fundamental feature of human history can be present in a single historical event; a particular natural phenomenon can comprise a whole set of natural phenomena. M. Wagenshein emphasizes that an individual phenomenon is not a step towards a totality but it is a mirror of that totality" (Skovsmose, 1994).

The second thesis defends the idea that it is possible to understand the whole complexity concentrating on a particular aspect. The general and complex things can be comprehended via the particular. The idea of exemplarity opposes a detailed structuring of the curriculum. O. Skovsmose (1994) explains that looking for complexity in particular is emphasized by means of the principle of exemplarity instead of simplification, e.g. concentrating on the theorem of Phitagoras students can obtain a global understanding of geometry. Via the theorem there is an entrance in the whole subject, interdisciplinary aspect and in a science. To M. Wagenschein, interdisciplinary is the result of an absorption which starts from a particular but „opening" question.

The third thesis manifests the idea that the subject in his or her totality can be caught, shaken or absorbed by a specific question. Therefore curiosity is being aroused and proceeds from opening questions and problems towards the interdisciplinary totality of values of humanity.

„The advantage of the notion of „exemplarity" is that it extends between the concrete situations of educational practice and philosophical interpretations of „reality", „knowledge", and „person"" (Skovsmose, 1994).

Teaching and learning according to the principle of exemplarity means revision of the choice of: teaching/learning material, methods, putting forward new didactical aims for classes (Wagenschein, 1965).

M. Wagenschein's ideas are supported also from Russian scientists (Васильева, 1991; Иванова, 2001), e.g. describing four main features of the principle of exemplarity: thematic rather than systematic acquiring of study material considering the students' interests; the usage of heuristic and problem-based methods which promote the development of students creative thinking; thematic choice and heuristic method is a prohibition of cumulative linearity and dogmatic material delivery which is the identification of study process and science; the study process should be creative and educational rather than focussed on getting ready and non-discutable knowledge (Васильева, 1991).

M. Wagenschein (1968) also described a teaching/learning process by means of the principle of exemplarity, which manifests itself in three ways: genetic, Socratic, exemplaric.

Genetic learning means finding out basic principles of a comparatively simple theme and usage of the knowledge got for discovering further coherences.

The features of genetic learning are the following: usage of bright phenomena (subjects, artefacts, events, etc.) and exposition; presence of actuality; presence of emotions, motivation and adventure (experience).

M. Wagenschein (1968) particularly stressed the importance of Socratic dialogue, and also according to M. Lipman et al. (1980) a dialogue is the main method among a pedagogue and pupils mentioning Socratic dialogue as an appropriate example. Listening attentively is very important during the dialogues and such kind of listening means also thinking because of aspirations to understand a speech of the second person and assess his/her conclusions.

Clear speech also is of great importance because it also is based on thinking – a speaker has to choose words with the purpose to substantiate understanding of a situation or phenomenon.

M. Lipman et al. (1980) views that the dialogue method is complicated enough because a teacher should be intellectually open towards pupils, well-informed and with a tendency to get new knowledge, self-critical and brave enough to recognise also lack of knowledge. The teacher has to respect views of every pupil.

A dialogue means looking for answers, art of discussions and also exposition of ideas in front of the audience. Therefore it is a relevant method for the future university graduates because they will be leading specialists and will co-operate with various specialist and non-specialist groups.

As regards exemplars they are the main themes or „islands" among other themes. The exemplars are the themes which logically group around them other themes and allow to implement the feature of entity, interdisciplinary, problem-based learning, student-centred approach, genetic and Socratic learning.

The principle of exemplarity is being used in Germany, Denmark and is known and investigated in other European countries as well both in general and tertiary education. It is used in project works and is combined with problem-based learning in many cases, particularly in exact sciences.

Project works in mathematics are popular in European universities and they comprise problem-based studies, interdisciplinary, participant-directed studies, the principle of exemplarity, etc. (Vithal et al., 1995).

Project works were carried out at Aalborg University (Denmark) and Roskilde University outlining a valuable experience in mathematics and

natural sciences teaching/learning perspectives both for teachers and students. The projects reflected possibilities, advantages and also weak sides of the project method and the principle of exemplarity. The key notions in the project works were: exemplarity and interdisciplinary.

The 2-year introductory study programme in the natural sciences at Roskilde University is an example of a project organised, participant directed, problem oriented, and interdisciplinary science study programme (Blomhøj and Kjeldsen, 2009).

The Project work had common features with geodesy laboratory works at LLU. Students themselves decided which problems they wanted to work with at Roskilde University. The students at LLU could not choose geodesy laboratory works by themselves. They had to work according to the sequence in the programme. But in both universities the themes became the central items of their project/laboratory works. The students themselves decided in which disciplines and methods from the sciences should be included in the project work (interdisciplinary feature) at Roskilde University. Students had to carry out four projects, one in each semester. Such approach developed their critical thinking both socially and professionally.

The project had been done in groups of four to seven students. The same group work in laboratory works had been organised in geodesy at LLU.

A particular accent in the Roskilde project was on: the thematic organisation of the project work and the notion of exemplarity, the problem orientation and the interdisciplinary of the problems, the assessment of the project work and the students' individual learning. The same items were also activated at LLU geodesy laboratory works.

Problem-oriented project/laboratory works should be one of the main methods of the course of geodesy because of their multisided effect on students learning. They foster critical and logical thinking, co-operation and setting-up solution versions. The problem-based method usually has higher emotional link to the work process than traditional ones because students discuss and look for solutions. The method also helps to accumulate their experience.

The principle of exemplarity, problem-based learning and interdisciplinary are connected mutually and should be implemented in up-dated study programmes. According to M. Wagenschein's ideas, the principle fosters students' perception of science as a cultural phenomenon and views from various angles. It helps to understand interdisciplinary of a definite theme or entire course, and to see that sciences do not function as absolutely autonomous units but they have overlapping fields.

The contribution of each student in the project/ laboratory works is assessed at the evaluation seminar using a check list. Students evaluate themselves and are evaluated also by a teacher at LLU. The students' successes are assessed in a final examination with an external assessor at the end of each semester at Roskilde University.

Mutual assessment is a final accent on students' aspirations to acquire the knowledge and skills by means of exemplars, interdisciplinary and problem-based learning.

Conclusions

1. The principle of exemplarity involves the following criteria: exemplars, genetic way, entity, interdisciplinary, student-centred approach, problem-based learning with usage of Socratic dialogue as one of the means of equal communication.
2. The criterion of entity involves three features: holism of the exemplar (binding together multi-sided cultural and scientific coherences), critical, and systemic thinking.
3. The principle of exemplarity has kept its importance in nowadays exact sciences studies, and there is a tendency to revise it anew and combine with other topical 21st century methods, e.g. a project work; the principle is used in Germany, Denmark and other English and German speaking countries.
4. The principle of exemplarity helps to avoid traditional thematic sequence discrepancies in laboratory works in the course of geodesy for the first year land service students at LLU.
5. Usage of the principle of exemplarity demands an extra work from a lecturer because a course has to be rearranged according to exemplars, and it means preparation for laboratory works in coherences with the science development aspects historically, interdisciplinary, holistically, and culturally.

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DEVELOPMENT OF CRITICAL THINKING FOR MEDICAL STUDENTS IN CHEMISTRY COURSE

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Abstract. Placing emphasis on high level of responsibility, professionalism and tendency for improvement is expected from medical students. A continuous flow of information puts medical students in front of a choice between the already known and the new. It is therefore necessary to think flexibly and to be ready to verify information and admit mistakes – it is necessary to be able to think critically.
While studying chemistry in Riga Stadiņš University, students have an opportunity to use critical thinking methods for certain purposes – investigation of laws of nature. Development of critical thinking therefore is an integral component rather than the goal of medical education. A complex education method with linked didactic methods was developed – the goals are development of critical thinking during practical work, development of study process organization skills, and critical analysis of information, situation modelling, self-assessment and self-dependence. In order for used didactic methods to work, levels of student qualification were taken in consideration and students were offered an opportunity to evaluate their work themselves. By adapting different forms of studying to each topic of theoretic course and practical work, it was possible to find the most effective as proven by student questionnaires.
As research shows, the most effective didactic methods are:
- special assignments where students have to verify given facts;
- situations where students are directed towards intensified analysis of conditions of assignment;
- mastering of science-based research principles which include promotion of theories, practical testing, result analysis, and conclusion drawing.

Key words: critical thinking, study process, reflection, didactic methods.

Introduction

There are two tendencies when determining goals of higher education: one which satisfies demands of market and demand for integration of higher education in market structure as a service and a component of production (industrial education, professional education, constructive education), and the second tendency which ensures lasting development of society by means of science and higher education, forms and maintains a value system of the society, provides acknowledgement of science as a value and bonds science with higher education. Both tendencies, however, create contradictions:

- new scientific disciplines are emerging thus broadening the range of specialities and creating new links between disciplines which are time consuming to master. At the same time, necessity to thoroughly study a problem narrows the scope;
- specialization in certain fields narrows the choice of methods used and creates professional conservatism. The ability to perceive something new is lost by relating everything to already known. Broad knowledge however not always allows selecting the most efficient method;
- society is interested in specialists with narrow scope and high productivity (including intellectual productivity). However, such knowledge quickly becomes outdated and preparing new specialists is costly;
- psychological factors are important as well: people feel comfortable in well known environment and new specialities must be mastered by new specialists.

By summarizing these tendencies it is clear that costs of preparation of new staff as well as reorientation will certainly increase.

In order to eliminate contradictions it is necessary to create conditions appropriate for new specialists in order for them to learn every new technology with minimal financial and psychological effort. In other words, the new specialist must strive to learn every new technology in a way for it to give financial benefit and psychological satisfaction. The disincentive factor is the lack of motivation after intellectual activity.

Modern society needs future-oriented pedagogy – system of intellectual and pedagogic development which shapes components of critical thinking in individuals. The main characteristic of such style of thinking as an intellectual system is ability to analyze problems by creating systematic links, distinguishing contradictions and their solutions, and predicting evolution of different solutions.

All of the above mentioned is expected from medical students while placing emphasis on high level of responsibility, professionalism and tendency for improvement. A continuous flow of information puts medical students in front of a choice between the already known and the new. It is therefore necessary to think flexibly and to be ready to verify information and admit mistakes – it is necessary to be able to think critically.

Only few students beginning their studies in university understand the meaning of critical thinking and analytical evaluation of study subjects. Most rarely use critical thinking as a tool for gaining new knowledge.

Mastering broad study material does not incorporate active thinking and reasoning rather than

learning by heart thus resulting in a lack of motivation. As a result gained knowledge is shallow, fragmentary, and students have no understanding of it. Students are well trained but not educated. This limits their ability to learn during working, adapt and to raise their intellectual level.

Without complex critical approach for evaluating new and contradictory information, the problem of low level of knowledge will not be solved. In order for students to gain knowledge during studies it is necessary to predict not only course contents but learning process in action as well. In order for students to think critically they must understand intellectual values expressed as continuous development, discipline and knowledge (Paul and Elder, 2001).

By gaining critical thinking skills, modern man gains an opportunity to use them throughout entire life for these skills are universal and are not bound by single scientific discipline. Differences between critical point of view and traditional concepts are a reflexive way of thinking, ability to accept and study new ideas, sceptical attitude towards what is already researched and ability to compare different opinions. Persons who think critically form their opinions by proving them and taking a definite position at the same time keeping in mind that this position may change during development of opinions.

Simply being involved in the process of critical thinking is not enough; it must be done well and should guide the establishment of our beliefs and impact our behaviour or action. Critical thinking is an important aspect of modern education as well as a necessary element for gaining success in information era. Though old standards based on good results of standardized tests are still suitable they can no longer be the foundation of judging academic success or failure (Huitt, 2006).

The word „critical" means evaluation. When we are thinking critically, we are evaluating both results of our thinking process as well as the process itself reflexive thinking. Thinking by searching for the right solutions is the opposite of reflexive thinking. By such thinking a person frees itself from reasoning why the answer is correct. Such thinking is a simple reaction of mind to external stimulation. It is thinking using algorithms. Such thinking can be developed by training and experience. Reflexive thinking does not provide „ready answers" – it is a process of forming hypotheses and moving towards findings.

The ability to think critically is vitally important. Of course we do not do our critical thinking in a vacuum. When we are confronted with a claim, usually we already have a certain amount of information relevant to the issue which allows us to find more information if necessary. It can be obtained by developing reading and listening skills and ability to evaluate arguments and predict consequences of statements (Moore and Parker, 1992).

Critical thinking and information as one of its integral components is what links all of researches mentioned in literature. Many authors define critical thinking together with other authors by highlighting nuances or specifying field of research.

The definition of critical thinking has changed somewhat over the past decade. Originally the dominion of cognitive psychologists and philosophers, behaviourally-oriented psychologists and content specialists have recently joined the discussion. The following are some examples of attempts to define critical thinking (Huitt, 2006).

- ...the ability to analyze facts, generate and organize ideas, defend opinions, make analytical thinking for the purpose of evaluating what is read;
- ...a conscious and deliberate process which is used to interpret or evaluate information and experiences with a set of reflective attitudes and abilities that guide thoughtful beliefs and actions;
- ...active, systematic process of understanding and evaluating arguments. An argument provides an assertion about the properties of some object or the relationship between two or more objects and evidence to support or refute the assertion. Critical thinkers acknowledge that there is no single correct way to understand and evaluate arguments and that all attempts are not necessarily successful;
- ...the intellectually disciplined process of actively and skilfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action;
- reasonable reflective thinking focused on deciding what to believe or do.

D. Halpern bases her explanation of critical thinking on connection between knowledge and thinking by using which it is possible to create new knowledge form existing knowledge. The goal of her book was formation and development of skills which characterize clear, precise and targeted thinking (Халперн, 2000).

Each of the separate groups has made significant contributions to our understanding of critical thinking. Contributors from the area of cognitive psychology (such as Paul Chance and Richard Mayer) delineate the set of operations and procedures involved in critical thinking. They work to establish the differences between critical thinking and other important aspects of thinking such as creative thinking. Contributors from the area of philosophy (such as Richard Paul) remind us that critical thinking is a process of thinking to a standard. Simply being involved in the process of critical thinking is not enough; it must be done well and should guide the establishment of our beliefs and impact our behaviour or action. Contributors from the area of behavioural psychology help to establish the operational definitions associated with critical thinking. They work to define the subtasks associated with final outcomes and the methodologies teachers

can use to shape initial behaviours towards the final outcomes. They also demonstrate how educators can establish the proper contingencies to change behaviour (Huitt, 2006).

In the world of pedagogy there are two basic interpretations one which explains critical thinking as analytic thinking and which stresses its cognitive aspects (as logical justification and argumentation skills which are necessary for careful reading, analytic reasoning and clear expression of one's thoughts). Thinking skills are an instrument which can be systematically developed.

The second interpretation which begins to appear in theoretical sources from 1998 – 2000 broadens the interpretation of critical thinking. Apart from rational aspect it also mentions emotional aspect as a significant part of critical thinking. Critical thinking is understood as a specific analytically evaluative way of thinking which is tended to realizing the nature of particular subject and which is characterized by autonomy, reflection, contextualism and interest. Critical thinking includes cognitive, social and communication skills as well as rational and emotional aspects. It is important in point of view of human education paradigm to incorporate both aspects in critical thinking concept. By highlighting only the rational aspect, development of thinkers which are not interested in using thinking skills to benefit society is promoted. Position of such person is authoritarian and cannot be thought of as a critically thinking person (Rubene, 2008).

The question regarding whether critical thinking is as a specific quality which is related to specific scientific discipline or is it a universal thinking quality which can be applied in different situations is very significant.

J. McPeck supports opinion that there is no reason to believe that a person which thinks critically within one field will think critically within others. This opinion is very significant in history of critical thinking development and it has cleared critical thinking concept. However, there are counterarguments (McPeck, 1990). Another approach is created by theory of R. Paul, broadening explanation of critical thinking – a universal development of principles of reasoning which can be applied to different fields (Paul, 1990).

Materials and Methods

During freshman year, students gradually understand that the amount of information to learn is very large and that study process is very intensive thus making good results reachable only by hard work. It is necessary to change high school teaching style and motivation. University lecturers must help students to develop a systematic approach, direct towards examining connections, system constants and variables. „General chemistry" is a supporting material for beginning of studies. It is developed to conform to different levels of knowledge and is intended to improve studying skills by incorporating didactical methods.

Critical thinking is not a by-product of studying chemistry. By critically evaluating every new fact, the study process becomes productive thus creating support for individual studying strategies.

Between different methods for development of critical thinking described in literature there are only few which are universal. Methods psychological and pedagogic justification of which highlights development of context independent critical thinking are chosen as supporting points. Main differences in literature describing critical thinking are examples which apply to all real life spheres and stress practical use of critical thinking. Specific elements oriented on real life application were chosen and approbated based on experience. As a result, a complex method with linked didactic methods was developed. It was used in Riga Stradiņš University during first-year student practical works in chemistry. The method is based on development of reflexively evaluated study experience which promotes self-determination in study process and future professional career.

By analyzing different methods for developing critical thinking (both universal and specific), active forms of work (practical work, seminars, dialogs, and presentations) were emphasised.

During work with first-year students, deviations from traditional university methods are necessary since there is a transition period. Different levels of qualification and the need to adjust accordingly increases significance of subjective conditions. It is impossible to demand instant analysis – one of the most significant components of critical thinking – of new information from all students.

For this specific reason, a material oriented on self-dependant learning „General chemistry" was developed. It approbated interactive methods for practical works as well as factors promoting self-organization skills and development of critical thinking.

The developed method consists of general work forms for organising the study process (lectures, practical work, seminaries etc.) and specific didactic methods.

Didactic methods for improving student critical thinking skills are:

- specific educational texts and tasks which are adapted for three phase model of critical thinking development – suggestion, perception, and reflection;
- study materials (books) containing information regarding how laws of science, theories and attitude towards once disclaimed ideas have changed over time;
- lecture materials which contain logic-based examples which highlight unproductiveness of unambiguous evaluation;
- mastering basic science based research principles which anticipate theory advancement, repeated practical verification, statistic processing, result analysis, and drawing conclusions;

- development of reflection thus encouraging students to engage in dialogue (analysis of questions and answers and listening tasks);
- information analysis and visualisation;
- problem situation creation and problem task solving.

Students are unable to evaluate whether one method derives from another, is it an advancement of the already known, is it an illustration or contradiction. During reading facts which derive one from another are not spotted. Technical terms are not connected with real life analogies.

In order to solve this contradiction it is useful to create special texts for studying by adjusting them in order to conform to three phase practical work model: suggestion, perception, and reflection.

Reading, for example, is a macro skill which coordinates several micro skills. Title is the first thing to consider, then comes introduction, then – problems or goals of the book. Unclear sentences and interpretations of concepts are considered afterwards. At the same time it is possible to find examples based on personal experience thus validating opinions of the author. These separate steps are joined together in order to create understanding of information read (Paul and Elder, 2001).

Perception of reading and writing as instruments for development of critical thinking in university is judged very contradictory. E. Volokov criticizes this method and objects against the use of high school methods in university (Волков, 2009).

The opinion of pedagogues and psychologists which values reflection of writing as an important condition for developing critical thinking skills, for example, theory of L. Vigotsky about relationship between thoughts and language and inner speech, can be mentioned as a counterargument. Written text gives an opportunity to read it again in case of failing to understand it; however, it lacks dialogic bond with reader meaning that process of understanding cannot be corrected by changing direction of dialogue and explaining the unclear (Выготский, 1982).

This is the skill necessary for obtaining ideas for further consideration and reasoning. However, not enough attention is paid to it both in school and university. Oral reflection is equally important. It allows to follow the study process and to encourage students to have a dialogue by asking questions and giving listening tasks followed by analysis of questions and answers. The next step is visualization.

The use of graphic organizers helps to visualize the already known and to add new information as well as to raise argumentation levels. Thought-guiding questions in order to focus thinking process:

1) What is my position regarding the subject, and which facts, arguments and processes must be understood?
2) Which layout will help to organize material and to show its meaning?
3) What type of graphic organizer will represent the way of understanding the material?
4) Which problems must be emphasized in order to promote thinking process of students (Clarke, 1991).

Lecturers themselves must understand why the selected graphic organizer is appropriate for particular purpose. Only then it is possible to help students understand adequacy of used graphic organizer for systematization of certain facts, ideas and processes.

Graphic organizers analyzed by John H. Clarke are intended for two main purposes organization of information which helps students reach conclusion by inductive thinking (graphics "from bottom to top"), and forming hypotheses, making decisions and solving problems using deductive thinking (graphics "from top to bottom").

Intensification of student thinking process is done gradually by guiding their cognitions toward contradictions. It can be realized by creating problem situations and problem solving exercises. Creating problem situations is effective only in cases when there is a logical connection with the already known. If contradictions between the new and already known cause amazement then there is will to find out more.

J. Dewey highlights „sense of burden" and psychological experience when coming across a problem. In order to solve the problem, J. Dewey suggests a procedure consisting of five steps (Rubene, 2004):

1) uncertain, ambiguous, confusing situations and doubts – at this stage it is important to define the cause of the problem and to realize its nature;
2) formulation of the problem in which a certain situation becomes a problem situation. … existence or lack of these stages separates reflection (controlled critical reasoning process) and uncontrolled thinking;
3) finding possible solutions of the problem, i.e. forming hypothesis, generating ideas. At this stage it is necessary to incorporate conceptual thinking;
4) verification of formed hypothesis – evaluation of theoretical reasoning, possible solutions, discussion of ideas;
5) practical, experimental proof of selected solution.

Given tasks included problems which students often solved incorrectly or about which categorical and unproductive conclusions were drawn (conclusions which involve different incompatible solutions). Problem exercises were developed by incorporating already known information which gained different meaning through different point of view. By solving problem exercises students must learn basic principles: statements, consequences, conclusions, problem investigation, evidence an argument presentation, contradiction and imperfection identification. By thinking critically these are not performed as separate operations but rather as complex. Exercise solutions allow evaluating student level of critical thinking.

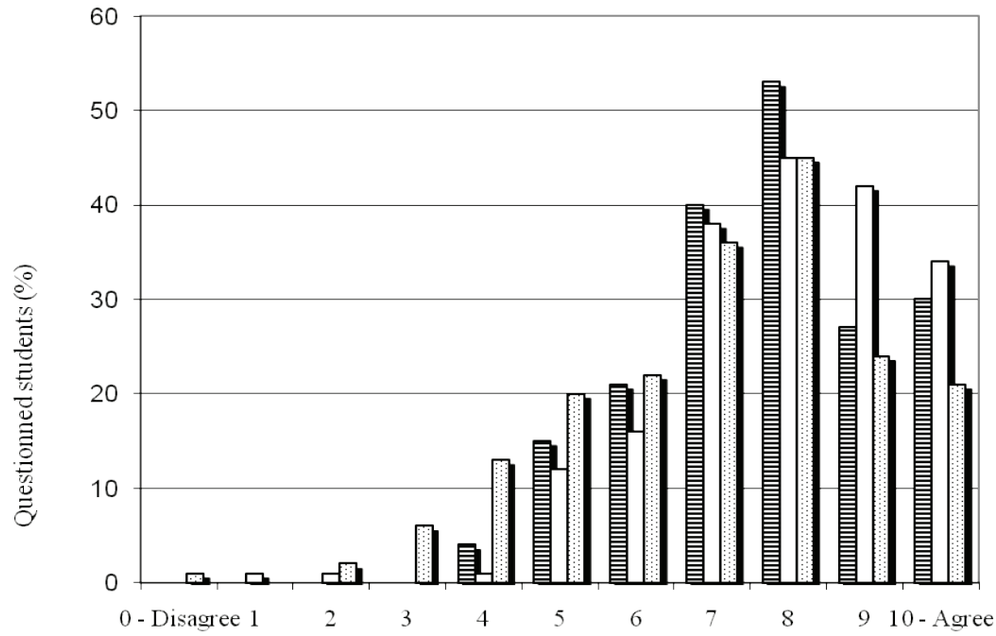

Figure 1. Results of survey regarding study material and didactic approaches

Results and Discussion

Development of critical thinking is a long-term process therefore development of evaluation and self-evaluation is a long-term process as well. High level critical thinking shows that skills of integrative thinking which are based on logical justified argumentation, criticism and self-evaluation of a professional (university graduate) are obtained (Ennis and Norris 1989).

Since given research shows work with first-year students, only low-level critical thinking can be evaluated – justification of evidence on a level of elementary reasoning – since there is not enough experience in evaluation and self-evaluation.

American education programme and evaluation researcher D. Pratt claims that humanity is the most important aspect of evaluation quality. Careful and human approach to evaluation corresponds to tasks of human reform of education and ecology of environment for development (Pratt, 2000).

Traditional evaluation system concentrates on evaluation of knowledge and skills rather than evaluation of development. Nowadays an emphasis is placed on the importance of self-evaluation.

By analyzing experience, one must highlight the importance of admitting mistakes rather than the grades themselves. Mistake analysis is one of several steps necessary for self-evaluation. By evaluating study quality, students improve their results. An effective evaluation process must include two way communications between students and university lecturers. Together with university lecturer evaluation of suitability of methodic material and effectiveness of didactic methods student questionnaires are also incorporated in development of critical thinking. Evaluation of critical thinking can be related to different levels of critical thinking. First-year students cannot evaluate critical thinking as a universal competence which can be applied to problem solving as well as situation analysis. Separate aspects of critical thinking were evaluated:

- problem solving skills and evaluation of one's own solution variants and evaluation of solution variants given by others;
- self-evaluation of one's level of qualification at the beginning and end of the course;
- development of individual studying strategy;
- proportion of explorative and reproductive methods in the study process;
- use of mastered critical thinking techniques in new situations;
- ability to compare one's own verification with verification of others within problem solving;
- critical evaluation of information sources;

- effectiveness of didactic approaches depending on their suitability for each individual study topic and situation;
- suitability of method for different student studying approaches and capabilities.

Questions in questionnaires are grouped in order to provide answers regarding study material "General chemistry", didactic methods used in organizing lessons and student self-dependence and development of individual studying strategy.

Students answered on a scale from 0 (total denial) to 10 (total approval). On questions whether the given study material “General chemistry” can be used as an example of information systemization, connection finding and analysis and whether chemistry course is mastered by reproducing facts or by developing critical thinking skills, most of the students answered affirmative or almost affirmative. Only 2% - 3% gave negative answers. Majority of students also answered that material is suitable for development of self-dependent learning skills. 150 out of 200 Riga Stradiņš University students questioned answered affirmative regarding suitability of study material for developing self-dependent study skills. The answers of the remaining 50 were almost affirmative. Results of the survey are shown in a chart (see Figure 1). Results of accomplished work are both stimulation to accomplish even more and a material for pedagogic analysis. It is a problem which can be solved by cooperation of students and lecturers. The objective of lecturers is to provide students with interesting opportunities to develop critical thinking skills. It is necessary for students to find subjects they are interested in and methods for studying as well as flexible studying environment.

Results of the survey cannot be considered as representative for all first-year students of RSU. However, they give an opportunity to evaluate actual situation in the faculty of Medicine.

Conclusions

1. Effectiveness of different didactic models and methods depends on their suitability for each particular subject and situation. Conformity to different studying forms and skills can be considered as apromoting factor for a positive attitude towards the study material.
2. Self-dependently organized study process can be considered as a self-determined study process: time planning, determination of priorities, and division of the study material in order to increase study effectiveness.
3. Development of an individual studying strategy (observation and evaluation of the study process as well as self-criticism) is the main factor for development of critical thinking during a self-determined study process.
4. By evaluating study quality, students improve their results. Effective evaluation process must incorporate two-way communications between university lecturers and students.

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