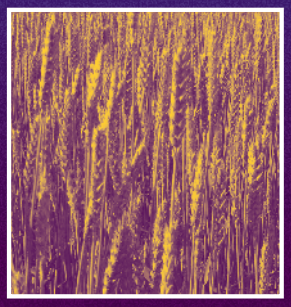



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EDITORIAL

With this issue of 2011, we bring 72 proceedings of the 122, which started life as presentations at the Annual 17th International Scientific Conference "Research for Rural Development 2011" held at the Latvia University of Agriculture, in Jelgava, on 18 to 20 May 2011.

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 252 researchers with very different backgrounds. There were 18 presentations from different universities of Lithuania, 2 from Estonia, 3 from Poland, 1 from Spain, 1 from Ukraine, 2 from Russia and 95 from Latvia.

Four independent reviewers estimated each article.

The proceedings of the Annual 17th International Scientific Conference "Research for Rural Development 2011" 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, environmental engineering, landscape architecture, information and communication technologies.

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

DETERMINATION OF ORGANIZATIONAL SUSTAINABILITY IN RURAL AREAS

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Abstract

The article analyses organizational internal and external environments, their possible correlations with 4 components of sustainability, and the principal determination models for sustainability of organizations. Based on the general principles of sustainable development organizations, a model for the determination of organizational sustainability has been developed. The use of self-organizing neural networks allows the identification of the external sustainability of each forest enterprise and the endeavour to explore vital, social, antropogenical and economical efficiency. The determination of the forest enterprise external sustainability is expected to help better manage the external sustainability of forest enterprises and explain the reasons for a respective level of external sustainability.
Key words: sustainability, sustainable organization, sustainable organizational environment.

Introduction

The analysis of the scientific literature on sustainable development leads to the observation that a substantial work has been done in this field; however, very little attention is given to the assessment of external organizational sustainability in scientific literature. The researches carried out in Lithuania have not examined the topic of external organizational sustainability assessment in detail.

In the real world, an organization functioning in a certain region generates many different types of data while performing functions assigned to it. When we examine the sustainability of such an organization or individual components of the organizational sustainability, we are dealing with the data describing each component of the organizational sustainability, the analysis of which presents a complex task, especially when the data of individual components of the organizational sustainability reflect a complex and integrated phenomenon, the sustainability of the entire organization. External organizational sustainability is generally characterized by a large amount of multicomponent indicators and indicator values. In the scientific literature, the data describing any component of organizational sustainability are commonly known as multidimensional data. It is very important for the persons in charge of organizational sustainability to retrieve the necessary information from the available multidimensional data which could help to understand the distribution of the forest enterprise external sustainability level, i.e. the distribution of external organizational sustainability across individual components of the forest enterprise sustainability as well as the reasons for a respective external sustainability level of the forest enterprise. Use of a visualization method for a self-organizing neural network makes this task easier.

According to Dzemydienė (2006), the science of artificial intelligence provides perspective for modern computer systems development. Artificial intelligence techniques enable simplification of the complex sustainable development processes of organizations and their more effective management; however, the expert assessment of the sustainable development indicators remains the essential condition for the application of this type of technique.

As an alternative to contemporary models of the sustainable development of organizations, we hereby present the model for the determination of organizational sustainability to facilitate targeted interventions inducing the sustainable development of an organization, performed by the sustainable development organizations' experts.

Forest enterprises play an enormous role in the competitive ability of a certain region. First of all, forest enterprises are large-scale forest managers acting in accordance with the Law on State and Municipal Enterprises and having the legal form of a state enterprise. Furthermore, forest enterprises own and exploit one of the basic natural assets of our country, a forest specifically, which shall serve the prosperity of the State and its citizens and preserve the landscape stability and the environment quality. Forest enterprises, at their own expense, restore cut down forests and plant new ones, develop and supervise them, protect them against fires, pests and diseases, and exercise environmental and recreational measures. The consensus of opinion is that the main purpose of the forest enterprise activities is sustainable forest management in order to meet the public needs for wood and other forest products and to perform the protective and recreational functions of forests. For this reason, it is appropriate to determine and examine the external sustainability of Lithuanian forest enterprises.

Research subject: External sustainability of Lithuanian forest enterprises.

Research objective: To determine the levels of vital, social, antropogenical and economical efficiency and external sustainability in forty Lithuanian forest enterprises on the basis of the developed model for the determination of organizational sustainability.

Research techniques: Analysis of Lithuanian and foreign scientific literature on sustainable development, statistical data analysis, questionnaire survey, expert assessment, simulation, ranking method for determining the indicator significance, visualization method for a self-

organizing neural network – the unified distance matrix (or U-matrix for short).

Materials and Methods

On the grounds of the organizational environment model developed by Brownlie (1987) whereby the breakdown of different organizational environment components in levels is explicitly presented, and the sustainable organizational environment model developed by us, the levels of internal and external sustainability can be distinguished.

Examination and assessment of organizational sustainability at two different levels allow us to determine the sustainability of internal and external organizational environment which is closely associated with the components functioning in internal and external environments. In addition, such analysis of organizational sustainability at different levels allows more accurate considerations on a respective level of organizational sustainability.

To illustrate the simplified determination and visualization process of the external sustainability of the forest enterprise, we have developed a model for the determination of the forest enterprise external sustainability.

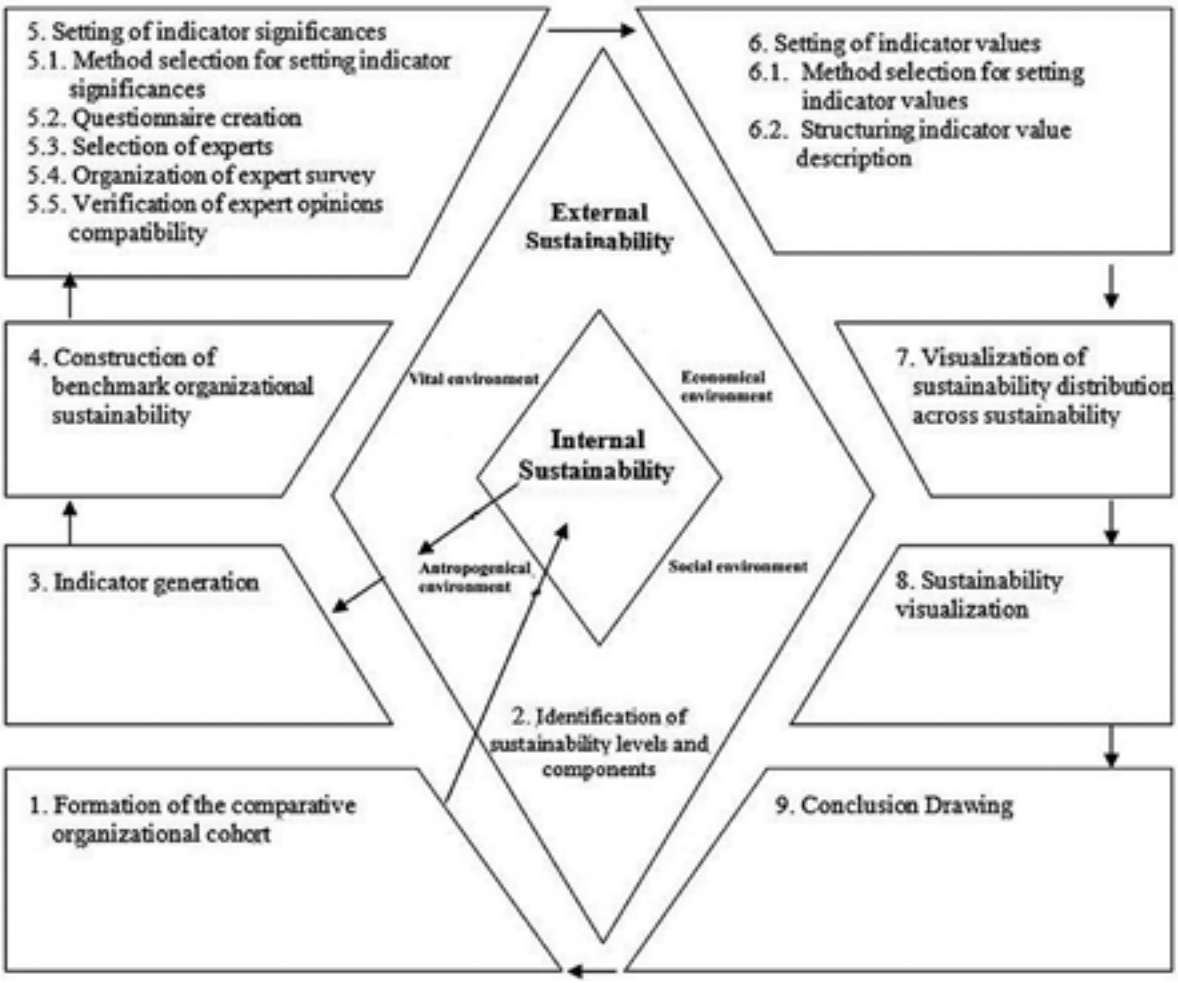

Figure 1. Model for Determination of Organizational Sustainability.

Source: Compiled by the authors.

The representation of the model for determination of organizational sustainability in Fig. 1 shows that the simplified determination process of a certain organization's sustainability (a forest enterprise, in the given case) can be divided into 9 basic stages. In the central part of the model (the second stage of the model), an intervention in the internal and external organizational environment is visualized, wherein the identified vital, social, and antropogenical internal and external environments form the basis for the creation of sustainable organizational environment.

The formation of the comparative organizational cohort is the first stage of the determination process of the forest enterprise sustainability, in which the model input function is actualized. The identification of sustainability levels and components is the second (intermediate) stage of the determination process of the forest enterprise sustainability which provides two sustainability levels and four sustainability components specifying the levels at which the determination process of the forest enterprise

sustainability will be carried out, and the organizational sustainability components across which sustainability distribution will be identified. In the given case, we are going to examine only the external sustainability of the forest enterprise. The generation of indicators is the third (intermediate) stage of the determination process of the forest enterprise sustainability. At this stage, the indicator-generating function of sustainable development researchers or professionals responsible for the sustainable development of the organization is actualized. The construction of the benchmark organizational sustainability is the fourth stage of the determination of organizational sustainability. The setting of indicator significances is the fifth stage of the determination of organizational sustainability which consists of the following five substages: a method selection for setting indicator significances, the creation of a questionnaire, the selection of experts, the organization of the expert survey, and the verification of expert opinions compatibility. The selection of methods to be used at the first and the fifth substages should have both, quantitative and qualitative reasoning. Prior to the expert selection procedure, it would be appropriate to have the expert selection criteria for the selection of experts. One of the most important expert selection criteria are their experience and academic qualification.

The setting of indicator values is the sixth stage of the determination of organizational sustainability which consists of the following two substages: the method selection for setting indicator values and structuring the indicator value description.

Visualization of sustainability distribution across the components of sustainability is the seventh stage of the determination of organizational sustainability. At the given stage, the U-matrix is generated by means of visualization methods for self-organizing neural networks. The U-matrix values are represented in the self-organizing map.

Separate U-matrixes are generated for each component of external and internal organizational sustainability, allowing the identification of the internal and external vital, social, antropogenical and economical efficiency of each organization or, in other words, the identification of the internal and external organizational sustainability distribution across the vital, social, antropogenical and economical components of organizational sustainability.

Sustainability visualization is the eighth stage of the determination of organizational sustainability.

Conclusion drawing is the ninth stage of the determination process of the forest enterprise sustainability, in which the model output function is actualized. At this stage, the new knowledge derived during all the previous stages of the sustainability determination process is summarized. This knowledge helps to make appropriate decisions in the positive inducement of organizational sustainability.

During the determination process of a particular forest enterprise's external sustainability, we can have a real time record of the values of a set of respective indicators of sustainability components which, if appropriately aggregated, can reflect the external sustainability of the organizational environment (see the seventh stage of the determination of organizational sustainability).

Each indicator of the forest enterprise sustainability is associated with a particular component of organizational sustainability, and the indicator value of organizational sustainability is in all cases related to time and a certain respective sustainability component of the sustainability level. In determining the sustainability of a certain forest enterprise, we can have a real time record of the values of a set of respective indicators of sustainability components which, if integrated into self-organizing maps (SOM), can turn into quantitatively expressed distances between each of the forest enterprises in question, by the values of which the organizational environmental sustainability of each forest enterprise can be determined.

In order to determine the forest enterprise external sustainability and its distribution across sustainability components, it is appropriate to use the the visualization methods for self-organizing neural networks and to generate the U-matrix Moreover, the U-matrix values should be placed on the self-organizing map to identify the existing data clusters.

To make the aforementioned comprehensible, we introduce the steps for creating the U-matrix and the self-organizing map of the forest enterprise external sustainability multidimensional dataset:

1. A set of the indicator values for the forest enterprise external sustainability and for the vital, social, antropogenical and economical components of sustainability consistent with the benchmark organizational sustainability is analysed. The given set presents the description of 20 quantitative indicators of external sustainability consistent with the benchmark sustainability for each forest enterprise and organization.
2. The size and topology of a self-organizing map is formed, based on the existing number of training vectors (21, in this case) and the values of the components of the vector M_{kl} are assigned.
3. A training process for the neural network is carried out during which the neurons- winners are identified.
4. A self-organizing map is produced.
5. Based on the data of the self-organizing neural network, the U-matrix is generated which represents the distances between neighbouring neurons that are calculated using Kohonen's (2001) formula:

$$\left\| M_p - M_{kl} \right\| \qquad (1)$$

Where:

M_p is the neuron neighbouring the M_{kl} neuron

Self-organizing maps (SOM) have the essential advantage to perform high accuracy multidimensional data clustering and visualization operations. It is for this reason

that the use of self-organizing maps in the visualization of multidimensional components of organizational sustainability is quite attractive Stefanovič and Kurasova (2009).

In the scientific literature, one can come across a comparatively large number of visualization methods for self-organizing neural networks (component planes, histograms, etc.). The U-matrix is one of the most popular visualization methods for self-organizing neural networks. The U-matrix is made up of distances between the neighboring neurons of the self-organizing neural network. E.g., with a dataset consisting of 4 columns and 150 rows, the U-matrix will be a vector of 150 rows and 4 columns. After generating the U-matrix from the initial data, its values must be placed on the self-organizing map which typically consists of rectangular or hexagonal neurons. The scientists Kraaijveld, Mao, Jain (1995) proposed a visualization method for self-organizing neural networks by means of which the average distances between neighbouring neurons are presented in gray or coloured scale tones. If the average distances between neighbouring neurons are short, the map components matching these neurons are light-coloured; longer distances between neighbouring neurons are dark-coloured. Consequently, the data clusters existing on the self-organizing map are determined by light tones and the margins are determined by darker tones Kohonen (2002), Dzemyda and Kurasova, (2002).

The visualization method for self-organizing neural networks, the U-matrix, was tested usung the multidimensional data model Fisher (1936) - the four-dimensional Fisher's iris dataset akin to the multidimensional data of organizational sustainability components.

It should be noted that the determined respective external level of organizational environmental sustainability has a strong influence on the external components functioning within organizational environments Dzemyda and Tiešis (2001).

Results and Discussion

Distribution visualization and determination of the forest enterprise external sustainability are possible only if the vital, social, antropogenical and economical levels of external efficiency for each forest enterprise have been defined showing the distribution of the forest enterprise external sustainability across all the components of sustainability.

In addition, the set quantitative values for the vital, social, antropogenical and economical levels of each forest enterprise's external efficiency account for the derived overall level of the forest enterprise external sustainability.

The vital levels of the forest enterprise external efficiency occasionally show the progress made by the forest enterprise within the external vital organizational environment.

We maintain that the U-matrix is one of the most popular visualization methods for self-organizing neural networks. In our case, the U-matrix is made up of distances between the neighboring neurons of the self-organizing neural network, which are placed in the generated U-matrix of the forest enterprise vital external efficiency multidimensional dataset.

The table below shows a fragment of the U-matrix of the forest enterprise vital external efficiency multidimensional dataset, which represents the distances between neighbouring neurons of the self-organizing neural network between forest enterprises and the benchmark organizational sustainability.

Table 1 shows the vital efficiency levels of the benchmark sustainability of each forest enterprise and organization that are based on a certain distance existing between the benchmark sustainability of the forest enterprise and organization. The less the distance, the higher the level of efficiency which declares a more significant progress made by a relevant forest enterprise within the external vital organizational environment in respect of other forest enterprises concerned.

It can be maintained that Ignalina Forest Enterprise is making an average progress within the external vital organizational environment. This is confirmed by Ignalina Forest Enterprise vital external efficiency level of 5.03 positioning between the benchmark organizational sustainability and the maximum and minimum average distance of respective forest enterprises.

Table 1

Fragment of U-matrix of Forest Enterprise Vital External Efficiency Multidimensional Dataset

	Forest Enterprise																			
No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
BOS	4.81	5.49	2.61	4.36	4.57	4.24	5.13	5.58	4.93	3.93	4.10	3.22	4.38	6.98	3.64	3.43	3.96	4.19	4.04	3.04
	Forest Enterprise																			
No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
BOS	5.76	5.69	4.43	4.35	3.66	4.93	6.77	6.69	4.62	3.47	5.78	4.83	5.03	2.89	7.45	4.61	3.53	4.75	3.76	5.97

Here:

1. Vilnius Forest Enterprise
2. Nemenčinė Forest Enterprise
3. Ukmergė Forest Enterprise
4. Švenčionėliai Forest Enterprise
5. Trakai Forest Enterprise
6. Šalčininkai Forest Enterprise
7. Jonava Forest Enterprise
8. Kaišiadorys Forest Enterprise
9. Prienai Forest Enterprise
10. Kaunas Forest Enterprise
11. Kėdainiai Forest Enterprise
12. Raseiniai Forest Enterprise
13. Kretinga Forest Enterprise
14. Šilutė Forest Enterprise
15. Kuršėnai Forest Enterprise
16. Tytuvėnai Forest Enterprise
17. Šiauliai Forest Enterprise
18. Pakruojis Forest Enterprise
19. Joniškis Forest Enterprise
20. Radviliškis Forest Enterprise
21. Kupiškis Forest Enterprise
22. Biržai Forest Enterprise
23. Rokiškis Forest Enterprise
24. Panevėžys Forest Enterprise
25. Telšiai Forest Enterprise
26. Rietavas Forest Enterprise
27. Mažeikiai Forest Enterprise
28. Jurbarkas Forest Enterprise
29. Tauragė Forest Enterprise
30. Anykščiai Forest Enterprise
31. Zarasai Forest Enterprise
32. Utena Forest Enterprise
33. Ignalina Forest Enterprise
34. Alytus Forest Enterprise
35. Valkininkai Forest Enterprise
36. Varėna Forest Enterprise
37. Druskininkai Forest Enterprise
38. Veisiejai Forest Enterprise
39. Šakiai Forest Enterprise
40. Marijampolė Forest Enterprise

BOS: Benchmark Organizational Sustainability

The social levels of the forest enterprise external efficiency occasionally show the progress made by the forest enterprise within the external social organizational environment.

Social efficiency levels of the benchmark sustainability of each forest enterprise and organization that are based on a certain distance existing between the benchmark sustainability of the forest enterprise and organization. The analysis of the data provided in the above table shows that the maximum distance of 8.92 exists between Ignalina Forest Enterprise and the benchmark organizational sustainability. Consequently, Ignalina Forest Enterprise is making the least progress within the external social organizational environment in comparison with other forest enterprises. This is confirmed by the lowest social external efficiency level recorded among all the forest enterprises. Meanwhile, the minimum distance of 6.45 exists between Šiauliai Forest Enterprise and the benchmark organizational sustainability. As a result, Šiauliai Forest Enterprise is making the most progress within the external social organizational environment in comparison with other forest enterprises as confirmed by the highest social external efficiency level recorded among all forest enterprises concerned.

It can be maintained that Trakai and Veisiejai Forest Enterprises are making an average progress within the external social organizational environment. This is confirmed by Trakai and Veisiejai Forest Enterprises social external efficiency level of 7.70 positioning between the benchmark organizational sustainability and the maximum and minimum average distance of respective forest enterprises.

The antropogenical levels of the forest enterprise external efficiency occasionally show the progress made by the forest enterprise within the external antropogenical organizational environment.

We maintain that the U-matrix is one of the most popular visualization methods for self-organizing neural networks. In our case, the U-matrix is made up of distances between the neighboring neurons of the self-organizing neural network, which are placed in the generated U-matrix of the forest enterprise antropogenical external efficiency multidimensional dataset.

Antropogenical efficiency levels of the benchmark sustainability of each forest enterprise and organization that are based on a certain distance existing between the benchmark sustainability of the forest enterprise and organization. The less the distance, the higher the level of efficiency which declares more significant progress made by a relevant forest enterprise within the external antropogenical organizational environment in respect of other forest enterprises concerned.

The economical levels of the forest enterprise external efficiency occasionally show the progress made by the forest enterprise within the external economical organizational environment.

We maintain that the U-matrix is one of the most popular visualization methods for self-organizing neural

networks. In our case, the U-matrix is made up of distances between the neighboring neurons of the self-organizing neural network, which are placed in the generated U-matrix of the forest enterprise economical external efficiency multidimensional dataset.

Economical efficiency levels of the benchmark sustainability of each forest enterprise and organization are based on a certain distance existing between the benchmark sustainability of the forest enterprise and organization. The less the distance, the higher the level of efficiency which declares more significant progress made by a relevant forest enterprise within the external economical organizational environment in respect of other forest enterprises concerned.

It can be maintained that Trakai Forest Enterprise is making an average progress within the external economical organizational environment. This is confirmed by Trakai Forest Enterprise economical external efficiency level of 10.22 positioning between the benchmark organizational sustainability and the maximum and minimum average distance of respective forest enterprises.

The levels of the forest enterprise external sustainability occasionally show the progress made by the forest enterprise within the external organizational environment.

We maintain that the unified U-matrix is one of the most popular visualization methods for self-organizing neural networks. In our case, the U-matrix is made up of distances between the neighboring neurons of the self-organizing neural network, which are placed in the generated U-matrix of the forest enterprise economical internal efficiency multidimensional dataset.

External sustainability levels of the benchmark sustainability of each forest enterprise and organization are based on a certain distance existing between the benchmark sustainability of the forest enterprise and organization. The analysis of the data provided in the above table shows that the maximum distance of 16.82 exists between Jurbarkas Forest Enterprise and the benchmark organizational sustainability. Consequently, Jurbarkas Forest Enterprise is making the least progress within the external organizational environment in comparison with other forest enterprises. This is confirmed by the lowest external sustainability level recorded among all the forest enterprises. Meanwhile, the minimum distance of 14.04 exists between Kėdainiai Forest Enterprise and the benchmark organizational sustainability. As a result, Kėdainiai Forest Enterprise is making the most progress within the external organizational environment in comparison with other forest enterprises as confirmed by the highest external sustainability level recorded among all forest enterprises concerned.

It can be maintained that Tytuvėnai Forest Enterprise is making an average progress within the external organizational environment. This is confirmed by Tytuvėnai Forest Enterprise external sustainability level of 15.43 positioning between the benchmark organizational sustainability and the maximum and minimum average distance of respective forest enterprises.

Conclusions

1. The sustainable development of forest enterprises can be induced by regulated, spontaneous or planned interventions which can be formed both, internally and externally, and which can be directed to the employees functioning within the internal environment of the organization or to the local/regional-scale customers, suppliers, partners and community members operating within the external environment of the organization.
2. The developed and described model for the determination of organizational sustainability explains the determination process of a certain organization's sustainability, which consists of 9 basic stages; however, it does not reveal all the side factors governing the determination process of organizational sustainability (decision-making, grouping of responsible persons, task assignment, coordinating actions, primary data collection, etc.).
3. The self-organizing maps (SOM) have the essential advantage to perform high accuracy multidimensional data clustering and visualization operations. It is for this reason that the use of self-organizing maps for the transformation of multidimensional components of organizational external sustainability into two-dimensional space is quite attractive.
4. The analysis of the data provided in a fragment of the U-matrix of the forest enterprise vital external efficiency multidimensional dataset showed that Valkininkai Forest Enterprise is distinguished for the minimum vital efficiency which is argued by the maximum distance of 7.45 existing between Valkininkai Forest Enterprise and the benchmark organizational sustainability. Meanwhile, Ukmergė Forest Enterprise is distinguished for the maximum vital efficiency which is argued by the minimum distance of 2.61 existing between Ukmergė Forest Enterprise and the benchmark organizational sustainability.
5. The analysis of the data provided in a fragment of the U-matrix of the forest enterprise social external efficiency multidimensional dataset showed that Ignalina Forest Enterprise is distinguished for the minimum social efficiency which is argued by the maximum distance of 8.92 existing between Ignalina Forest Enterprise and the benchmark organizational sustainability. Meanwhile, Šiauliai Forest Enterprise is distinguished for the maximum social efficiency which is argued by the minimum distance of 6.45 existing between Šiauliai Forest Enterprise and the benchmark organizational sustainability.
6. The respective vital, social, antropogenical and economical levels of the forest enterprise efficiency indicate the distribution of each forest enterprise's external sustainability and account for the causes of levels of a certain external sustainability.
7. The analysis of the data provided in a fragment of the U-matrix of the forest enterprise external sustainability

multidimensional dataset proved that Jurbarkas Forest Enterprise is distinguished for the lowest level of external sustainability which is confirmed by the maximum distance of 16.82 existing between Jurbarkas Forest Enterprise and the benchmark organizational sustainability. Meanwhile, the minimum distance of 14.04 existing between Kėdainiai Forest Enterprise and the benchmark organizational sustainability proves that Kėdainiai Forest Enterprise is distinguished for the highest external sustainability level.

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ANALYSIS OF TREE FELLING, REGENERATION, IMPORT AND EXPORT DYNAMICS IN LATVIA

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Abstract

Forest resources are Latvian national treasure that plays an important role in both ecology and economics of Latvia. Although a number of studies give summaries of statistical data, they have also been used as the basis for this study. Therefore, statistical analysis of the data on acquisition, regeneration, import and export of forest resources in Latvia has been carried out in this study. The aim of the study is to identify the available statistical information on the forest resources in Latvia by ascertaining the amount of available information, types of statistical data used in identifying information on tree fellings, annual afforestation, import and export, and to carry out analysis of the acquired data. The statistical information has been obtained from the websites of the State Forest Service and the Statistical Office of the European Communities **(**Eurostat). As a result of the study, we have obtained the dynamics of tree felling and forest regeneration by dominant tree species. The study also reveals the dynamics of import and export of timber resources of the main products. The study was carried out in 2011, in Latvian.
Key words: timber resources, statistics, Latvia.

Introduction

Forest resources are one of the largest Latvian riches. Forest resources have an important role both from an environmental and economic point of view. The fact that forest land occupies 49.9% (Meža resursi…, 2011) of the national territory proves it. In order to be able to discuss a sustainable utilization of forest resources, it is necessary to identify the current situation. Although statistical data are used in studies quite frequently, it is not always possible to use the information compiled by others. This can be explained by the fact that studies should use current available statistics, as well as each study has to use a different type of statistical data. Therefore, this study provides information on acquisition, regeneration, import and export of the forest resources in Latvia (see Figure 1).

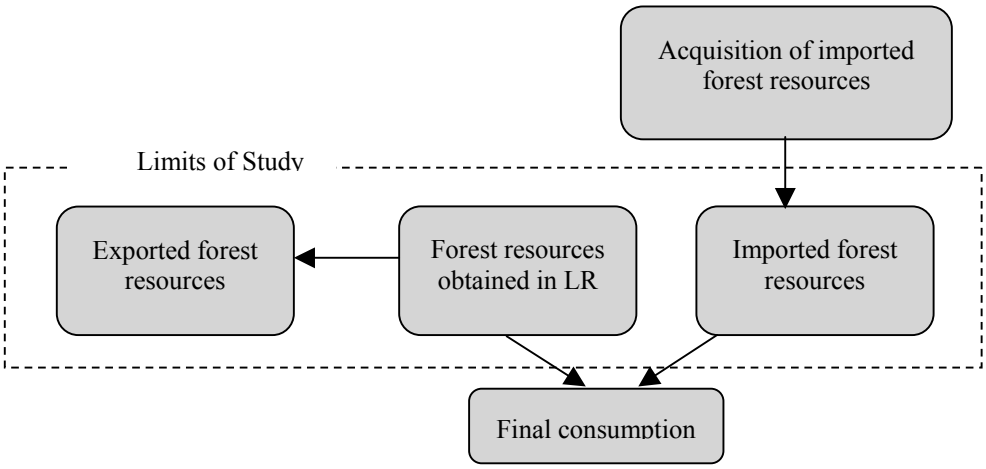

Figure 1. Limits of study.
Source: The chart made by Blumberga and Blumberga, 2011.

The aim of the study is to identify the available statistical information on the forest resources in Latvia by ascertaining the amount of available information, types of statistical data used in identifying information on tree fellings, annual afforestation, import and export, and carry out analysis of the acquired data.

Materials and Methods

The study carries out statistical analysis of data. It was carried out in 2011, in Latvian. The study analyzes data on the dynamics of tree felling and annual afforestation. The data are obtained from the State Forest Service which is a state administration civil institution subordinated to the Minister of Agriculture (Valsts meža..., 1999). According to the Regulations of the State Forest Service one of

its functions is to check the quality of the data of forest inventory (Valsts meža..., 2004). The aim of forest inventory is to obtain statistical information on the condition of forest resources in the country (Meža inventerizācija..., 2007). The data has been collected by compiling the information submitted by forest owners or legal manager in accordance with the rules on the flow of information provided for in the Forest Inventory and the State Register of Forests. The data of forest inventory are submitted to the Latvian Central Statistical Bureau, and they publish the summary of the data in their online database (www.csb.gov.lv). Consequently, the statistics provided by the Forest inventory is considered to be a source of high-quality information in our country.

The forest statistical data are publicly available on the website of the State Forest Service (www.vmd.gov.lv) in Forest Inventory section for the period of 2000 to 2009, although the website stated that the information relates to the period from 2001 to 2010; in addition, these data are free of charge. This means that the information on forest and game resources and their utilization are available in the file 2001, and it includes information beginning from the year 2001 (Meža statistika…, 2001 - 2010). The data for 2009 are considered to be the most topical from currently available, as there are no data available for the year 2010 yet.

The information on the forest statistics is available in 13 forms. An explanation regarding the information viewed in each form was last added to the data array, published in a form of a CD in 2008. The data from the CDs of years 2001 to 2010 from Form 6 and 7 have been used in the study. Form 6 contains information regarding the volumes and areas of tree felling, and their division according to the types of felling and dominant species. Information on administrative area and division into state and private forests is available. Form 7 contains information about the volume of regenerated areas, their division according to the type of property (state, other forests and forests in the country in total), and regenerated, dominant species, and types of regeneration: natural or artificial, forest site types (Meža statistika, 2001 - 2010).

The information on import and export of forest resources has been acquired from the European Community Statistical Office (EUROSTAT), online databases (http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/). The information can be found in External Trade Section. Data have been chosen by using a combined nomenclature on the level of 4, 6 and 8-digits. The data are free and considered to be presentable.

The monographic or descriptive method was used in the study. This method is based on literature review. In addition to the descriptive method, the graphical analysis of statistical data was used in the study. This method is used to perceive the phenomenon as a whole demonstrative and easy, and also makes it possible to determine the effects of development trends. Graphics have great demonstration features that let us comprehend the main content.

Results and Discussion

After the selected statistical information has been summarized, the results are as follows: during the period from 2000 to 2009 the highest tree felling was in 2003, namely - 11678 thousand m^3. While it was the lowest in 2008 – 8962 thousand m^3 (see Figure 2). Viewing the dynamics of tree felling by dominant tree species, the conclusion is that pines, spruces and birches are being felled the most. The proportion of the three species from the total volume of the felled trees varies in the range of 80% to 86% over the period of time viewed.

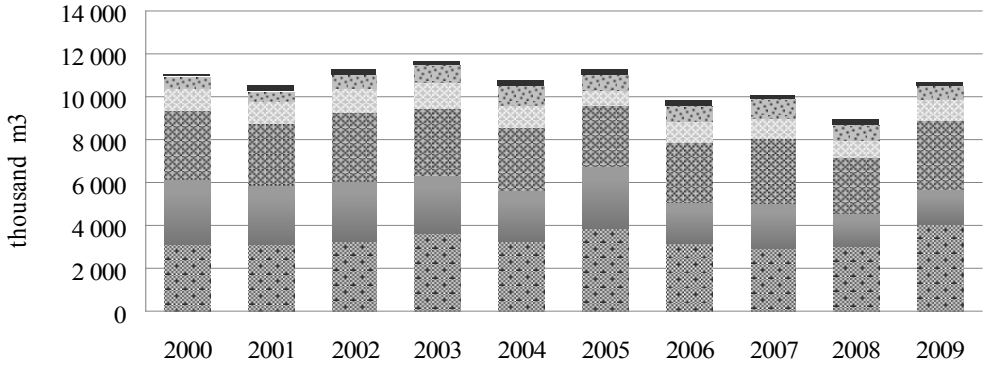

Figure 2. Dynamics of tree feeling by dominant tree species (Meža statistika..., 2001-2010):

As stated in the annual report of 2004 "The Evaluation of Resource Consumption" drawn up by the Latvian Environment Agency, the annual logging in the period from 1991 to 2003 increased from 4.4 million m^3 to 11.7 million m^3. The tendency is opposite in the years starting from 2003, i.e. annual felling reduces. As mentioned in the annual report the volume of tree felling has become more stable (1999 – 2003), there have not been sharp increase or decrease in the above mentioned volumes until 2006.

Afforestation dynamics of dominant species shows the

same trend as in tree felling dynamics. Where dominant afforestation species are - pine, spruce and birch (see Figure 3.). Since 2001 a land area where aspen is a dominant specie has increased. The aspen afforestated areas have increased by 4277 ha, when compared to the years 2001 and 2009.

In the evaluation of resource consumption it has been mentioned that the most often used tree in 1997 is spruce, whereas in 2000 – it is a birch.

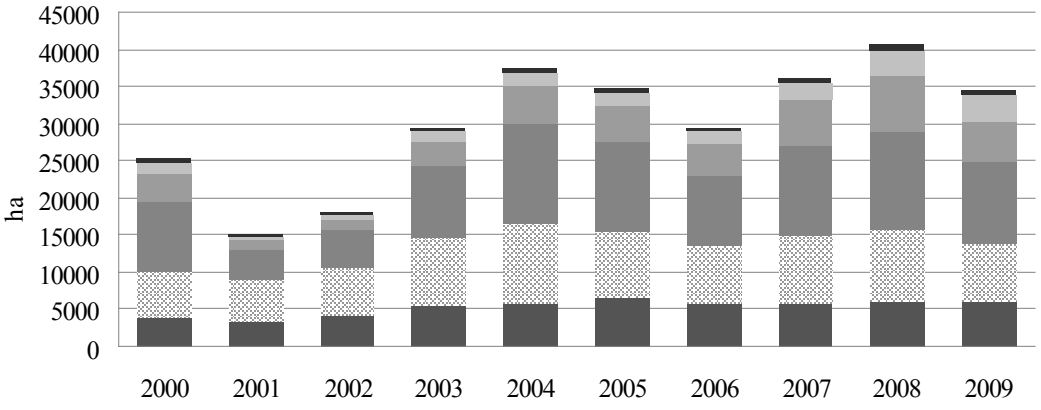

Figure 3. Dynamics of afforestation by dominant species (Meža statistika..., 2001 -2010):

pine spruce birch aspen grey alder others

There was an increase in the import of timber resources during the 2000 -2007 period. This increase is greatly influenced by the volume of the imported sawn timber and round timber. In 2000, the import of round timber was 113 thousand tons, in 2007 it was - 1222 thousand tons. Respectively, the import of sawn timber has increased from 94 to 393 thousand tons (see Figure 4).

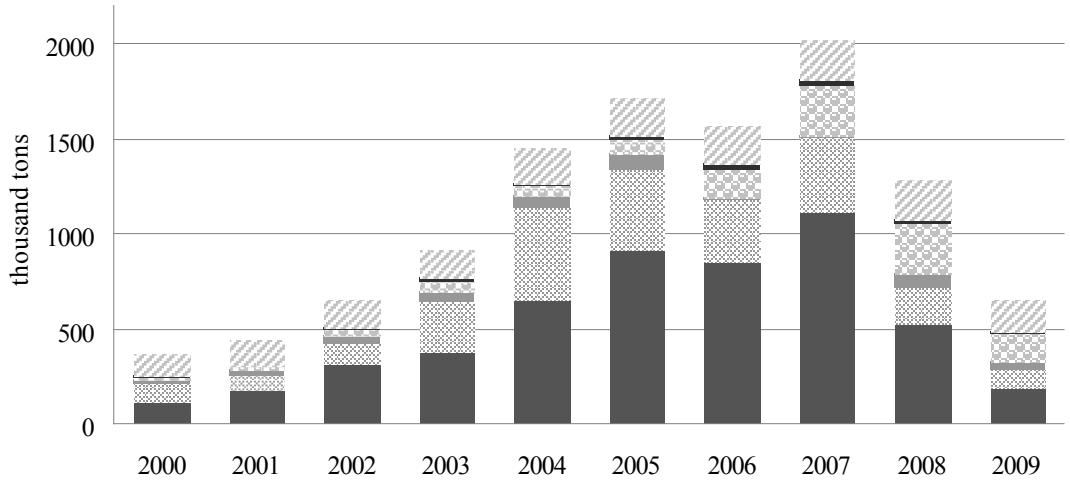

Figure 4. Dynamics of the import of timber resources (External trade, 2011):

paper and cardboard, their products; printed books, newspapers etc.
furniture
others
timber structures; fiberboards
sawn timber
round timber

As stated in the evaluation of resources, consumption imported timber resources have an upward trend, it can be seen also in this study.

The increase of the import of round timber and sawn timber could be explained with the situation that demand of Latvian forest industry is higher than supply. It is also affected a low price set by the country of importation (Resursu patēriņa..., 2004).

Upward trend was observed in the export dynamics of timber resources (see Figure 5) till the year 2005. Latvian timber export is dominated by three main products - fuel wood, round timber and sawn timber, which are included in the 'Evaluation of Resource Consumption'.

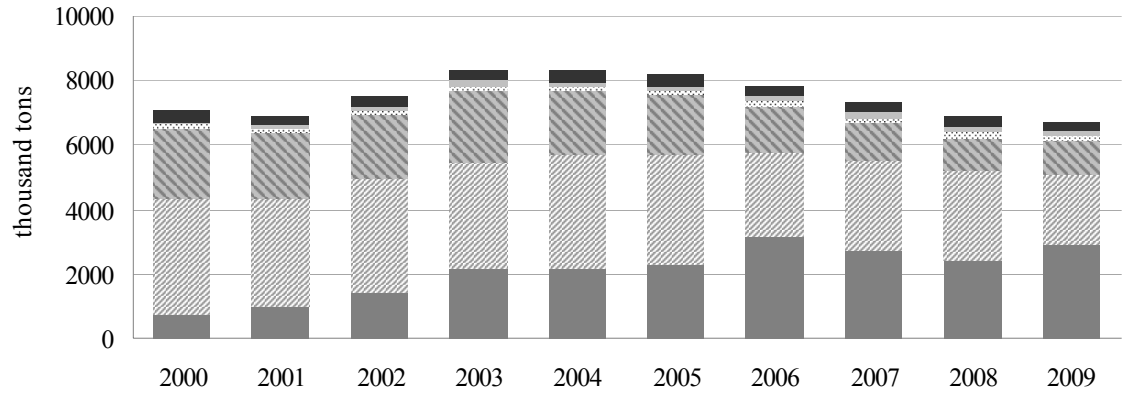

Figure 5. Export dynamics of timber resources (External trade, 2011):
fuelwood round timber sawn timber plywood package others

The information and data compiled during the study will serve as a basis for further studies.

Conclusions

1. Statistical information on forest resources in Latvia is available. There is a vast array of information data which could be adapted to a particular study.
2. The dominant felling and afforestation species are birches, pines and spruces. The proportion of the three species from the total volume of the felled trees varies in the range of 80% to 86% over the period of time 2000 to 2009. The aspen afforestated areas have increased by 4277 ha, compared to the years 2001 and 2009.
3. Since 2008 the import dynamics of timber resources has decreased, which is most likely related to the global economic crisis.

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FINE-ROOT BIOMASS AND MORPHOLOGY IN SCOTS PINE *PINUS SYLVESTRIS* L. YOUNG STANDS

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Abstract

In the summer 2010, a study of the below-ground biomass of young (12 - and 14-year-old) Scots pine *Pinus sylvestis* L. stands was carried out in central Latvia. The fine-root (diameter < 2 mm) biomass, tips, length and volume were determined for the mineral soil layer (0 – 60 cm) by core sampling. The main objective was to determine the average fine-root biomass and morphological characteristics in different classes of young stands of Scots pines. The mean fine-root biomass was calculated for the whole stand by using below-ground biomass measurements of different components of sample trees and measurement of the tree stand. The amount of dry fine-root biomass in the soil layer was 5.3 ± 1.6 t ha^{-1} in the 14-year-old stand and 3.6 ± 1.5 t ha^{-1} in the 12-year-old stand. The study showed that the largest portion (52%) of the total fine-root biomass of 12 - and 14-year-old Scots pine stands was located at a depth of 0–10 cm, decreasing in deeper mineral soil layers. The average morphological characteristics of fine roots were higher in the older stand. Analysis of the morphology of fine roots showed that at soil depth of 0 – 10 cm the mean root length was 233 ± 44 cm, volume – 1.3 ± 0.6 cm^3, value of tips – 537 ± 104 and diameter – 0.7 ± 0.1 mm per 100 cm^{-3}.
Key words: fine roots, *Pinus sylvestris*, biomass, soil layer, morphological characteristics

Introduction

The world forests contain 80% of all above-ground carbon and 40% of all below-ground carbon (Dixon et al., 1994). Fine roots are the most significant components contributing to carbon cycling in forest ecosystems. Up to approximately 75% of the annual net primary production can be allocated to fine roots (Gill and Jackson, 2000). Thus, fine roots play a key role in forest ecosystem carbon and nutrient cycling and accumulation.

Fine roots are non-woody, small-diameter roots and their associated mycorrhizae, and they are important for the water and nutrients uptake of the forest (Finer et al., 2011). Fine roots are significant for taking up water and nutrients from soil, and environmental factors such as air temperature, soil acidity, precipitation and nutrient availability in soil affect the functioning of the roots. Thus, the distribution and development parameters of fine roots in soil layers determine the above-ground vitality and productivity of trees (Jackson et al., 1996; Vogt et al., 1996).

The average fine-root biomass has proven to be smaller in boreal forests (in cooler climatic conditions) than in temperate and tropical forests (in warmer climatic conditions) (Jackson et al., 1996). The fine-root biomass differences between boreal and temperate to tropical forests depended on the availability of water and nutrients. Many experiments have shown that the fine-root biomass in boreal and temperate forests increases along with precipitation; root biomass correlates with the availability of soil nutrients and amount of water, and it has usually been smaller in the same geographical area when the availability of nutrients is higher (Vogt et al., 1996; Finer and Laine, 1998; Helmisaari et al., 2007) or water availability is poorer (Leuschner et al., 2004; Meier and Leuschner, 2008).

Morphological plasticity of fine roots has been proposed as a mechanism by which plants respond to variation in soil nutrient supply (Hodge, 2004; Lõhmus et al., 1989). Alterations in fine-root morphological traits reflect exploitation of water and nutrients in the soil. The most frequently-measured functionally important morphological indicators of fine roots are root length, root area, and root density, which are believed to be indicative of environmental changes.

Relatively few studies have been carried out on fine root biomass production and morphology characteristics in relation to stand age. In this study, the main objective was to determine the average fine-root biomass and morphological characteristics in different classes of young stands of Scots pines.

Materials and Methods

Experimental stands

The research was carried out in two young stands of Scots pine, established on a former agricultural lands in central Latvia, Ozolnieki region. The stands represent different age groups – 12 and 14 years (Table 1). One experimental plot (500 m^2) in each stand was established in the summer 2010. The plots are not replicated, but therefore statistical analysis (descriptive statistics) of the data between stand age years is used. The stands were situated on a similar site and soil type.

In both Scots pine stands there was sandy loam soil, with a relatively smaller humus layer, but saturated with nutrients. The site type according to classification is *Hylocomiosa* (Bušs, 1981).

Table 1

Same characteristics of the research stands

Characteristics	Stand age years	
	12	14
Plot area (m^2)	500	500
Numbers of trees (per ha)	2145	2925
Mean diameter (cm)	11.2	10.3
Mean height (m)	7.7	8.2
Basal area (m^2 ha^{-1})	21.0	24.3
Stand volume (m^3 ha^{-1})	92.2	115.4

Fine roots sampling

Root sampling was conducted in August 2010. The soil core sampling method was used to collect fine roots (diameter ≤ 2.0 mm). Twenty soil cores (volumetric samples 100 cm^3 and core diameter 50 mm) per sampling were randomly taken in both sample plots for determination of the fine-root biomass. The soil cores were divided into five layers by depth: 0 – 10 cm, 11 – 20 cm, 21 – 30 cm, 31 – 40 cm and 51 – 60 cm of the mineral soil. The samples were placed in polyethylene bags, transported to the laboratory, and stored in a refrigerator at 4 °C until the analysis.

Laboratory analysis

In the laboratory, the roots were washed and separated into Scots pine roots and roots of other plants. Small and coarse roots (diameter > 2 mm) were excluded from the analysis.

Fine roots are generally defined as nonwoody, small-diameter roots (Nadelhoffer and Raich, 1992), but there is no established convention defining the diameter-size range of fine roots (Fogel, 1983). In this study, roots smaller than 2 mm were regarded as fine roots.

The morphology indices of *Pinus sylvestris* fine roots were analyzed by using the digital image analysis system WIN-Rhizo 2002c (Regents instruments, QC, Canada). The roots were placed in a transparent box filled with water (to facilitate root visibility) on a scanner. The image analysis software scanned all the fine root fragments and calculated morphological parameters, such as root length, and number of root tips. After scanning, the separated fine roots were dried at 105 °C until reaching constant weight, and weighted to determine the dry biomass. Based on the results, the following average morphological indices were calculated: root length, root volume, root diameter, root tip density and biomass at soil layer depth of 0 – 10 cm, 11 – 20 cm, 21 – 30 cm, 31 – 40 cm, 41 – 50 cm and 51 – 60 cm.

Results and Discussion

Fine root biomass

The amount of fine-root biomass varied between soil layers. A major portion of the Scots pine fine roots (46%) was found in the upper mineral soil immediately below the humus layer (Helmisaari et al., 2002). There was significant prevalence of fine-root biomass in the top soil layers, decreasing at greater soil depth (Claus and George, 2005; Makkonen and Helmisaari, 1998; Fujii and Kasuya, 2008; Helmisaari et al., 2002). C. Trettin et al. has noted that roots allow for efficient uptake of water and nutrients from the surface layers of soil (Trettin et al., 1999). Our 12 - and 14-year-old stands had dry fine-root biomass of 1.8 ± 0.5 t ha^{-1} (52%) and 2.7 ± 0.4 t ha^{-1} (52%) in the upper mineral soil (0 – 10 cm), which is nearly equal to the fine root biomass range reported by other authors. The investigations showed that there was a clear relation between the average fine-root biomass of a stand and the depth of the mineral soil layer, which is described by the coefficient of determination R^2=0.89 (Figure 1). The vertical distribution of the fine root biomass of both Scots pine stands decreased with increased soil depth. The main fine-root biomass of 12 - and 14-year-old Scots pine stands was located at a depth of 0 – 10 cm, decreasing in deeper mineral soil layers.

There were significant differences between the soil layers and average fine-root biomass in the Scots pine stands ($p<0.05$) (Figure 2). The distribution of fine-root biomass in soil layer 0 – 60 cm was higher in the older stand (14-year-old) – dry biomass 5.3 ± 1.6 t ha^{-1}; in the younger stand (12-year-old) – dry biomass 3.6 ± 1.5 t ha^{-1}.

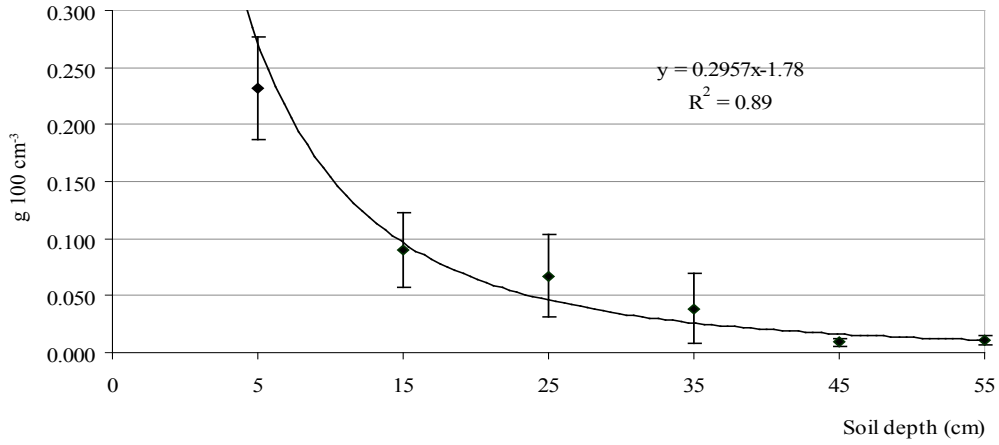

Figure 1. Average fine root biomass and its changes in the soil layer of 12 - and 14-year-old Scots pine stands.

The average dry fine-root biomass of 12 - and 14 – year - old Scots pine stands at a depth 0 – 10 cm is 2.3 ± 0.4 t ha^{-1}, but decreases in deeper mineral soil layers: at a depth of 10 – 20 cm – 0.9 ± 0.3 t ha^{-1}, at a depth of 20 – 30 cm – 0.7 ± 0.3 t ha^{-1}, at 30 – 40 cm – 0.4 ± 0.3 t ha^{-1}, at 40 – 50 cm – 0.1 ± 0.03 t ha^{-1}, and at 50 – 60 cm – 0.1 ± 0.04 t ha^{-1}.

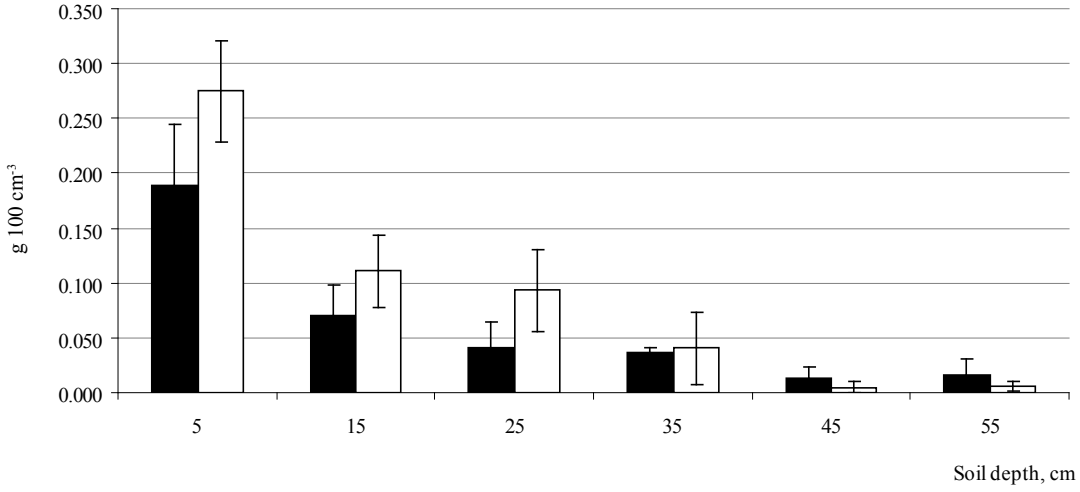

Figure 2. Comparison of fine-root biomass in the different soil depths of 12 - and 14-year-old Scots pine stands: ■ 12 years, □ 14 years.

Fine root morphology

The depth distribution of morphological characteristics of fine roots varied with stand age (Makkonen and Helmisaari, 2001). The fine root length, density and volume in the surface soil layer were higher than at a greater soil depth. The fine root morphology showed marked distinctions between the Scots pine stands, but these root morphology differences did not lead to significant differences ($p>0.05$) in the fine root length, volume, and diameter or root tip (Figure 3).

The average morphological characteristics of fine roots were higher in the older stand, but there were no significant differences between the young Scots pine stands in terms of fine root morphology. The analysis of fine root morphology showed that at soil depth of 0 – 10 cm the mean root length was 233 ± 43 cm, volume – 1.3 ± 0.6 cm^3, value of tips – 537 ± 104, and diameter – 0.7 ± 0.1 mm per 100 cm^{-3}.

Except for the deepest roots, the mean diameters of all fine roots ranged between 0.7 and 0.6 mm in the upper layers. Roots in the upper 30 cm of soil were, on average, thicker than roots at a depth of 30 – 60 cm (0.7 ± 0.02 versus 0.4 ± 0.1 mm). These values are slightly larger than those reported by J. Roberts for a *Pinus sylvestris* L. stand: 0.28 mm in the first 15 cm (Roberts, 1976).

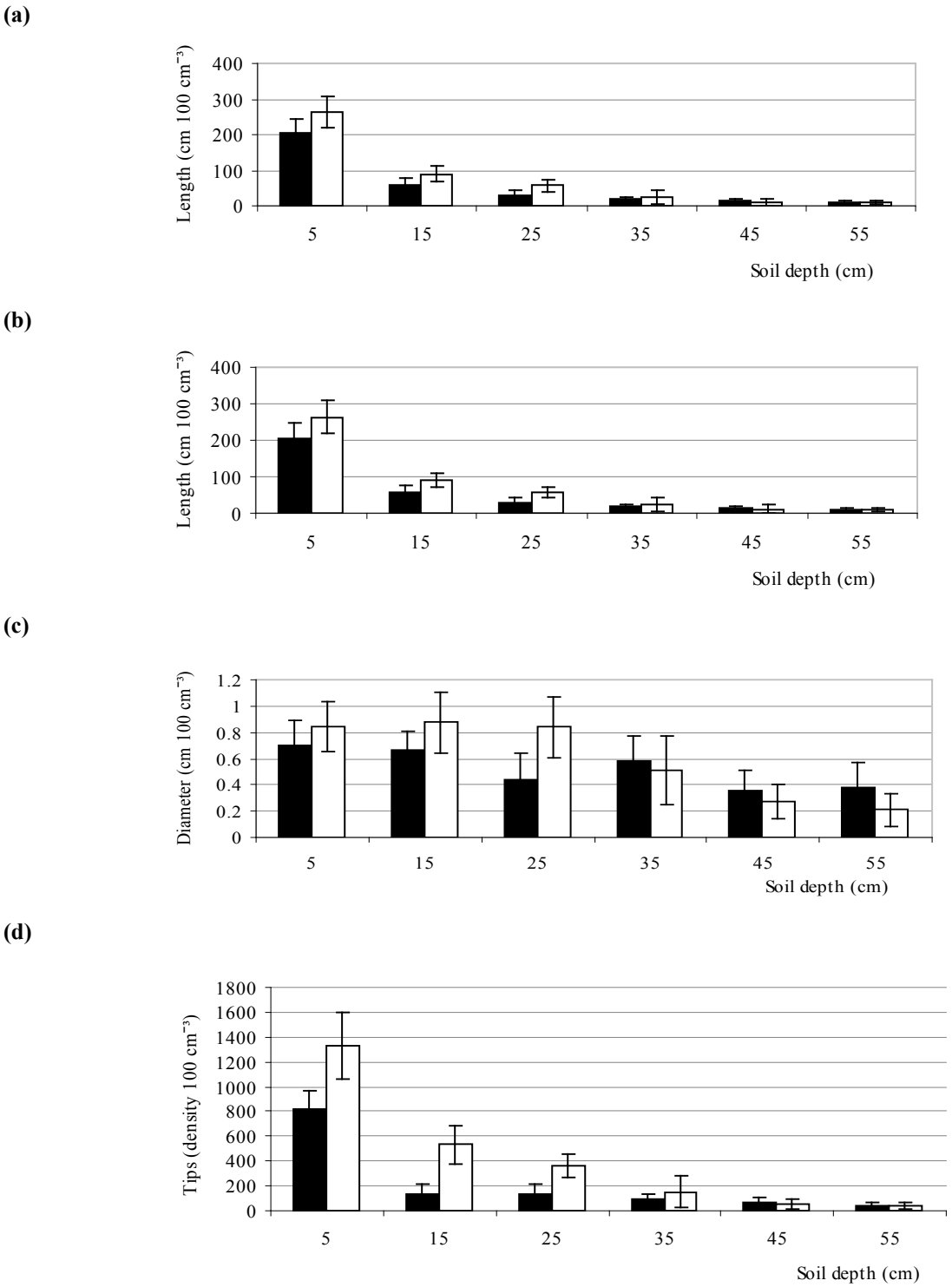

Figure 3. Average morphological characteristics (**a** root length, **b** root volume, **c** root diameter, **d** root tip density) of fine roots in young stands of Scots pine: ■ 12 years, □ 14 years.

Conclusions

The vertical distribution of the fine root biomass of the Scots pine stands decreased with increased soil depth. The largest part of the fine-root biomass is located in the upper mineral soil layers (0 – 10 cm). The dry fine-root biomass in 12- and 14-year-old Scots pine stands had 1.8 ± 0.5 t ha^{-1} and 2.7 ± 0.4 t ha^{-1} in the upper mineral soil (0 – 10 cm). Total fine-root biomass in soil layer 0 – 60 cm was higher in the older stand (14-year-old) – dry biomass 5.3 ± 1.6 t ha^{-1}; in the younger stand (12-year-old) – dry biomass 3.6 ± 1.5 t ha^{-1}. The mean morphological indicators of the fine roots were higher in the 14-year-old stand than in the 12-year-old stand.

Acknowledgements

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CHARACTERIZATION OF SEVERE DAMAGES OF SPRUCE (*PICEA ABIES* (L.) H.KARST.) STANDS IN RELATION TO SOIL PROPERTIES

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Abstract

Severe damages of spruce stands were found during recent years in several countries of the Baltic sea region. Characteristic indications of these damages are trees with brownish drying tops distributed across the whole compartment. During the first year only forests on drained organic soils suffer. In the second and third years, according to experiences gained in Lithuania, the damages move to other stand types. In Latvia, the first signals about the damages of spruce stands arrived from the company 'Rīgas meži' in May, 2010. 'Rīgas meži' found damaged stands in 2 forestries. The most of the damaged stands were on organic soils. The inspection of other forests by the State forest service identified similar damages in Southern part of Latvia as well as in other regions with considerable areas of organic soils. In August, 2010 'Rīgas meži' did their own inspection in Olaine and Tīreļi forestries and found out that 24% of spruce stands has characteristic signs of damages, and in 10% of stands dead or significantly damaged trees were found. Due to theses damages, about 300 ha of spruce stands were harvested in sanitary clear-felling in 2010. Spreading of spruce bud scale, *Physokermes piceae* (Schrnk.), is found to correlate with damages of spruce stands in Latvia and Lithuania. This pest is well known in both countries, but never before it caused any serious damages to spruce stands. In Sweden another bud scale insect (*Physokermes inopinatus* Danzig & Kozár) is found to be the reason for spruce damages.

Key words: spruce dieback, *Physokermes piceae*, spruce bud scale, soil characteristics.

Introduction

Norway spruce *Picea abies* (L.) Karst. is one of the most common tree species in Latvia. According to the State forest service, spruce stands cover about 0.5 mill. ha (18% of forest area in Latvia) with total growing stock 572 mill. m^3 (15.8% of total growing stock) (Valsts meža dienests). Norway spruce contributes the most to the soil podzolization process, in compaison with other tree species, because it has the most acidic litter (Kārkliņš et al., 2009). Norway spruce grows well in Latvia on weakly acidic loamy soils. It is shade-tolerant and sensitive to wind damages tree specie. The needles and even young shoots may suffer from late spring frosts. Norway spruce also suffers from long drought periods and is not tolerant against pests and diseases (Mauriņš, 2006).

During recent years heavy damages of spruce stands in different forest ecosystems is not unique for Latvia, but takes place in the whole Baltic region. Therefore, this problem needs comprehensive investigation in the whole region to evaluate role of different biotic and abiotic stress factors and environmental characteristics, like soil conditions, in triggering of the spruce damages and identification of potential solutions to minimize the risks in future. Exchange of information with Lithuanian, Swedish and Belarus foresters approved that the most of the recent cases of spruce damages are coincident with distribution of bud scale insects, particularly, in Latvia and Lithuania increased population of the spruce bud scale *Physokermes piceae* (Schrnk.) identified in damaged stands (Valstybinė Miškų Tarnyba, 2010). Up to now the most serious damages of forests this pest has caused in Southern European countries. For instance, in Turkey spruce bud scale is well known pest in *Picea pungens* Engelm. plantations (Turguter and Ülgentürk, 2006). In Latvia, spruce bud scale is a common pest in parks, where it colonizes weakened trees growing in sunny and dry places. However, up to now no serious damages of forest ecosystems are associated with this pest (Rupais, 1999; Plīse, 2007).

Bud scale insects *Coccodea* belong to *Homoptera* suborder of *Hemiptera* order. The family's characteristic feature is its high ability of adaptation to parasytic way of living on host plants (Rasiņa and Rupais, 1994). Host plants of bud scale insects are different species of spruce, including Norway spruce, blue spruce *Picea pungens* Engelm., Engelmann Spruce *Picea engelmannii* (Parry) Engelm. white spruce *Picea glauca* (Moench) Voss and others (Rupais, 1979). Information about distribution of the spruce bud scale in the Baltic sea region and damages caused by this pest is limited. No scientific publications on this pest and considerable damages of spruce stands it causes were identified within the scope of this study.

The female adult spruce bud scales are approximately 3 mm in diameter. They are found stationary in colonies of 3-8 individuals located at the base of new growth, most often on the lower branches. Note that within the scope of this study the highest concentration of the spruce bud scale females were found on tops of the trees. Mature females are brown to reddish brown. Males have about 1 mm long wings. They are of rare occurrence. One generation of insects grows up every year. In winter, larva stays on young shoots nearby buds or sometimes on needles (Ozols and Spuris, 1985; Plīse, 2007). In May larva moves to basement of opening buds nearby old bud scales. New females

grow up in May and June (Ozols and Spuris, 1985). They move to stem and branches and suck juice from vascular tissues. This leads to dieback of bark, bending and disease of shoots. Reduction of increment of young shoots and shorter needles on young shoots are characteristic for heavily affected trees. Sometimes trees may die due to damages made by the spruce bud scale. Sometimes there are so many spruce bud scale females that they completely cover surface of branches and stems and bark is completely hidden (Воронцов, 1982).In the end of June or beginning of July females lay eggs below the shield and die (Ozols and Spuris, 1985). According to different studies, one female can produce 800-3000 reddish eggs (Новак, 1974; Turguter and Ülgentürk, 2006; Valstybinė Miškų Tarnyba, 2010). From these eggs small pink larva comes out in July. Larva stick to young shoots or bottom part of needles. In October larva is changing shell and becomes more brownish. Afterwards larva continues to suck trees and stick for winter in axils of shoots or nearby top buds. In spring minor part of larva moves to needles where they transform into pronymphs. Below the shields, which are covered with waxy filaments, pronymph transforms into mature males. Major part of larva in spring stick to the bud scales at the tops of shoots, where they drop their shells and transform into yellow females, which gradually become darker brownish and can be easily visually identified (Valstybinė Miškų Tarnyba, 2010). Females of spruce bud scale suck juice of trees and produce honeydew, which becomes covered with sooty mold, which is used as food by saprophytic fungi *Apiosporum pinophilum* Fuckel. These fungi can be easily identified by dark or black colour of foliage and shoots. According to the research data thick layer of fungi can negatively affect transpiration and photosynthesis causing the so called winter drying (Новак, 1974; Valstybinė Miškų Tarnyba, 2010). The fungi may affect assimilation, breathing, and can cause dieback of tissues, thus reducing increments and decreasing aesthetic value of trees in parks (Шевченко and Цилюрик, 1986).

The literature does not provide evidences of relation of heavy tree damages and the spruce bud scale or fungal sooty mold, but they are usually noted as factors which can weaken trees making them less tolerant to other stress factors. The spruce bud scale usually occupies weakened trees in dry and nutrient pure stand types. Increase of population of other pests like honeydew *Cinara piceae* Panz. also point to weakening of trees. Population of any species of insects is constantly affected by complex of factors, which causes fluctuations in size of population. Favourable conjuncture can cause extraordinary rapid increase of population with following decrease due to spreading of natural enemies or diseases. Epidemic distribution of the spruce bud scale may continue for 2...3 years; however, they can cause avalanche-like reaction of distribution of other pests in weakened stands. Tolerance of forest stands is determined not only by properties of single trees, but also by characteristics of the whole compartment – age, species composition, structure of crown coverage, soil properties and forest management practices (Воронцов, 1982).

The aim of the study is to evaluate, how soil properties affect distribution of damages, and whether there are particular soil characteristics prohibiting distribution of the damages. Specific tasks of the study are analyses of soils from properties from damaged and healthy or less damaged stands to identify whether there are statistically significant differences between those groups of plots and correlation between intensity of damages and soil properties.

Materials and Methods

The sample plots (60 in total) were established in 30 blocks of AS 'Latvijas valsts meži' (LVM) managed forests, where spruce damages were identified by foresters. The blocks for the study were selected if one visually identifiable part of the block is damaged more than others, and there are no mechanical or other borders between these parts of the blocks. Consequently, 2 sample plots (damaged and healthy or less damaged) were established in every block. Circular sample plots (500 m^2 each) were established in each damaged and healthy or less damaged part of block to identify characteristics of stands and level of damages. Location, species and diameter of all trees were measured and height of 9...11 sample trees of each represented specie was measured to calculate height of trees. Damages were classified in 4 categories: healthy trees, weakly damaged trees with brown tops, heavily damaged trees with defoliation or dechromation of 60% of the crown and dead trees. 'Damage index' (number of trees with more than 60% of defoliation or dechromation) were used to classify intensity of damages.

Soil samples were collected outside the circular sample plots in 4 repetitions (15...20 m to North, South, East and West from the centre of the circular plot) in each sample plot. Augers for undisturbed soil sampling were used. Samples were taken from 0...10 and 10...20 cm depth in all soils and from 20...40 and 40...80 cm soil layer in mineral soils and from every 10 cm deep soil layer down to 80 cm depth in organic soils. 100 cm^3 sample probes in 3 repetitions were taken at each depth in centre of sampled layer. After delivery to laboratory soil samples were dried in 105 °C and weighted (with uncertainty ± 0.1 g) to determine soil density. After weighting samples from the same layers from every plot were mixed together to determine soil texture; exchangeable acidity; content of ammonia and nitrates; total nitrogen; total, carbonate and organic carbon; aqua regia extractable potassium, phosphorus, magnesium, calcium and manganese; exchangeable manganese; and sum of exchangeable cations.

Soil texture (proportion of sand, dust and clay particles in fine earth) was determined according to LVS ISO 11277 2000 standard. Nitrates ($N\text{-}NO_3^{-1}$) were determined after extraction in 0.1 M NaCl solution using colorimetric VISOCOLOR Nitrate 50 tests. Exchangeable ammonia ($N\text{-}NH_4^{+1}$) was determined in the same solution according to the ISO 14256-2:2005 standard. Total nitrogen (N) was determined using modified Kjeldahl method according to LVS ISO 11261 standard. Total carbon ($C_{tot.}$)

was determined with elementanalyzator LECO CR-12 incinerating samples in 1 370 °C temperature in oxygen flow. Carbonates ($C_{carb.}$) were determined with calcimeter according to ISO 10693 1995 standard. Difference between $C_{tot.}$ and $C_{carb.}$ is organic carbon ($C_{org.}$). Exchangeable acidity (pH) was determined in 1:5 0.01 M potassium chloride (KCl) solution with pH-meter. Agua regia extraction was done using microwave digestion according to LVS ISO 11466:1995 standard. Aqua regia extractable potassium (K) was determined using flame emission method according to ISO 9964-3:1993 standard. Aqua regia extractable calcium (Ca), magnesium (Mg) and manganese (Mn) were determined using atomic absorption method according to LVS ISO 11466:1995 standard. Mixture of acetylene and air were used for flame emission and atomic absorption, incineration temperature – 2125...2400 °C. Aqua regia extractable phosphorus (P) were determined with colorimeter according to LVS 398 (2002) standard. Exchangeable manganese ($Mn_{ex.}$) was determined in 0.1 M barium chloride ($BaCl_2$) using atomic absorption according to ISO 14254:2001 standard. Exchangeable cations were determined using titrimetric method according to ISO 11260:1994 standard. Relations between concentration and stock of $C_{org.}$ and N, $C_{org.}$ and P, Mn and $Mn_{ex.}$ were evaluated additionally, because these indicators are often mentioned as important for characterization of forest growth conditions (Pinay et al., 1992; Albuquerque and Mozeto, 1997; Shen et al., 2007). Obtained results of chemical composition of soil were recalculated to absolutely dry mass and volume units (kg ha^{-1} per layer – 0...10; 10...20; 20...40 and 40...80 cm layers) to be able to compare availability of nutrients in organic and mineral soils. Regression and correlation analysis is used for data evaluation. T-test with 95% confidence is used for significance analysis.

Results and Discussion

Density of different soil layers in damaged and healthy or less damaged part of blocks does not differstatistically ($p>0.05$). Comparison of average density values per plot also did not provide statistically significant difference. However, investigation in SIA 'Rīgas meži' (RM) demonstrated significant difference in soil density – upper layers in damaged plots were more loose (Bārdule et al., 2011).

Comparison of carbon stock in soil did not demonstrate significant differences. Average carbon stock in 0...80 cm deep soil layer in damaged plots is 292 tons $C_{org.}$ ha^{-1}, but in healthy or less damaged stands – 332 tons $C_{org.}$ ha^{-1}. In sample plots established in RM managed forests this difference was statistically significant (Bārdule et al., 2011). This can be explained by broader representation of mineral soils in LVM sample plots. Correlation was found between carbon stock and the damage index (Figure 1). This approves assumption that spruce stands on peat soils suffer more from the damages.

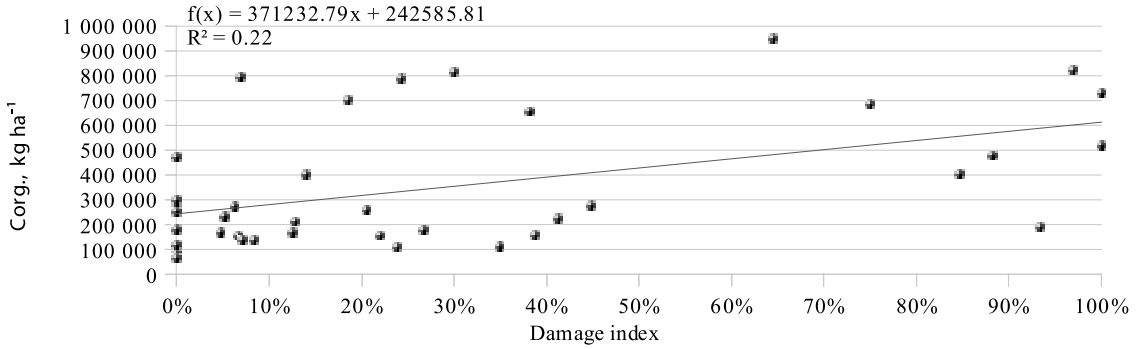

Figure 1. Relation between $C_{org.}$ and damage index.

Soil pH is found to be important factor affecting scale of damages in RM managed forests. More damaged stands had more acidic soil (Bārdule et al., 2011). In LVM managed stands this assumption was not approved; no statistically significant difference was found, when all soil layers were compared. Average pH in upper 0...20 cm deep soil layer is 4.1; in the RM plots in damaged plots it was – 3.3 and in healthy plots – 3.8 (Lazdiņš et al., 2010). However, comparison of pH and damage index in separate soil layers showed correlation between pH in 10...20 and 20...40 cm deep soil layer Figure 2. In more damaged stands pH is higher than in healthy or less damaged stands.

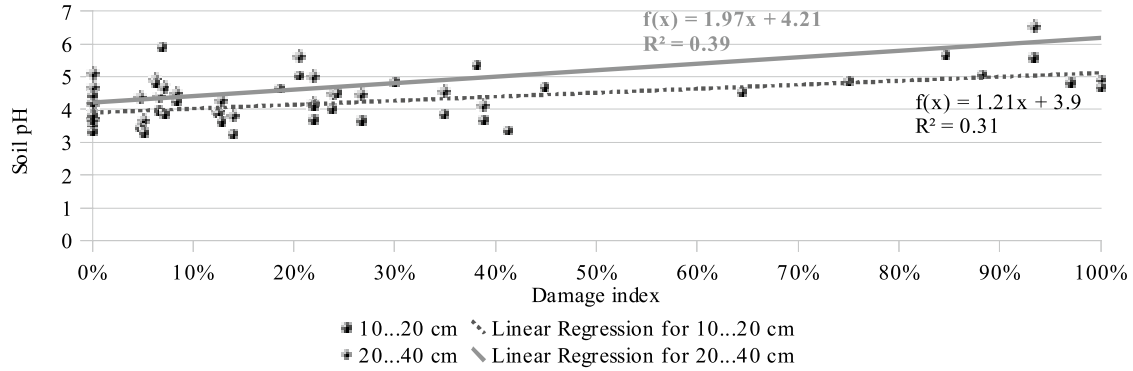

Figure 2. Relation between soil pH at 10...20 and 20...40 cm depth and damage index.

There was no statistically significant difference in stock of $N\text{-}NH_4^{+1}$ in damaged and healthy or less damaged plots. At the same time stock of $N\text{-}NO_3^{-1}$ is one of the few measures being significantly different in damaged and healthy or less damaged stands (p=0.03). Soils of damaged stands have more $N\text{-}NO_3^{-1}$. Stock of $N\text{-}NO_3^{-1}$ correlates with depth of organic layer (r=0.53).

Evaluation of N stock in soil in RM forests demonstrated significant difference between damaged plots and healthy or less damaged stands. The N stock correlated with $C_{org.}$ stock and depth of organic layer (Bārdule et al., 2011). No correlation in damaged and healthy or less damaged plots was found in the LVM plots; however, N stock is larger in upper soil layer (0...10 cm) of damaged plots and situation is opposite in deeper soil layers (Figure 3). The difference is not statistically significant. Average N stock in 0...80 cm deep soil layer is 15.5 tons ha^{-1}. Linear correlation found between the N stock and damage index (Figure 3). Furthermore, similarly to the RM plots, correlation with depth of organic layer was found (r=0.92, p<0.05). This approves, that the heaviest damages occur on organic soils with weakly decomposed peat and considerable nitrogen stock. Note, that studies in RM plots demonstrated that severity of the damages negatively correlates with depth of groundwater; higher groundwater level presumes more severe damages (Bārdule et al., 2011). High groundwater level is the reason for shallow root system, which means that only part of nutrients located in aerated soil layer above the groundwater is accessible to plants.

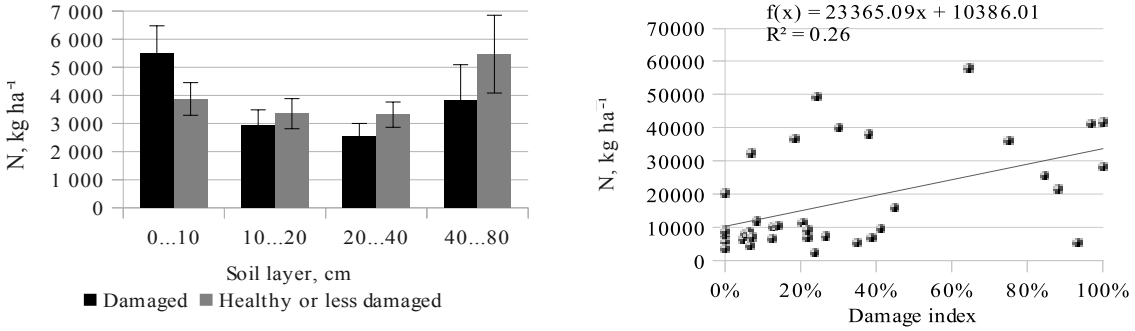

Figure 3. Total N stock in damaged and healthy or less damaged plots in different soil layers (left) and relation between stock of N and damage index (right).

Relation between $C_{org.}$ and N (C/N) characterizes availability of N in soil. Average C/N in topsoil is 12. If C/N increase above 24, the most of soluble N in soil is utilized by micro organisms and plant growth can be limited by lack of N (AGRO, 2004). Average C/N in topsoil (down to 20 cm depth) in damaged plots is 23, in healthy or less damaged plots – 25; difference is not statistically significant. Obtained results approves that more vulnerable to the damages are spruce stands on poor soils; however, no correlation was found between the damage index and C/N.

In contrast to finding in the RM sample plots (Bārdule et al., 2011), no significant difference was found in K stock between damaged and healthy or less damaged plots. Correlation coefficient of the damage index and K stock is the following: r=-0.52, p<0.05. Even stronger correlation was found between the K stock and depth of peat layer (r=-0.64, p<0.05). Exponential trend line demonstrating intensity of damages depending on the K stock is shown in Figure 4. Lack of K is characteristic for poor organic soils. It can be easily determined by yellow colour of young needles (Huber et al., 2004). Only few trees with yellowish needles were found in the experimental plots; therefore, in spite of reserves of K that are sufficient for a tree growth, there might be lack of K in more damaged plots for other important functions, like securing of frost and disease tolerance.

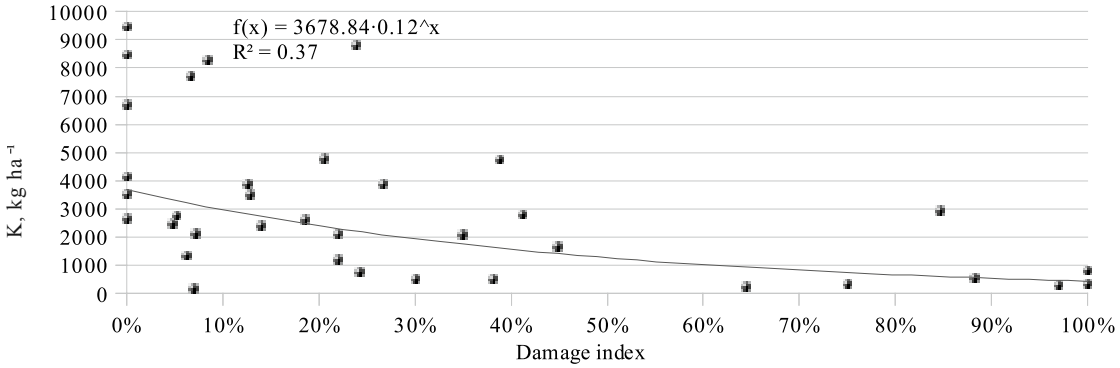

Figure 4. Relation between K stock and damage index.

No statistically significant difference between damaged and healthy or less damaged plots was found for Ca stock. However, Ca is the only cation which demonstrated significant positive correlation with damage index ($r=0.63$, $p<0.05$); exponential trend line is shown in Figure 5. Strong positive correlation was found between Ca stock and depth of organic layer in soil ($r=0.93$, $p<0.05$). All other treated cations behaved in the opposite way, showing weak or moderate negative correlation with depth of organic layer. The same was found also in RM plots, where Ca stock correlated with depth of peat layer in deeper soil layers (Lazdiņš et al., 2010). No explanation is found in literature for correlation of the damages and Ca stock. Some scientists note, that increase of Ca stock can lead to reduction of growth parameters; however, normally it is associated with formation of considerably less acidic soil conditions (Jonard et al., 2010; Małek, 2009), which is not the case in this study.

Mg is important component of chlorophyll and lack of this element may cause disturbances of photosynthesis. The Mg stock in soil in the experimental plots is similar to the K stock; however, no significant difference was found in the Mg stock between damaged and healthy or less damaged plots. No correlation was found with the damage index either.

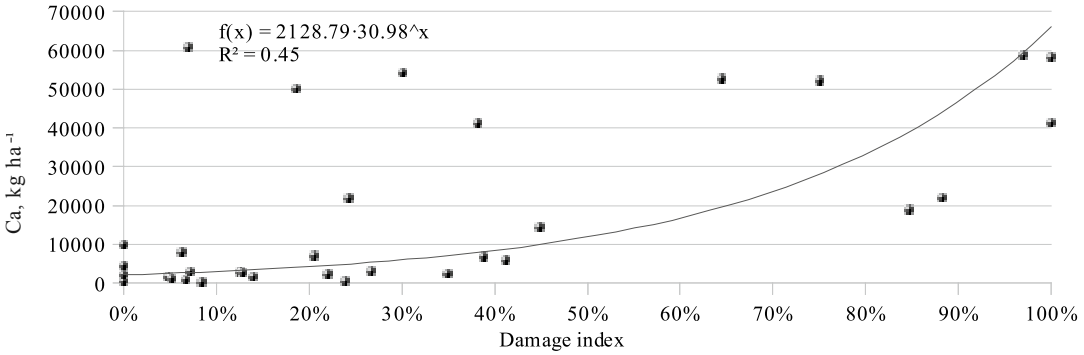

Figure 5. Relation between stock of Ca and damage index.

Relation of Mn stock between soil and reduction of growth characteristics of spruce is one of the most often discussed issues of vitality of spruce stands. However, the research data are limited, also in European prospective. In 2007, Institute of Biology and LSFRI Silava implemented study on estimation of reasons of dieback of spruce stands. Rare extraction method (in 1 M HCl) was used in the project; hence it was not possible to compare these data with values obtained in the study or figures available from the forest monitoring sites. The project, however, approved relation of reduction of growth to content of soluble K in topsoil as well as demonstrated relation of soluble Mn to the growth of spruce (Nollendorfs, 2007).

Comparison of damaged and healthy or less damaged plots within the scope of this study did not show significant difference in Mn_{ex}. Aqua regia extractable Mn, as well as $Mn_{ex.}$ in damaged plots in all soil layers, excluding upper 10 cm, demonstrated smaller stocks. Correlation between $Mn_{ex.}$ and soil pH was not found (Figure 6).

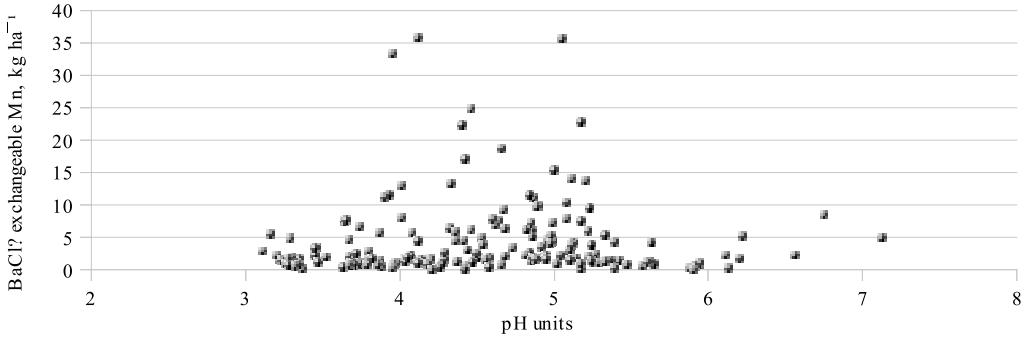

Figure 6. Relation between $Mn_{ex.}$ and pH.

P stock in soil down to 80 cm depth in damaged plots is 1.9 tons P ha^{-1}, in healthy or less damaged plots – 1.5 tons P ha^{-1}; however, no statistically significant difference was found. Comparison of $C_{org.}$ and P relation in damaged and healthy or less damaged stands shows that the relation is smaller in damaged stands (less P in soil); however, the difference is not statistically significant (Figure 7). No correlation was found between P stock and the damage index.

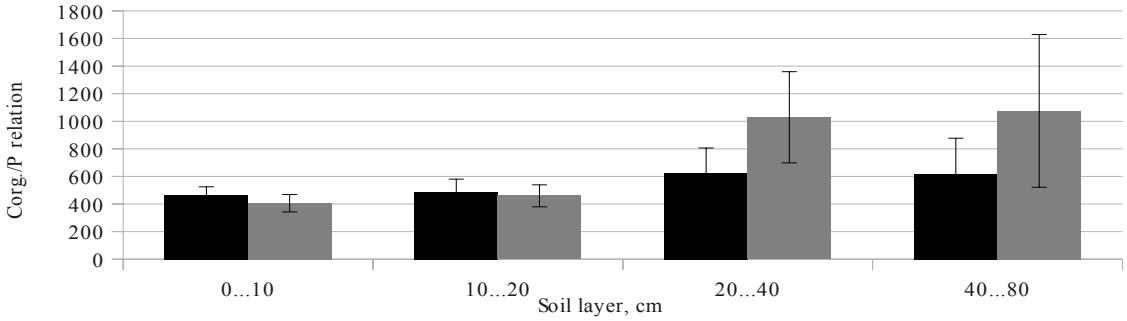

Figure 7. Relation between $C_{org.}$ and P in damaged and healthy or less damaged plots in different soil layers.

Conclusions

1. Results of the study approve that soil properties affect severity of damages; however, there is no single parameter or easily identifiable set of parameters, which can be noted as a source of the problem. The parameters affecting growing conditions are not the same in different plots, but the common issue is that they are well known from the earlier studies as indicators of better or worse growing conditions.
2. Sample plots established in LVM represent broader range of soils, including carbonaceous soils, in contrast to the earlier study at RM, where only few soil types differing mainly by depth of organic layer were represented. This is the reason, why correlations between soil characteristics and damage index, as well as difference between damaged and healthy or less damaged plots is not so distinguished as found in earlier studies.
3. Significant positive correlation was found between the damage index and $C_{org.}$ and N stock, which are positively correlating with depth of organic soil layer, which means that more severe damages occur on peat soils. Moreover, according to results obtained in the RM, severity of the damages increases with increase of groundwater level; therefore, distribution of damages points to groundwater as a factor temporary or permanently intensifying negative effect of lack or abundance of certain elements.
4. Comparison of pH approved, that damages distributes in case of both extremes – if soil is too acidic and too basic. Similarly in natural conditions on drained shallow peat, soils can influence other elements as well. For instance, it might influence Mn which might be associated with degradation of growing conditions in case of abundance and can improve growth in case of limited stock in upper soil layers.
5. The study raised question about the role of Ca in distribution of damages. According to the results, Ca correlates with damage index; however, there are no literature references about spruce damages caused by abundance of Ca, except the extreme cases associated with considerable increase of alkalinity of soil.
6. The only chemical element, which demonstrated moderately strong negative correlation with the damage index, is K. This means that additional reserves of K in topsoil layer might improve growth conditions and compensate temporary or permanent deficient of K due to fluctuations of groundwater level. K can be applied as mineral fertilizer, which is historically known, but forgotten due to high costs, forestry practice, as well as wood ash, which contains also other nutrients necessary for plants.

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RADIAL GROWTH OF NORWAY SPRUCE IN THE POLLUTED WESTERN PART OF LATVIA

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Abstract

Environmental pollution that has been one of the key issues for decades has still not lost any of its topicality. In order to study the impact of air pollution on the growth of Norway's spruce (*Picea abies* (L.) Karst.), 31 sample plots were established at different distances and directions from the pollution points in the Western part of Latvia. The plots were established starting from the year 2008 summer-autumn season and finishing with the spring of 2009. The selected stands were 32 - 171 year old and of different forest site types. The selection was used in the State Forest Service database and cartographic materials. Empirical data was obtained from each of the plots which reflected the environmental effects on the trees. To ascertain the effect of air pollution on the growth of Norway spruce, the algorithm based on additional increment to volume was used. Air pollution affects eating, regardless of age and the type of growing conditions. Pollution effects are closely related to the distance from the source.
Key words: air pollution, Norway spruce, dendrochronology, volume increment.

Introduction

If there were no anthropogenic effects, forest areas would be much greater. To the humanity, utilization of forest valuable products has brought their material well-being. At first, the forest was used in its primitive sense, but gradually human activity has considerably expanded. Nowadays, consequently, no direct use of the forest affects the physical and chemical factors that are especially dangerous because of their effects which are very difficult to discern visually.

The growth of industries and large urban agglomerations during the last half century has given a rise to significant changes in the natural environment, resulting in an adverse impact on many of its elements. Air pollution, especially taking into consideration its impact on a larger area, has become a very serious problem. This problem is quite evident in the environment. There has been a greater amount of emissions of pollutants into the atmosphere. Over the last decade the amount of damage to the forest to be investigated has increased not only at the local level but also at the regional level. Harmful compounds emitted into the air have severely impaired health status in many groves in Europe (Breymeyer, 1997; Kandler and Innes, 1995). Similar results have also been observed in Japan, where as a result of pollution and different climatic factors the growth of Norway spruce has decreased (Kobayashi, 1992).The Western part of Latvia should pay a particular attention to air pollution issue. In this part of the country, the focus is on steel and cement production companies, as well as there is an influence of cross-border pollution (Nikodemus et al., 2004; United Nations, 2006). Air pollution in developed countries started to decline already around 1980, while in the Central and Eastern Europe - around 1990 (Kupcinskiene et al., 2008). Although the level of pollution from industrial facilities has decreased, it still has a significant proportion of around 50% of the total pollution level (Pärn, 2006). Pollution from cement production can be neutral, stimulating or have toxic effects depending on the concentration (Pärn, 2006). Gaseous pollutants are expressed in phytotoxic effects particularly in terms of sulfur and nitrogen oxides (SO_x and NO_x), which lead to decreasing the physiological efficiency of foliage and defoliation (Bytnerowicz et al., 2004).

The aim of this study is to determine influence of air pollution on mature and medium Norway spruce stands in the Kurzeme region.

Materials and Methods

The installation of plots

The plots were established starting from the summer-autumn season 2008 and finishing with the spring of 2009. To cover the study area, two transects, each comprising 15 plots, were developed in the region of Kurzeme. So, the total number of plots was 31, and one control plot arranged in a potentially less contaminated area. The west side of transect was assigned the denotation 'Z' (a starting point N56^{0}31'26.05' E21^{0}2'13.08 end point E23^{0}4'51.031 N57^{0}21'18 .910''), but the eastern side of transect was granted the conditional designation 'D' (the starting point N56^{0}23'32 .185'' E22^{0}10'15.84'' end point ''E23^{0}16'02.984'' N57^{0}03'52 .90''). The sample plots' layout is displayed in (Figure 1). The geographical point of the notional line was placed in the plots. The researched middle-aged and mature stands of spruce were used in the selection of the forest register of the State Forest Service and cartographic materials. From the information obtained, equally spaced stands with no visible damage to bark beetle and use windfall effects were selected for the plots as possible areas of location.

Figure 1. The location of sample plots.

Methods of sampling and measurements

Each plot was 400 m^2; the exact location of the plot was determined by the GPS receiver. Where possible, it was attempted to select Norway spruce stands of different age, about 32 – 171 year old, growing under similar site conditions. The trees that were sampled were either dominant or co-dominant. 20 samples were taken from each of 31 study sites. Increment cores were taken with the Pressler's increment borer at breast height, one core per tree (in the case of site K (Kontrole), samples were taken from 50 trees) on the southern or southwest side of the bole using a 4.3 mm increment corer. The prepared samples were placed in plastic material boxes with a diameter of 6 mm, labeled and prepared for transportation. In the laboratory, each core, when dry, was mounted onto a grooved holder, and the surface of the cores was cleaned and finished using sandpaper (No 80, 120 and 240). Afterwards, the tree ring width of each sample (655 cores in total) was measured with the accuracy of 0.01 mm. The measurement data was registered using the tree-ring measuring system 'Lintab 4' (RINNTECH Frank Rinn engineering distribution Hardtstrasse 20-22 D-69124 Heidelberg, Germany) that includes a stereomicroscope series 234 with the table and Electronic data collector. The measurement data was registered using the program 'T-tools Pro' (Mechanik Labor GmbH).

Data Processing

The method used in this work is based on the additional volume increment calculation algorithm. It is about growing stock increase or loss as a result of the factors under study. This method is based on the analysis of the characteristic years and abrupt changes in tree-ring width. The abrupt changes reflect severe changes in eco-physiological conditions, which lead to stimulation or impediment of cambium activity for several successive years (Schweingruber, 1986). By measuring the ring width, one can obtain the information on an individual tree or stand growth course of all specialties. Control is used to describe trends of changes without influence of pollutants of regional evaluation period. This should include the change in general climatic factors during the period under consideration in the environment where there is no exposure to the studied factors. The ring width is used for the adequate performance of the tree stand response. Environmental impact characterization informative is investigated in addition to the increase in growing stock (Liepa, 1996), as compared to other inventory data that shows the wood volume increase or decrease to a much complete extent.

Growing stock growth is divided in two parts - the growth of that breed that would be incurred in the previous growing conditions and in addition to growth caused by the factor studied. This increase may also be negative. In this case, it is an indication of the influence factor of harmful effects. The distinction is cumulative and refers to the current stock of additional increment. The parameters expressed are m^3 ha^{-1}, which facilitate the evaluation of economic aspects. Thanks to this method, it is possible to detect the specific years characterized by an abrupt increase in the number of trees with, for example, reduction in annual increment more clearly than by means of other methods (compare Kobayashi, 1997). In order to have a better comparison between stands of different density, the following figure calculates the reduced value, expressed in cubic meters per square meter -stand basal area.

Using the measurements of tree rings width, tree height and diameter at breast height, the stand's additional increment is calculated with the method of I. Liepa (Liepa, 1996).

$$Z_M^{kp} = 12732{,}4\Psi\left(GH^{\alpha}D^{\beta lgH+\varphi-2} - G_t H_t^{\alpha} D_t^{\beta lgH+\varphi-2}\right) \quad (1)$$

Where Z_M^{kp} – The cumulative additional increment
G; G_t – basal area at breast height
D; D_t – diameter at breast height
H; H_t – stand's height
Ψ; α; β; φ – coefficients

Results and Discussion

To see the stand's development during the particular time period, we use the additional increment. To display the course of the study accumulation factor, the reduced cumulative additional increment is used. The method can

be used for the determination of the response of trees to various factors such as forest management activities, air pollution etc. via changes in their volume growth. The results of transects are shown in Table 1. and Table 2.

Table 1

Forest stands Changes in transect 'Z'20-year period

Code of sample plots	Volume increment m^3 ha^{-1}	Reduced volume increment m^3 m^{-2}	Basal area m^2 ha^{-1}
Z15	9.57	0.26	36
Z14	37.26	1.19	31
Z13	13.8	0.49	28
Z12	12.81	0.24	55
Z11	12.01	0.4	30
Z10	47.62	0.97	49
Z9	24.12	0.44	55
Z8	12.11	0.45	27
Z7	15.98	0.31	51
Z6	13.28	0.29	22
Z5	24.79	0.54	45
Z4	30.55	0.89	34
Z3	7.56	0.25	31
Z2	16.54	0.43	39
Z1	19.47	0.65	30

Table 2

Forest stands changes in transect 'D'20-year period

Code of sample plots	Volume increment m^3 ha^{-1}	Reduced volume increment m^3 m^{-2}	Basal area m^2 ha^{-1}
D15	19.07	0.49	39
D14	25.99	0.34	75
D13	10.91	0.33	33
D12	18.22	0.73	24
D11	31.05	1.14	27
D10	22.65	0.53	43
D9	11.46	0.57	20
D8	14.74	0.51	29
D7	14.48	0.36	40
D6	24.53	0.69	35
D5	17.53	0.46	38
D4	33.94	0.92	37
D3	22.70	0.57	40
D2	24.49	0.61	47
D1	17.11	0.39	43

Normalized additional growth can be assessed with stand development over the period. The environmental situation can be observed if the time period is known, as well as it is possible to observe whether the latter contributed to or restricted the studied factor or factor group effects in the stands.

Dendrochronological techniques were used to investigate the influence of climatic factors on the radial growth of Scots pine (*Pinus sylvestris* L.) under the impact of dust pollution in the industrial region of Northeast Estonia. The cement dust emissions had a minor negative effect on the radial growth of spruce (Pärn, 2006).

There is normalized increase in debt in addition to all the trees of the overall trend during the period of the individual intervals.

The stand is formed during the period that can be used

in additional increment. Further, to show the effect of the accumulation process under study (the impact trend), taking the reduced volume increment. Using a reduced cumulative additional increment, different age, composition and density stands can be compared. This additional increase is expressed in the stands square cross-section; thus, we can compare different trees in different growing conditions by having only those indicators. This process makes it easier to evaluate the development of trees over a given period of time presuming the that ecological situation observed affected the studied factor on the forest stand. Normalized cumulative increase of debt influences stand development without distinguishing between the overall trends over a period.

Table 3

Analysis of Variance for increment in 2003 (5-th year period)

Source	*P-Value*
Liepāja	0.0088
Mažeikai	0.0089

Implementing the additional multi-factor analysis of variance, one can verify the interaction of specific factors on the stand. In this case, the additional analysis of the additional increases for the 5-year intervals mathematically confirms the relationship between the contamination points Mažeikai, Liepaja and stands response. In these periods, p-value is <0.05, which confirms the statistical relationship between growth and distance from the source of contamination.

To exclude additional unknown factors to the spruce stands in Kurzeme, in addition analysis on source of pollution area should be carried out. In addition, attention to the pollution of chemical composition and its changes over time should be paid. They help foster understanding of the development time and improve the outlook, particularly if major polluters are changing their production technology.

Conclusions

1. The reduced additional increment is not related to stand age and forest site types, because they act on the stand basal units.
2. The pollution in Liepaja and Mažeikai affected Norway spruce stands, which has been statistically proven. The confirmed relationship between additional increment and distance to Liepaja at the 95% confidence test is conducted with the multi-factor variance.
3. To rule out random checks, additional tests were carried out with a view to examine other factors which may significantly affect the growth of spruce stands in Kurzeme.

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PROFITABILITY OF SILVER BIRCH (*BETULA PENDULA* ROTH.) BREEDING IN LATVIA

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Abstract

Economic importance of Silver birch in Latvia has been increasing in last decade, triggering scientific research, dedicated to improvement of this species, including tree breeding. Bulk of progeny trials will reach the evaluation time in next few years; therefore, decisions for further tree breeding activities have to be made. The aim of our study is to evaluate profitability of silver birch breeding, based on current situation in the year 2010 and circumstances in Latvia and assess the factors that might notably influence the result. Analysis considers all available breeding material and links between tree breeding, seed orchards and end product – forest stand, regenerated with improved plants in order to evaluate profitability of different alternatives based on differential approach. Results reveal that differential benefits from forest regeneration with selected birch material in comparison to natural regeneration, in areas with highest site indexes (Ia-II) with 3% interest rate and at least part of the stands managed in order to maximize yield of large diameter trees at age of final felling, are positive. The highest profitability can be reached if selection of best individuals is done based on clonal testing, genetic gain is maximized and combined with proper silvicultural praxis and annual planting area (utilization of seeds from selected trees) are maximized.

Key words: differential benefits, birch improvement, selection.

Introduction

Silver birch is one of the birch species (*Betula pendula* Roth. and *Betula pubescens* Ehrh.) that in forest inventories are not distinguished from each other and together occupy 28.2% of forest area, being the second most widespread after Scots pine (Anonymous, 2008). During the 20th century birch in most of the forest areas was treated as a species of secondary importance that needs to be removed in thinnings in favor of coniferous trees. Economic value of birch has not been fully recognized until few decades ago. Birch is used now in plywood production that accounts for more than 10% of total export value of forest sector products (Anonymous, 2008) and also plays an important role in furniture production. Birch wood is used also in production of sown goods, ship boards.

After the collapse of the Soviet Union, large areas of agricultural lands are abandoned. Natural afforestation of these lands mainly is with birch. Birch is used also as one of the main species (38% of area) for afforestation of former agricultural lands. That has triggered plant production (nursery industry): in recent years on average around 4 million birch seedlings are produced annually and only minor portion of it (30%) used in forest regeneration on forest lands.

The advancement in recognition of birch value and use has triggered significant research activity in fields of plant production and afforestation technique (Liepiņš, 2003, 2004), thinning of birch stands (Zālītis and Zālītis, 2002) and tree breeding activities of this species. A large number of forest stands has been inventoried across Latvia, plus trees and phenotypically valuable trees selected altogether in 37 stands. Seeds from trees of theses stands have been used to establish open-pollinated progeny trials in 3 contracting sites in Latvia, altogether occupying 60 ha. This material forms a basis for further tree breeding activities.

As the demand for birch plants was growing, plus-trees were phenotypically selected and joint-stock company (JSC) 'Latvia's State Forests' established birch seed orchard in plastic greenhouse for production of improved seed material. That, in turn, triggered further interest in selection of new set of clones with even higher genetic value that would serve as a parent trees for new generation of planted forest stands. Bulk of the birch progeny tests is close to the evaluation and selection age i.e. close to the point of beginning of the second breeding cycle. Therefore, it is important to analyze the alternatives for further breeding activities in order to select the most economically efficient one.

Numerous theoretical studies have addressed the issue of the efficiency of and comparison among the breeding strategies (Danusevicius and Lindgren, 2002a, b, 2005) recently. Excel-based calculation tools have been developed to optimize the necessary amount of breeding material at different stages, scale the genetic diversity vs. genetic gain and compare breeding strategies (Danusevicius and Lindgren, 2002a, b). However, the studies have not been used for practical analysis in Latvia and have a number of limitations (like – no considerations of genotype-environment interaction, very limited available knowledge in values of some of the parameters etc.) for stand-alone practical application. Theoretical approaches of economic evaluation of profitability of tree breeding have been analysed by A. Ahtikoski (2000). It also included practical analysis of Scots pine and Silver birch seed orchards in Finland; however, the basis for optimization of tree breeding activities was not presented.

In order to maximize the gain from use of selected material, a detailed economic analysis for relative weights of different traits in selection index has been carried out

mainly with species used in short rotation plantations (Lowe et al., 1999; Dinus and Welt, 1995), but recently also for Scots pine in Sweden (Berlin et al., 2009). This approach, however, requires detailed data on genetic parameters of traits and their importance in particular production process that are not available in our case.

The aim of the study is to evaluate profitability of silver birch breeding based on current situation and circumstances in Latvia and assess the factors that might notably influence the result.

Materials and Methods

All available breeding material of silver birch in Latvia can be divided in 2 groups:

1) open-pollinated progenies of 921 phenotypically selected plus tree or superior stand tree that have reached the age of 10 years in 2010 when this study was done;
2) progenies of 360 controlled crosses of 100 untested (phenotypically selected) clones in seed orchard that have reached the age of 4 years.

Both groups of available material can be integrated at the end of the second breeding cycle of the first group; therefore, it is chosen as a time horizon for the analysis.

For the bulk of material (first group) it is planned to establish 2 breeding populations, based on delineated provenance regions (eastern and western), and using altogether 150 trees – phenotypically selected progenies from the most productive and qualitative open-pollinated families, since the mother trees are not available any more. Among the members of the breeding population, double-pair mating will be performed. For further activities 3 different alternatives are compared: 1) phenotypic (FEN) selection of the best individuals within a family; 2) clonally (VEG - vegetative) testing, where the selection of candidates within a family and their vegetative propagation is performed, followed by the establishment of clonal progeny trials and backward selection of the two best candidates from each family; 3) progeny (GEN - generative) testing, where phenotypic selection of candidates within a family and their flowering stimulation to obtain seeds is done, followed by the establishment of open-pollinated progeny trials and backward selection of the two best candidates from each family. Planned activities, that are not explicitly analyzed in the study, but costs are added to each of the alternatives:

1) for the first group of material, before the beginning of the second breeding cycle: repeated measuring of part of the trials, selection of individual trees within superior families;
2) for the second group of material: tending work in progeny trials, measurements, selection of individual trees within superior families.

The comparison of alternatives is based and differential approach is used, i.e., only positions of benefits and costs, which differ between 2 regeneration methods – natural and planting of selected material – are considered (Ahtikoski, 2000). In the analysis differential costs are based on prices of the year 2010 and represented by:

1) costs of tree breeding activities, obtained from practical experience in the Latvian State Forest Research Institute 'Silava' according to activities needed to carry out each of the alternatives (FEN, VEG, GEN);
2) costs of seed orchard establishment and maintenance, obtained from the JSC 'Latvia's State Forests', that owns the productive birch seed orchards in Latvia;
3) costs of regeneration: plants, soil preparation, planting, and two extra cleanings, information from the results of the tenders of the JSC 'Latvia's State Forests'.

The differential benefit is represented by additional yield and shorter rotation time (cutting by target diameter, if possible) of the stands regenerated by the selected reproductive material. Values of genetic gain for each of alternatives, scale and timing of tree breeding works were partly assessed using the 'Breeding Cycle Analyser' (Danusevicius and Lindgren, 2002a, b) with genetic gain per unit of time as the target to be maximized (Table 1).

Genetic gain of an improved stand expressed relative to diameter and height growth of an unimproved stand was calculated based on constant proportional advantage approach (Ahtikoski, 2000).

Growth models for traditional (high initial density, delayed, low intensity thinnings) and targeted (aimed to maximize the mean diameter and total volume of trees at the final felling age, and characterized by low initial stand density) silvicultural systems and thinning regimes, the same for naturally regenerated and planted (improved) stand were chosen, based on recommendation of P. Zālītis and J. Jansons (2009). The assortment structure in thinning and final felling was calculated according to the algorithm developed by R. Ozolins (Ozoliņš, 2002). The assortment prices for the years 2006 - 2010 were obtained from Central Statistical Bureau and JSC 'Latvia's State Forest'. Assortments were set as follows: first grade logs (top diameter exceeds 25.9 cm, length 4.9 m), second grade (18 - 25.9 cm, 4.9 m), third grade (14 - 17.9 cm, 4.9 m), pulpwood (6 - 13.9 cm, 3 m), firewood (3.0 - 5.9 cm, 2 m).

Area of seed orchard was based on minimal number of clones to ensure genetic diversity as well as predicted seed needs, assuming that all birch stands on fertile soils would be clear-felled and replanted with improved material. Selected set of clones is set to be used for 24 years, since none of the alternatives could switch to new set of clones of higher genetic quality faster than that.

Table 1

Scale and timing of tree breeding works based on different alternatives used in analysis

Size of breeding material and duration of different phases		Tree breeding alternative		
		FEN	VEG	GEN
Duration of activity, years	Recombination	6	6	6
	Time before	2	4	2
	Testing of progenies	25	12	14
	Time after	-	-	5
	Time before	-	-	2
	Testing of candidates	-	-	12
	Total time	33	22	41
Size of breeding material	Number of families	150	150	150
	Number of trees per family	300	100	120
	Number of candidates	-	40	25
	Number of progenies/ramets per candidate	-	40	35

To ensure unbiased comparison between regeneration methods and breeding alternatives, net present value (NPV) was calculated with the interest rate 3%.

Results and Discussion

Results reveal that NPV of tree breeding costs are highest in VEG alternative, followed by GEN (60% of VEG costs) and FEN (40%). Genetic gain of FEN alternative is approximately 79% of the other alternatives that is according to theory (Falconer and Mackay, 2004) and reflects increased precision of selection, based on progeny testing. In the current situation (prices and costs of the year 2010, on average a bit below 500 ha y^{-1} birch planting used, predictions of genetic gain for height and diameter 14% for FEN and 18% for VEG and GEN, targeted and traditional silviculture applied in equal proportions of area) highest differential benefit is achieved with VEG alternative (88 LVL ha^{-1}), followed by GEN (51 LVL ha^{-1}) and FEN (34 LVL ha^{-1}). Influence of amplitude of different genetic gains is presented in Figure 1.

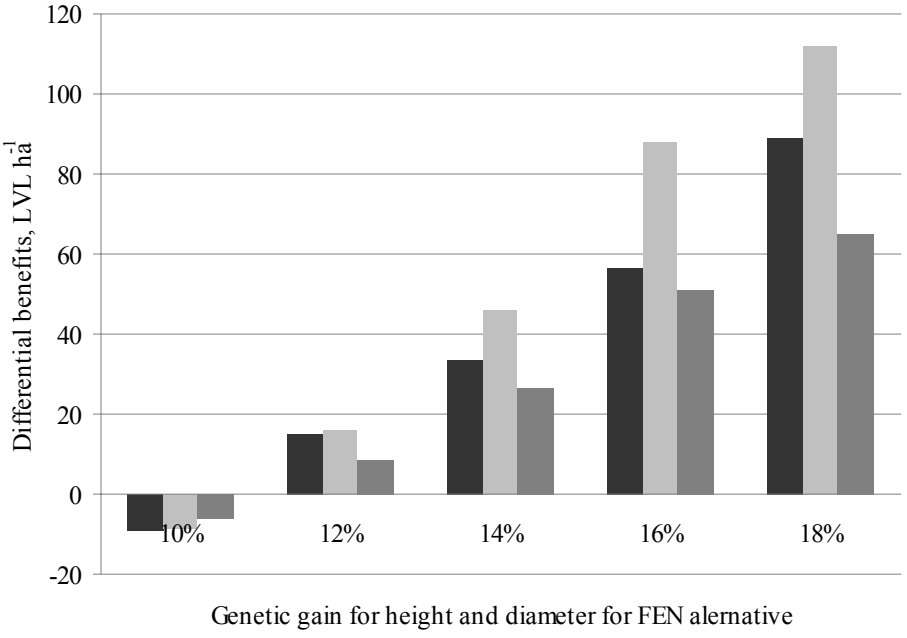

Figure 1. Comparison of differential benefits from selection alternatives:
FEN VEG GEN

Genetic gain for other alternatives calculated proportionally to that of FEN selection alternative
Assumed, that birch planting will be carried out 500 ha y^{-1} and targeted and traditional silviculture applied in equal proportions of area.

Results reveal that superiority of selection based on clonal testing (VEG) remains across the range of genetic gain levels, that exceed 10%, and is increasing in absolute value, as higher the genetic gain is. It is in line with conclusions of L.-G. Stener and G. Jansson (2005) that also noted superiority of vegetative (clonal) testing.

Figures of genetic gain used in this study are in line with other published estimates: at the age of 10 years, 10% gain in height and 18% in diameter has been found for silver birch (Stener and Jansson, 2005). Other studies report no notable difference in genetic gain at the age of 10 and 20 - 36 years, the absolute value being 29% for yield (Hagqvist and Hahl, 1998) that would roughly correspond with 14% increase in height and diameter. Genetic gain 10% - 25% at age 21 - 32 years are estimated (for height) and 20% predicted for yield at mature age for Scots pine (Jansson, 2007; Andersson et al., 2006; Ståhl and Jansson, 2002) for the first breeding cycle. Considerable decrease in genetic variation have been found between wild population and selected plus trees, but the next steps of selection, based on progeny testing corresponds to only marginal changes in genetic variation (Bouffier et al., 2008). Therefore, it can be assumed that the possibility of further improvement in next breeding cycle remains the same as in the first one.

Value of differential benefits is influenced not only by genetic gain, but also by annual planting area and fluctuation in assortment prices (Table 2).

Table 2

Differential benefits from selection alternatives, LVL ha^{-1}

Assortment prices as in year	Annual planting area and selection alternative								
	500 ha y^{-1}			5000 ha y^{-1}			7500 ha y^{-1}		
	FEN	VEG	GEN	FEN	VEG	GEN	FEN	VEG	GEN
2010	34	88	51	71	162	95	72	165	97
2009	24	73	42	62	147	86	63	150	88
2008	143	280	164	181	354	208	182	357	210
2007	169	327	191	206	401	235	208	404	237
2006	85	181	105	122	255	150	124	258	151

Genetic gain for height and diameter 14% for FEN and 18% for VEG and GEN alternatives
Assumed that and targeted and traditional silviculture applied in equal proportions of area

Annual planting area has a profound effect on value of differential benefits: as it increases from 500 ha year^{-1}, planted during the last decade on average, up to 5000 ha year^{-1} the differential benefits increases by 60% on average, ranging from 25% to more than doubling. It is related to constant costs involved in equation – the more the area increases, the lower are the costs of seed orchard establishment and maintenance per one hectare planted with material grown from selected seeds. Tight link between economic value of tree breeding process and the size of the area, where selected forest reproductive material is utilized, is also noted by other authors (Ledig and Porterfield, 1982).

Fluctuation of wood prices has remarkable influence on the value of differential benefits: difference between the lowest and highest estimate for the same alternative and annual area of planting varies 2.4 – 5.0 times. That indicates the importance of selection of proper final harvest time, based on market conditions in order to reap highest benefits from the use of selected material in forest regeneration. Results also demonstrate that rather conservative genetic gain estimate ensures positive differential benefits from tree breeding and use of selected material, even with the least beneficial alternative and in years with the lowest wood prices.

Silvicultural system has a notable influence on stand parameters. Results demonstrate that stands with 'targeted' management regime, involving only one commercial thinning ensures notably higher differential benefits than stands with 'traditional' one regardless of selection alternative or wood price conditions (Figure 2). Main cause of it is faster diameter increment in 'targeted' management, providing opportunity to shorten rotation period as well as to obtain higher proportion of most valuable assortments. In the study we were not able to address aspects of genotype-silvicultural system (like initial spacing, intensity of pre-commercial thinning etc.). Only few studies of this aspect have been carried out in the region based on very limited Scots pine material. They indicate that genotype – initial spacing interaction might have a practical importance (Roth et al., 2007; Persson, 1994). Selection of assortments in our study is based only on dimensions, and quality is not considered. However, studies demonstrate that up to 90% of proportion of veneer logs from tree is determined by branch quality (Hagqvist, 2001). Genetics is even more important than the silviculture in determining quality traits of birch, like natural pruning (Zālītis and Zālītis, 2002), branch diameter and angle (Hagqvist and Hahl, 1998), wood quality (Koski and Rousi, 2005). Genetics has significant effect even on slenderness of trees (Kroon et al., 2008). Therefore, increased quality and proportion of the most valuable assortments could be an important part of differential benefit from use of selected material and shall be addressed in further studies, as soon as there is sufficient data from National forest inventory and older birch trials. Average proportion of elite-grade logs could be determined also by equations, developed by P. Zalitis

and colleagues (Zālītis et al., 2002), but it does not allow to consider the additional gain from quality improvement. Constant proportional advantage, adding the genetic gain to parameters of unimproved stand at any age, is used in our study. However, genetic gain could be different at different age, and thinning regime could be optimized to reap highest benefits from the use of selected material.

Considering the above mentioned – thinning regime not optimized, quality traits not estimated and elite veneer assortment not assessed – as well as probability, that no extra cleanings might be needed for planted stand in comparison to naturally regenerated. It can be stated that the results of our study are close to the lowest limit of estimates of differential benefits from the use of selected material.

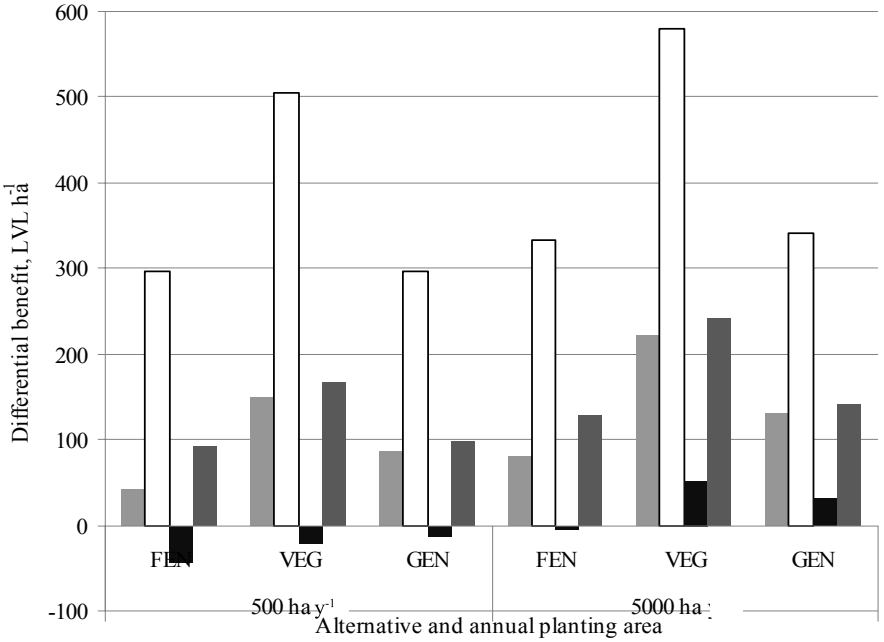

Figure 2. Influence of silvicultural system applied on the differential benefits from forestry in the year of high (2007) and low (2009) wood prices:
2007 traditional 2007 targeted 2009 traditional 2009 targeted
Genetic gain for height and diameter 14% for FEN and 18% for VEG and GEN alternatives.

Interest rate used in the study – 3% – might seem rather low, but it is in line with values usually used in economic analysis in forestry (Pentinten, 1999; Pesonen and Hirvelä, 1992).

Conclusions

1. Differential benefits from forest regeneration with selected birch material in comparison to natural regeneration, in areas with the highest site indexes (Ia-II) with 3% interest rate and at least part of the stands managed in order to maximize radial increment, is positive
2. Selection of best individuals based on clonal testing is the most expensive, least time consuming alternative that ensures highest differential benefits across the range of genetic gain levels, that exceed 10%, and is increasing in absolute value, as higher the genetic gain becomes
3. Factors like annual planting area, silvicultural system used for management of planted stand, and fluctuation of wood prices have a profound effect on value of differential benefits, therefore need to be considered in order to maximize it.

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INFLUENCE OF GENETIC FACTORS ON NORWAY SPRUCE (*PICEA ABIES* (L.) KARST.) ABOVE-GROUND BIOMASS AND ITS DISTRIBUTION

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Abstract

It is essential to have information on the tree biomass due to the fact that it is an important ecosystem pool for reporting changes in carbon stocks of forests and increased attempts to diversify the energy sources. In Latvia, comparatively few studies have focused on this topic so far. Our study was conducted on two 36 - 38 years old Norway spruce plantations. Detailed stem analysis of 39 trees was performed, and biomass of the above-ground tree components was determined. We analyzed tree and clone-level biomass distribution, biomass relations with tree dimensions and dependence on the genetic factors. The mean total biomass (kg d.w.) of all analyzed sample trees was 131.4 ± 10.58 kg, the mean biomass of stem 85.9 ± 6.98 kg, the mean biomass of dead branches 8.3 ± 0.82 kg, the mean biomass of living branches 23.5 ± 2.34 kg and the mean biomass of needles 13.7 ± 1.22 kg. On average, 66.1% of biomass was allocated to the stem, 6.4% to the dead branches, 17.4% to the living branches and 10.1% to the needles. The biomass of the analyzed trees positively correlated with all tested tree parameters - DBH, tree height, stem volume. Typically, with increasing tree parameters total biomass and stem biomass increased rapidly but branch and needle biomass increased slowly. Significant differences of tree dimensions were detected between the clones, and the differences in total biomass and stem biomass were clearly correlated with the differences in tree dimensions over clones. No significant impact of the clone was found specifically on the tree biomass or its distribution.
Key words: Norway spruce, above-ground biomass, genetic factors.

Introduction

Information on tree biomass and its distribution is important for at least two reasons. Forest ecosystems are essential elements of the global carbon cycle, as well as the cycle of other greenhouse gases (GHG) likely affecting the climate. The Kyoto Protocol of the United Nation Framework Convention on Climate Change acknowledges that forests may contribute to the mitigation of the greenhouse-effect (UNFCCC, 1998). According to the IPCC Guidelines for National Greenhouse Gas Inventories (2006), one of five ecosystem pools for reporting changes in carbon stocks of forests is above-ground biomass (along with below-ground biomass, deadwood, forest floor material and mineral soil).

During recent decades the aim of reducing global GHG emissions has led to increased attempts to diversify the energy sources (Ericsson and Nilsson, 2006). The growing interest for forest energy sets new demands for the necessary information on the biomass distribution to ensure more accurate estimates of the potentially available amounts.

Several studies on the conifer biomass estimation in the Nordic countries based on a large and representative material have been published and give reliable biomass estimates as well as require variables that are normally measured in forest inventories or can be easily estimated from the forest inventory data. The biomass functions for different above- and below-ground tree components of pine, spruce and birch developed by Marklund (1988) are most commonly used. In Finland, functions for predicting stem and crown biomass were developed by Hakkila (1979, 1991). Biomass functions for pine, spruce and birch in Finland have been published by Repola et al. (2007) and Repola (2009). Some other researchers present results on Norway spruce biomass – Tamm (1969) has studied biomass of stem, branches and needles of 50-85 years old spruces growing in southern and middle Sweden, Eriksson (1976) has presented functions for spruce biomass production and Wilhelmsen and Vestgjordet (1974) have constructed preliminary tables for determining the dry weight of merchantable spruce stems in Norway to name few. Several studies on spruce biomass have been conducted in the central Europe, for example, Burger (1939) studied biomass and tree components of Norway spruce in northern Switzerland and Wirth et al. (2004) developed generic biomass functions for Norway spruce in the central Europe.

Despite the considerable share of forest biomass in the energy sector in Latvia, comparatively few studies have focused on this topic so far. During the recent years the interest in biomass of fast-growing deciduous tree species, especially grey alder, has gradually increased. Miezite and Dreimanis (2009) have developed equations for the estimation of biomass of grey alders with DBH≤3.0 cm and 3.0<DBH≤26.0 cm based on 1888 sample trees from 55 plots. Daugaviete has studied biomass accumulation in young naturally regenerated grey alder stands (Daugaviete et al., 2009; Daugaviete, 2010). So far there has been only one study on the biomass structure of Norway spruce in Latvia (Liepa and Blija, 2008). During this study biomass expansion factors for branches, needles, stumps and roots were developed based on 21 sample trees. The stem biomass was calculated from the stem volume and default wood density value, and the branch component included both dead and living branches.

Growth and wood properties of trees are clearly

influenced by genetic factors. However, genetic improvement exclusively for volume growth or selection of fast-growing provenances without considering other aspects may have negative effect on wood density of Norway spruce (Persson and Persson 1997). Consequently, a certain gain in volume does not necessarily mean also a gain in dry biomass. Still breeding provides an opportunity to select provenances with an optimal combination of growth and wood properties (Wang et al., 2000; Zhang and Morgenstern, 1995). As the recent obligations regarding the share of renewable energy in the EU have increased a need to identify production potential of forest biomass, also the influence of genetic entries and provenances should be considered in the studies. The aim of this research was to study tree and clone-level biomass distribution, biomass relations with the tree dimensions and dependence on the genetic factors.

Materials and Methods

The study was conducted on two Norway spruce plantations, further in the text referred to as the site I and site II. Site I: experiment No 51 in Database of long term forest experiments – was started in 1975, initial spacing 1.5x2. Site II: experiment No 747 was started in 1973, initial spacing 2×1 m, one silvicultural thinning was carried out in the year 1998.

In total, 39 trees were felled and breast height diameter (cm), tree height (m), height to lowest green branch (m) and diameter of the thickest branch below 2 m height (mm) were measured. The trees were destructively sampled: the branches were removed, and the stem was divided into 1 m long sections. These stem sections were weighed. Dry branches and green branches were weighed separately for each crown section for 14 trees (8 from Site I and 6 from Site II) and jointly (for all crown) for 25 trees from Site I. Stem wood samples were taken from 5 stem sections and branch wood samples – from 4 living crown sections and dry branch section. Relative and absolute wood moisture were determined for each stem and branch section.

Moisture content was determined according to standard LVS CEN/TS 14774-2: naturally moist samples weighed (precision 0.1g), dried in 105 ± 2 °C until constant mass was reached and weighed (precision 0.1g). For detection of moisture content of needles sample of 5g was dried in AND MX-50 Moisture Analyser.

Dry biomass of stem and branches was calculated, using equation for the relative wood moisture in each stem/branch section:

$$W_0 = (G_1 - G)*100/G_1, \quad (1)$$

where

G_1 – mass of fresh wood of each stem/crown section, kg

G – mass of absolute dry wood of each stem/crown section, kg

W_0 – relative wood moisture, %

Stem biomass was calculated for 5 stem sections, dead branch biomass – for dead branch section but living branch biomass – for 4 crown sections (where possible) or for the whole length of the crown. Starting point of green crown (bottom line of section 1) was set at the whorl with at least 1 green branch that was not separated form other whorls with at least 1 green branch by more than 1 whorl. Total length of green crown (from this point up to the apical bud) was divided into 4 equally long sections, starting from the bottom. The part below the green crown was considered as dry branch section.

To estimate the weight of needles, 6 trees from Site II were sampled in the following way: 1 random branch from every whorl in the living crown was removed and weighed in fresh condition together with the needles. Afterwards the branch was dried to remove the needles (not to a constant weight). The needles and the branch were then weighed separately. Relative moisture of fresh and dry needles was measured. By usage of the equation for relative moisture, it was possible to calculate mass of fresh needles and fresh needle mass to fresh branch mass (with needles) ratio for each sample branch. These values were used to determine fresh mass of branches and fresh mass of needles for each crown section (where possible) or for all crown length. The approach was similar with the relative needle moisture values. It was found that on average fresh needle mass to fresh branch mass (with needles) ratio is 0.40 ± 0.017 and relative moisture of fresh needles is 55.3 ± 0.22%.

Stem volume of each sample tree was calculated according to the equation developed by Liepa (1996).

The compliance of biomass data with normal distribution was tested using one-sample Kolmogorov-Smirnov test. The dry weight biomass for all fractions of the analyzed trees was in all cases normally distributed (p=value for the total biomass 0.772, for stem 0.710, for dead branches 0.196, for living branches 0.269, for needles 0.678).

Relations between different biomass components were tested with correlation analysis (Pearson's coefficient) and dependence of the tree biomass components on the tree parameters (DBH, tree height and stem volume) were analyzed with linear regression analysis. The impact of genetic factors (clone) on the tree dimensions and biomass components was analyzed with one-way ANOVA. Only Site I trees were included in the genetic impact analysis, as in Site II each sample tree has different set of parents; therefore, they are not genetically similar to each other.

Results and Discussion

Biomass components and distribution

On site II, mean total biomass was significantly greater than on site I (p=0.003). The same was true for the stem biomass (p=0.001), but no significant differences between the sites were found for the branch and needle biomass (Table 1). The tree with the largest biomass value in Site II had a total biomass of 353.2 kg dry weight (d.w.) and stem biomass of 249.7 kg d.w., while the tree with the largest biomass in Site II had corresponding values of 240.3 kg d.w. total biomass and 123.0 kg d.w. stem biomass. The maximum individual tree dead branch biomass and living

branch biomass values for Site II were 23.7 kg d.w. and 49.6 kg d.w. and for Site I 25.0 kg d.w. and 74.5 kg d.w., respectively. The maximum individual tree needle mass for Site II was 30.2 kg d.w. and 30.3 kg d.w. for Site I.

Table 1

Mean biomass values of sample trees on Site I and Site II

Parameter	Site	Number of trees	Mean
Total biomass, kg d.w.	I	33	123.4±8.88
	II	6	175.2±47.88
Stem biomass, kg d.w.	I	33	78.9±5.31
	II	6	124.6±32.51
Dead branch biomass, kg d.w.	I	33	8.2±0.80
	II	6	8.9±3.20
Live branch biomass, kg d.w.	I	33	23.1±2.35
	II	6	25.9±8.64
Needle biomass, kg d.w.	I	33	13.3±1.19
	II	6	15.7±4.73

The mean total biomass (kg d.w.) of all the analyzed sample trees was 131.4 ± 10.58 kg, the mean biomass of stem 85.9 ± 6.98 kg, the mean biomass of dead branches 8.3 ± 0.82 kg, the mean biomass of living branches 23.5 ± 2.34 kg and the mean biomass of needles 13.7 ± 1.22 kg.

The dry weight above-ground biomass of different compartments where, on average: stem 66.1%, dead branches 6.4%, living branches 17.4% and needles 10.1% (Figure 1).

Liepa and Blija (2008) report the following results for site index I[a] and I Norway spruce stands: 74.3% of biomass allocated to the stem, 12.7% to the branches and 13% to the needles. In their study biomass for the tree components was calculated in fresh condition, the age of the sample trees was not determined and the DBH of sample trees ranged from 8.0 cm to 42.7 cm.

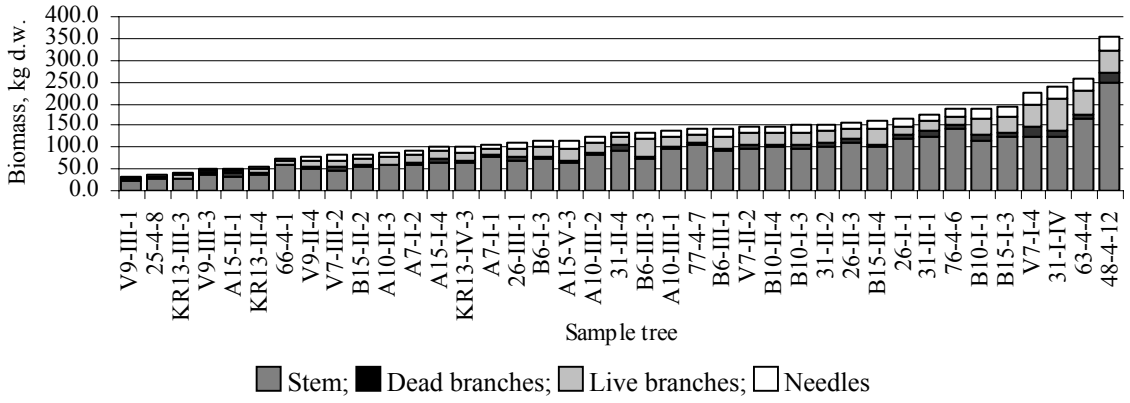

Figure 1. Proportional distribution of different compartments of dry weight biomass.

Our data on biomass distribution was comparable with the results presented by some other researchers. Eriksson (1976) has reported a biomass value of 60% for stems based on several other studies. In 17 - 54 years old spruce plantations growing on abandoned farmland a mean value for stem biomass was 56% and for branch biomass – 20% (Johansson, 1999). The stem, branch and needle proportions in Jokela`s et al. (1986) study of 47 - 52 years old Norway spruce stands was 64%, 25% and 11%, respectively. Brække (1986) studied 31-year-old Norway spruce stands on fertilized peat-soil sites and found that stem biomass proportion was 61%, branch biomass proportion – 21% and needle biomass proportion – 18%. The stem percentage of the total above-ground biomass in older spruce stands (50 - 85 years) was 76 - 86% and the corresponding values for branches were 8 - 15% and for needles – 6 - 10% (Tamm, 1969). Ingerslev and Hallbäcken (1999) concluded that the stem wood and living branches in 59 years old Norway spruce stand contained the main part of the above-ground biomass – approximately 80% (approximately 83% in our case). Kantola and Mäkelä (2006) found that for young Norway spruce trees (25 years) 41% of the biomass are allocated to the stem, 28% to the branches and 31% to the needles. The stem biomass proportion considerably increases with the tree age and for middle-aged stands (67 years) it reaches 84.9%.

Kantola and Mäkelä (2006) also reported differences in the biomass proportions depending on the slenderness of

the trees – the proportion of the stem biomass is greater in the most slender trees. Our results in this aspect were similar: the stem biomass proportion in 5 the least slender (slenderness ratio H/D 0.7 - 0.8) sample trees was 62%, in 5 medium slender (H/D 0.9 - 1.0) sample trees – 65% and in 5 most slender sample trees (H/D 1.1 - 1.5) – 71%. Site I trees were on average slightly less slender than Site II trees (H/D 0.9 and 1.0, respectively).

We detected positive correlation between all above-ground biomass components (Table 2). The highest correlation occurred between the needle biomass and live branch biomass, our results being similar to those presented by Repola (2009). Also correlation between needle biomass and stem biomass was strong.

Table 2

Correlation between above-ground biomass components of the sample trees

Biomass component	Stem biomass, kg d.w.	Dead branch biomass, kg d.w.	Live branch biomass, kg d.w.	Needle biomass, kg d.w.
Stem biomass, kg d.w.	1	0.73	0.73	0.83
Dead branch biomass, kg d.w.	0.73	1	0.62	0.72
Live branch biomass, kg d.w.	0.73	0.62	1	0.94
Needle biomass, kg d.w.	0.83	0.72	0.94	1

All correlation significant at 0.001 level

Biomass correlation with tree parameters

The biomass of the analyzed trees positively correlated with all tested tree parameters - DBH, tree height, stem volume. Typically, with increasing tree parameters total biomass and stem biomass increased rapidly, but branch and needle biomass increased slowly (Figure 2). The linear correlation of the total biomass and stem biomass was strong with the DBH, tree height and stem volume (linear correlation coefficients R=0.96, R=0.81 and R=0.97, respectively), the linear correlation of the dead branch biomass was medium strong with all tested parameters (R=0.77 with DBH, R=0.62 with tree height and R=0.78 with stem volume), the linear correlation of live branch biomass was strong with the DBH (R=0.82) but medium strong with the tree height and stem volume (R=0.53 and R=0.74, respectively). The linear correlation of the needle biomass was strong both with the DBH and stem volume (R=0.88 and R=0.83, respectively) but medium strong with the tree height (R=0.67).

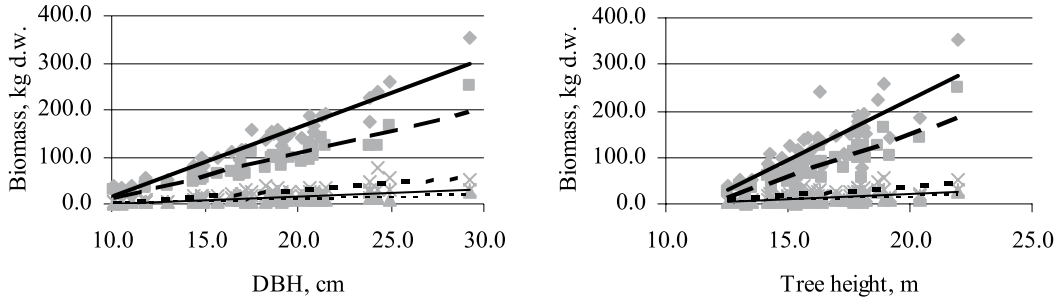

Figure 2. Biomass production by DBH and tree height.

Our results were in accordance with the findings of other authors. Johansson (1999) reported high correlation (R=0.98) between tree diameter and total biomass production. Results from Skovsgaard et al. (2006) confirm that the dry weight of branch wood depends on the DBH. Lehtonen et al. (2004) have found nearly linear relationship between stem volume and different biomass components. Several authors conclude that tree biomass is primarily a function of DBH, and its dependence on the tree height is weak (Crow, 1978; Payandeh, 1981; Korsmo, 1995). However, care must be taken in dense stands where increased density normally results in more stem biomass and less branch and needle biomass (Naidu et al., 1998). Probably a combination of DBH and tree height would be reasonable for the biomass estimation of trees suffering from competition. In our study we tested the relation between tree biomass components and stem size index D^2H that has been used by Albaugh et al. (2009) in the study of Norway spruce biomass in Sweden. The linear relation between this combined index and biomass of various components was in all cases higher than in cases when tree parameters were used alone (for total biomass R=0.98, for stem biomass R=0.99, for dead branch biomass R=0.88, for live branch biomass R=0.86 and for needle biomass R=0.91).

Impact of genetic factors on the tree dimensions and biomass

We detected significant differences of the tree dimensions between the clones (Table 3). The most pronounced were the DBH differences – the mean DBH of the clone 31 was considerably larger (22.4 ± 1.96 cm) than the mean DBH of others. The difference, however, was significant only between the clone 31 and clone V9 and KR13 with the smallest DBH values (p-values of one-way Anova 0.039 and 0.041, respectively).

Differences for total above-ground biomass and its components between the clones were observed. The largest total above-ground and stem biomass was found in clone 31 – the one with the largest DBH value. The smallest total and stem biomass values were found in clones V9 and KR13 – the ones with the smallest mean DBH values. Equal statement was also true for live branch biomass. The largest dead branch biomass was, however, found in clone V7 and the largest needle biomass – in clones V7 and B10. Statistically significant differences existed between clones in total above-ground biomass (p-value of one-way ANOVA 0.009), stem biomass (p-value 0.004) and dead branch biomass (p-value 0.034). Differences in total biomass and stem biomass are clearly correlated with the differences in tree dimensions over clones. However, this is not so clearly obvious in case of the dead branch biomass. For example, clone A10 with rather large DBH has comparatively small dead branch biomass.

Table 3

Mean dimensions and dry weight biomass values of analyzed clones

Clone	D, cm	H, m	Stem biomass	Dead branch biomass	Live branch biomass	Needle biomass	Total biomass
B6	18.5	15.8	78.8	6.9	29.6	15.1	130.4
A15	14.6	15.1	53.0	8.1	17.6	10.2	89.0
V7	19.3	16.9	89.1	13.8	29.9	18.6	151.4
B10	19.3	18.0	103.9	10.7	29.9	18.6	163.0
26	18.3	16.7	99.8	7.9	22.4	14.0	144.1
V9	12.8	13.8	38.2	3.5	8.0	4.4	54.1
KR13	12.8	13.9	42.4	3.8	11.7	6.7	64.5
31	22.4	17.0	109.9	12.8	35.5	17.1	175.4
B15	18.4	17.4	92.4	8.5	27.1	16.3	144.4
A10	17.7	15.0	78.6	4.6	20.4	13.1	116.7
A7	16.9	16.4	67.7	7.6	15.2	9.1	99.6

The largest biomass proportion was observed in clone V9 for the stem (72%), in clone A15 for the dry branches (9.7%), in clone B6 for the live branches (22.7%) and in clone V7 for needles (12.0%) (Figure 3).

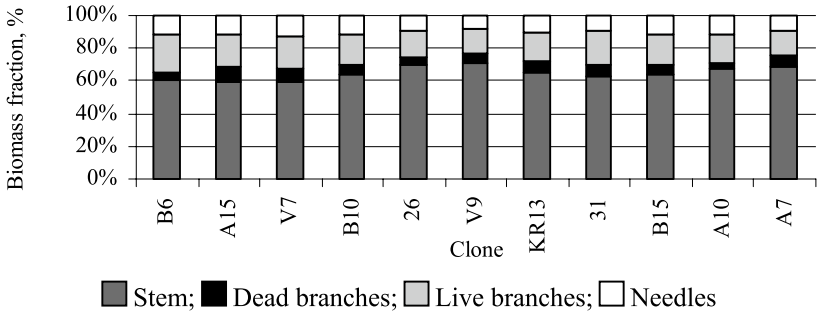

Figure 3. Proportions of above-ground biomass components in the clones.

For the clone 31 with the largest total biomass, the relative proportion of stem biomass was 64.2%. This clone had comparatively high live branch proportion – 18.8%. The proportion of needle biomass was rather similar for all clones (10 - 12%), except in V9 – only 8%. None of the differences were statistically significant. Kilpeläinen et al. (2010) report higher needle biomass proportion and lower stem biomass proportion in their study of 28 years old Norway spruce provenance trial.

To determine the effect of genetic entry specifically on the tree biomass and its distribution, a sub-sample of 24 trees was selected excluding the trees with the smallest and the largest DBH values, (consequently, clones V9 and KR13 were fully excluded). In this sub-sample the DBH ranged from 14.5 cm to 20.9 cm and the impact of the clone on the DBH was not significant (p-value of the on-way ANOVA 0.441). We found out that the impact of the clone on the biomass components and their distribution was not significant (Table 4).

Table 4

The impact of clone on the tree biomass components and its distribution, p-values of one-way ANOVA

Biomass component, kg d.w.	p-values of one-way ANOVA	Biomass component, %	p-values of one-way ANOVA
Total biomass	0.321	-	-
Stem	0.285	Stem	0.168
Dead branches	0.237	Dead branches	0.427
Live branches	0.398	Live branches	0.401
Needles	0.570	Needles	0.671

Other authors have found significant effects of genetic entry on wood density (Zubizarreta Gerendiain et al., 2009). This variable was not included in the present analysis. Other important factors that can doubtlessly have impact on the biomass value and its proportions are site conditions, tree spacing and thinning (competition). To analyze all these, more comprehensive study material is required. This study, however, provides some important basic knowledge of Norway spruce biomass distribution and its dependence on tree dimensions, which can serve as a basis for further research in this field.

Conclusions

1. The mean total biomass (kg d.w.) of all the analyzed sample trees at the age 34 - 37 years was 131.4 ± 10.58 kg, the mean biomass of stem 85.9 ± 6.98 kg, the mean biomass of dead branches 8.3 ± 0.82 kg, the mean biomass of living branches 23.5 ± 2.34 kg and the mean biomass of needles 13.7 ± 1.22 kg. On average, 66.1% of biomass was allocated to the stem, 6.4% to the dead branches, 17.4% to the living branches and 10.1% to the needles.
2. The biomass of the analyzed trees positively correlated with all tested tree parameters - DBH, tree height, stem volume. Typically, with increasing tree parameters total biomass and stem biomass increased rapidly whereas branch and needle biomass increased slowly.
3. Significant differences of tree dimensions were detected between the clones, and the differences in total biomass and stem biomass clearly correlated with the differences in tree dimensions over clones. No significant impact of the clone was found specifically on the tree biomass or its distribution.

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CARBON ACCUMULATION IN OVERGROUND AND ROOT BIOMASS OF GREY ALDER (*ALNUS INCANA* (L.) MOENCH) AEGOPODIOSA

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Abstract

Considering specific role of forest in carbon cycling, the scope of the study is evaluation of assimilation of carbon dioxide in a single grey alder stand. The National statistical forest inventory demonstrates that total area of afforested farmlands is 314 thousands of ha, including 212 thousands of ha are grey alder stands. Empiric data are collected in 2011 in 15 years old grey alder stand representing Aegopodiosa site type, site index II. Dendrometric characteristic of the stand are estimated using a method of 6 sample tree plots. Average height of dominant trees is 9.6 ± 0.14 m, diameter at breast height - 6.7 ± 0.18 cm, volume of stem - 0.02002 ± 0.00673 m^3, number of trees per ha – 5806 ± 560, growing stock - 116.2 ± 20.0 m^3 ha^{-1}. Density of the grey alder stem wood is 411.0 ± 2.2 kg m^{-3}, average relative moisture - 51.6 ± 0.13%. Dry biomass of grey alder in the evaluated stand is 73.4 tons ha^{-1}, including stem biomass - 65.3%, branches - 11.1%, leaves - 2.3%, stump - 6.8% and roots - 14.6%. In average evaluated stands accumulated 36.9 tons ha^{-1} of carbon removing from atmosphere 135.5 t ha^{-1} of CO_2. Wood density is estimated according to ISO 3131:1975 standard, moisture content – according to EN13183-1:2002 standard.

Key words: forest, density, conversion factors, photosynthesis equation.

Introduction

Latvia signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1992 and ratified it in the parliament of the Republic of Latvia in 1995. The aim of the UNFCCC is reaching stabilization of the concentration of greenhouse gases (GHG) in the atmosphere up to the level to prevent dangerous anthropogenic interference in the climate system. GHG are natural and anthropogenic gaseous compounds in the atmosphere absorbing and re-emitting infrared radiation. They are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), as well as indirect GHG – carbon oxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (VOC). In accordance with the Kyoto protocol of the UNFCCC (ratified by the parliament of the republic of Latvia in 2002) Latvia, individually or in a joint action with other countries, should reach the level when aggregate anthropogenic direct GHG (CO_2, CH_4, N_2O, HFC, PFC and SF_6) emissions by the years 2008 - 2012 are 8% below emission level of 1990 (LR Vides ministrija, 2010).

During the previous century annual increase of level of anthropogenic emissions was 2.5% on average. One of the factors affecting increase of anthropogenic emissions is reduction of forest area (Nikodemus et al., 2008). Forests cover about 30% of the terrestrial territories of the Earth, and unfortunately there is a tendency of reduction of forest coverage. There are published data, which approve that each hectare of forests sequestrates about 100 tons of organic carbon (Daugaviete et al., 2008).The mount of biomass produced by different tree species is relevant to average density of wood (Miezīte, 2008). Grey alder is fast growing tree specie with high photosynthetic activity and considerably high rate of removals of CO_2 in biomass and soil (Liepa and Gaitnieks, 2002). According to the State forest service data, the area of grey alder stands in Latvia is 192 kilo. ha or 7% of the total forest area, turning this tree specie into one of the most common in Latvia (Gadskārta, 2008). Grey alder is one of the pioneer species, which actively invades abandoned farmlands; therefore, it has an important role in reduction of concentration of GHG in the atmosphere. It should be noted, that ecological role of grey alder is not completely evaluated yet, including the potential of carbon sequestration, especially in relation to quantitative issues of this process on a former farmlands.

The main mechanism securing sequestration of carbon in forest ecosystems is the process of photosynthesis, which uses light energy to convert atmospheric CO_2 into organic compounds, producing woody biomass. Due to this reason biomass method, based on assumption that carbon stock is linearly correlating with biomass, is often used to estimate rate of carbon sequestration. In practice it means, that biomass should be estimated first and then, knowing average concentration of carbon in biomass, the carbon stock can be easily calculated.

The bottleneck of the method is estimation of biomass fractions of the tree and the whole stand. This applies particularly on non-timber fractions of biomass (branches, leaves, stump and roots), which cannot be easily determined directly. This problem is usually solvable by elaboration of the expansion factors, which allow to calculate different biomass fractions from a stem volume or growing stock of a stand.

Biomass stock in a tree or stand depends from content of water in wood; these parameters are closely correlating (Līpiņš and Liepa, 2007). Therefore, it is important to

note moisture content which applies to specified biomass figures. The most important are 2 moisture levels – fresh biomass (SB) and absolutely dry biomass (SM), which is determined by drying until constant weight. The SM multiplied by carbon content in absolutely dry biomass is used to estimate carbon stock. Carbon content in biomass csan be determined using chemical methods, which combines analyzes of different fractions of biomass and statistical evaluation of obtained results (Daugaviete et al., 2008). Note, that there is another method of estimation of carbon stock, which is based on summarized equation of photosynthesis (Liepa, 2005; Bārdulis, 2010).

Studies on carbon sequestration potential of grey alder in Latvia, in spite of broad distribution of this specie, is limited. The scope of our study is to estimate carbon accumulated in above- and below-ground biomass of the grey alder in 15 years old stand representing fertile (Aegopodiosa) growth conditions. According to the aim specific tasks of the project are: 1) evaluation of dendromethric characteristic of the grey alder stand; 2) estimation of above- and below-ground biomass of the stand; 3) elaboration of expansion factors for different biomass fractions of the grey alder and calculation of sequestrated carbon and CO_2 in the grey alder stand.

Materials and Methods

The study material was collected in August, 2007 in unmanaged 15 years old grey alder stand growing on fertile dry soil (Aegopodiosa site type) in Jelgava municipality Vilces parish, Eižāti – Mežsargi property. The stand originated due to natural afforestation of abandoned farmland.

Dendromethric characteristics of the stand are obtained using so called 6 trees sample plot method (Kramer and Akca, 1982). Fifteen sample plots are established in the stand, measuring 90 trees in total. The applied measuring approach belongs to a group of methods of rounded sample plots with variable radius. The radius of sample plot is determined by distance from center of the sample plot to the center of the sixth closest tree. This is considered during calculation of the stand dendromethric characteristics (Miezīte, 2008). Diameters at the breast height and G. Kraft classes of least 6 trees are determined in every sample plot. Manual caliper is used to determine diameter at the breast height of the trees. Accuracy of the measurement – 0.1 cm. Height of 15 trees in the stand was determined using VERTEX height meter with the accuracy of 0.1 m.

Site index of the stand is determined using growth tables of the grey alder elaborated by P. Mūrnieks (Mūrnieks, 1963). Data obtained in the sample plots were used to calculate basal area, growing stock and number of trees in the stand as well as the basal area, diameter, height and volume of average tree (Miezīte, 2008). Stem volume (V, m^3) is calculated using equation No. 1 (Liepa, 1996):

$$V = \phi \times L^{\alpha} \times D^{\beta \lg L + \varphi} \quad (1),$$

where

L – height of tree, m;

D – diameter of tree with bark, cm;

$\Psi, \alpha, \beta, \varphi$ – empiric coefficients (grey alder: ψ=0.7450 ·10^{-4}; α=0.81295; β=0.06935; φ=1.8546).

Above- and under-ground fractions of biomass of the grey alder is calculated using sample tree method. Selected trees were cut down with chainsaw Husqvarna – 254 XP. After cutting the trees were split into fractions – stem, branches and leaves, and all fractions were separately weighted. Below-ground biomass consists of stem and joined underground part of the trees. The root system of each sample tree was extracted separately. After extraction soil particles were washed down from the roots, then the below-ground part was dried for a short time and weighted. Weighting of fractions of the sample trees were done in the field using KERN scales (accuracy ± 0.02 kg). Samples for determination of dry mass SM of all fractions were taken in 3 repetitions and dried in laboratory to constant weight in 80 °C temperature (Uri et al., 2002).

Density of wood in this study is determined according to ISO 3131 (1975) standard, and moisture of wood – according to EN 13183 – 1 (2002) standard.

Seven sample trees as possible equally distributed across the range of the tree diameters at the breast height stand (4.5 - 9.3 cm) were used for evaluation of distribution of different biomass fractions in the studied stand. Height distribution of sample trees is 8.0 - 12.4 m. Trees representing different G. Kraft classes were used for the evaluation. Studies by foreign authors as well as our former investigations approve, that total biomass as well as distribution of biomass between different fractions is determined by the diameter at the breast height. This relation follows to a power regression equation (Liepa, 2005). In our study this regression is used for quality assurance of the field works.

From the point of view of easiness of the biomass calculations, it is reasonable to split a tree or a stand into 2 fractions – stem and non-stem fractions, because besides the method of biomass expansion factors the method of basic wood density P_{red}, characterizing the amount of absolutely dry biomass per volume unit of fresh biomass (for instance, tons m^{-3}), can be used to estimate the biomass. According to literature, basic density of grey alder is usually assumed similar to spruce – $P_{red} = 0.365$ (Боровиков, 1989). According to our studies, basic density of the grey alder stem wood P_{red} = 0.4110 ± 0.0022 tons m^{-3}.

Respectively stem biomass SM_{st} expressed in tons can be calculated by equation No. 2:

$$SM_{st} = \tilde{n}_{red} \times V \quad (2),$$

where

V – stem volume or sum of stem volumes (growing stock), m^3.

Non-stem part of trees (branches, leaves, stump and roots) can be estimated only using the expansion factors based on easily acquirable arguments – the stem volume or growing stock. Thus multiplication of the expansion factors with the stem volume or growing stock will produce biomass of particular fractions. The expansion factors are calculated using statistical methods on the base empiric data (Liepa, 2005). Expansion factor c_i of fresh material SB expressed in tons m^{-3} can be calculated with equation No. 3:

$$c_i = \frac{m_i}{v} \quad (3),$$

where

m_i – biomass of the sample tree fraction i, tons;

v – volume of sample tree, m^3.

Expansion factor ca_i of dry material SM can be calculated using equation similar to the formula No. 3, putting absolutely dry biomass in place of m_i.

Note that expansion factors c_i and ca_i can be estimated also for the stem biomass and used for quality control of the calculations.

The fact that carbon stock is proportional to the biomass stock is utilized to calculate carbon stock in biomass. It is approved that independantly from the tree species carbon content in wood varies in considerably narrow range (Brown, 1999; Saliņš, 2002). M. Daugavietis (2006) found that absolutely dry biomass of the grey alder characterizes with the following average values: ash 0.3%, carbon 50.3%, hydrogen 6.3% and oxigen 43.1%. A. Bārdulis (2010) add, that leaves of the grey alder contain 52.5% of carbon. Multiplication of the SM and the carbon content results in accumulated carbon M_C. Carbon is 27.27% of atomic weight of CO_2 molecule, therefore CO2 removed from the atmosphere M_{CO_2} can be calculated using the following equation:

$$M_{CO_2} = 3.667 M_C \quad (4)$$

Statistical processing of empiric data was done with Microsoft Excel 2007 using descriptive statistics, correlation and regression analysis (Arhipova, Bāliņa, 2003).

Results and Discussion

Dendrometric characteristics of trees and stands are correlating and depend on many factors. While growing, trees are affected by several factors and character as well as intensity of the effects depends on the age of the stand (Liepa et al., 1991). Dendrometric characteristics of the studied stand were calculated data of all 90 measured trees. The stand corresponds to 2.8 site index quality class (Mūrnieks, 1963). Average diameter at the breast height D = 6.7 ± 0.18 cm, but average height of trees calculated according to the height curve equation (5) H=9.6 m with R^2=0.99, ($p<0.05$) and $3.8 \leq d \leq 10.4$ cm.

$$H = 5.176 \ln(d) - 0.216 \quad (5)$$

Number of trees in the stand is 5806 ± 560 per ha^{-1}, coefficient of variation 37.3%. Average stem volume (1) is 0.02002 ± 0.00673 m^3 (coefficient of variation 38.8%), basal area – 21.82 ± 2.4 m^2 ha^{-1}, growing stock – 116.2 ± 20 m^3 ha^{-1} with average net increment 7.7 m^3 annually, which is a bit less than values obtained in Swedish studies (8.4 m^3 annually) about increment in sixteen 4 to 36 years old grey alder stands on former farmlands (Johansson, 2000). Dominant stand consists of 76% of all trees and undergrowth – of 24% of trees.

Distribution of fractions of fresh and dry biomass in studied stand is estimated by extraction of sample trees and weighting of each fraction separately. Weighting results of fresh biomass SB are shown in Table 1. Fractions are distributed in the following order: stem – 64.6%, branches – 11.3%, leaves – 3.8%, stump – 6.7% and roots – 13.6% (relative moisture of wood 51.6 ± 0.13%). Ratio of above-ground (leaves+branches+stem) and below-ground (stem+roots) biomass is 3.9:1, which is contrasting with findings of other authors (Uri et al., 2008). According to these studies ration of above-ground and below-ground biomass is 3:1. Note the different variability of data characterizing different biomass fractions – the smallest variability found in root biomass (coefficient of variation s%=46.9%), the largest – in biomass of leaves (s%=80.6%). It is possible, that these values characterize competition of sample trees and their neighbour trees, in other words – difference in density of the stand in places, where sample trees were extracted. Empirical data about dry biomass SM are summarized in Table 2.

Considering labor intensity of collection of empiric data number of sample trees is minimal – only 7. These trees represent equal range of dimensions of trees growing in the stand and regression analysis is used for mathematical evaluation of empirical material; however, taking in account the key role of obtained data in development of the expansion factors, additional evaluation of representativeness of the sample trees was done. Practically it was implemented by comparison of average dendrometric characteristics of the sample trees (PK) and all measured trees (PL). Results of comparison: PL h = 9.6 m, PK h = 9.8 m; diameter at the breast height – PL d = 6.7 cm, PK d = 6.9 cm; stem volume – PL v = 0.02002 m^3, PK v = 0.01966 m^3. Difference in all cases was less than 3%, which approves the representativeness of the sample trees; in other words – they can be used to develop biomass expansion factors.

Table 1

Dimensions of trees and fresh biomass (SB)

No	d, cm	h, m	V, m^3	Total biomass, kg	Stem, kg	Branches, kg	Leaves, kg	Stump, kg	Roots, kg
4	4.5	8.0	0.0072	10.14	6.56	0.42	0.18	0.60	2.38
3	4.7	8.4	0.0082	11.50	7.04	1.94	0.36	1.08	1.08
6	6.0	11.0	0.0165	22.84	13.90	2.80	0.70	1.04	4.40
7	7.0	12.4	0.0245	29.16	20.16	2.68	0.80	1.72	3.80
5	7.9	11.9	0.0300	40.48	26.09	4.63	1.42	2.52	5.82
2	9.0	11.9	0.0386	46.95	31.36	5.20	2.06	2.86	5.47
1	9.3	12.3	0.0423	56.37	35.30	6.90	2.80	4.68	6.69
X	6,9	11.0	0.0217	31.06	20.06	3.51	1.19	2.07	4.23
S	28.1	17.2	58.5	56.9	57.1	62.4	80.6	68.2	46.9
S_x	0.73	0.70	0.0053	6.68	4.33	0.83	0.36	0.53	0.75

Note: X – mean; *S* – relative standard deviation; S_x – standard error of mean.

Table 2

Dry biomass of sample trees (SM)

No.	Total biomass, kg	Stem, kg	Branches, kg	Leaves, kg	Stump, kg	Roots, kg
4	4.92	3.2	0.2	0.06	0.29	1.17
3	5.47	3.4	0.9	0.11	0.53	0.53
6	10.98	6.8	1.3	0.22	0.51	2.16
7	14.15	9.9	1.3	0.25	0.84	1.86
5	19.53	12.8	2.2	0.44	1.23	2.85
2	22.62	15.4	2.5	0.64	1.4	2.68
1	27.04	17.3	3.3	0.87	2.29	3.28
X	14.96	9.83	1.67	0.37	1.01	2.08
S	46.9	28.1	57.3	63.0	80.2	68.2
S_x	0.37	0.73	2.13	0.40	0.11	0.26

Quality of field works is also evaluated according to strong correlation between diameter at the breast height and total biomass, which can be expressed as a power regression equation. This finding is approved in several studies (Liepa, 2005; Miezīte, 2008) including this research (Fig. 1). Taking into account that empirical points are grouped closely around the power regression curve (R^2=0.902, $p<0.05$), it can be considered that empirical data are acquired correctly, consequently following to the methodology and can be utilized in the following calculations.

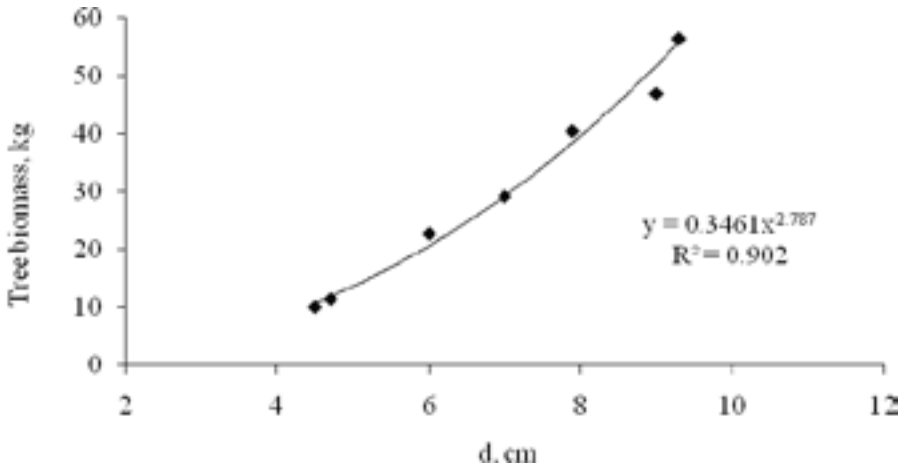

Figure 1. Regression characterizing relation between diameter at breast height and tree biomass.

Biomass expansion factors are calculated for fresh (SB) and dried (SM) biomass. According to the methodology, they are expressed in tons m^{-3} as ratio of particular fraction of biomass and the stem volume (3). Results of calculations of the expansion factors are shown in Table 3 and can be utilized for calculation of biomass fractions of the grey alder. A particular biomass fraction can be calculated by multiplication of the stem volume or growing stock in m^3 and the expansion factor of specified fraction. For instance, biomass of fresh branches in the studied stand can be calculated using the following approach: $SB_{branches} = V \cdot c_z = 116.5\ m^3\ ha^{-1} \cdot 0.1468$ tons $m^3 = 17.1$ tons ha^{-1}. SB and SM expansion factors are calculated as weighted average. The weighting was done: for stem fraction – against stem volume, for other fractions – against diameter at the breast height. This procedure is considered useful to reduce effect of number of sample trees to evaluate expansion factors.

Table 3

Parameters of calculation of evaluated grey alder stand in Aegopodiosa growth conditions

Parameter	Biomass fraction				
	stem	branches	leaves	stump	roots
Expansion factors of fresh biomass SB c_i, t m^{-3}	0.8388	0.1468	0.0469	0.0872	0.1873
Fresh biomass in the stand, t ha^{-1}	97.7	17.1	5.5	10.2	21.8
Share of the SB fraction, %	64.2	11.2	3.6	6.7	14.3
Expansion factors of dry biomass SM ca_i, t m^{-3}	0.4110	0.0697	0.0146	0.0426	0.0919
Stock of dry biomass in the stand, t ha^{-1}	47.9	8.1	1.7	5.0	10.7
Share of the SM fraction, %	65.3	11.1	2.3	6.8	14.6
Carbon content in dry biomass SM, kg C per kg of biomass	0.503	0.503	0.525	0.503	0.503
Accumulated carbon C, t ha^{-1}	24.1	4.1	0.9	2.5	5.4
Accumulated carbon C, t m^3	0.2067	0.0351	0.0077	0.0214	0.0462
Sequestrated CO_2, t ha^{-1}	88.3	15.0	3.3	9.2	19.7
Expansion factors of carbon cc_i, t m^{-3}	0.2067	0.0351	0.0077	0.0214	0.0462

The sum of expansion factors of different biomass fractions and a tree diameter at the breast height (1.3 m) have an insignificant correlation (R^2=0.217, $p<0.05$) due to dendromethric diversity of sample trees (different trees are selected advisedly to represent different G. Kraft classes and diameters). This correlation, pointing at the necessity to calculate expansion factors as the weighted average, allow to estimate SB and SM fractions of a stand or bunch of stands using only weighted values of the expansion factors of particular species, which considerably simplify estimation of the biomass stock, as it is necessary to know only one value – the growing stock, to estimate total biomass or specific fractions of biomass in the stand.

Carbon accumulated in the studied stand can be expressed as a product of two values – expansion factor of specific biomass fraction ca_i and carbon content in biomass, CO_2 can be calculated by using equation No. 4. In order to calculate carbon stock, expression of carbon content in tons per m^3 of fresh wood is more handy approach. In this case carbon stock can be calculated directly by multiplication growing stock with the content of carbon per m^3. Results of calculations of carbon stock and accumulated CO_2 are shown in Table 3.

Conclusions

The study data on non-stem biomass fractions of trees are obtained from 7 sample trees growing in Jelgava forest district, in 15 years old grey alder stand characterized by Aegopodiosa growth conditions, site index 2, growing stock 116.2 ± 20 $m^3\ ha^{-1}$, number of trees 5806 ± 560 per ha^{-1} ($p<0.05$).

Expansion factors c_i of non-stem biomass fractions (branches, leaves, stump and roots) of the particular grey alder stand can be calculated as ratio between biomass of the biomass fractions and the stem volume, the application is restricted to the trees having diameter at breast height 4.5…9 cm.

Carbon stock in the grey alder stands can be expressed as a product of expansion factor of particular biomass fraction ca_i and carbon content in this fraction, but in case if carbon content should be calculated directly from volume units (m^3) of fresh wood, then carbon stock can be estimated by multiplication of the expansion factor with timber volume or growing stock.

The results of the study approves that the evaluated method can be applied to elaboration of biomass and carbon expansion factors for grey alder stands on regional or national scale.

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ECONOMIC ASPECTS OF GAME MANAGEMENT IN LATVIA

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Abstract
At different points in the history there have been attempts to evaluate the volume and value of separate game-related goods and services in Latvia; however, so far there have been no comprehensive studies covering the role of the game management and its impact on Latvia's economy. Such data would be necessary not only to evaluate the impact of the game management on Latvia's economy, but also to set appropriate priorities in cases where game animals cause damage to other sectors of economy. In order to evaluate the role of the game management in the national economy, lists of the game-related goods and services have been drafted, sources of information have been identified to determine the volume and monetary value of the goods and services in the 2009/2010 hunting season, as well as a methodology has been developed to acquire the missing information. It has been determined that the total monetary value of the game-related products was 3.66 million LVL, while the game-related services accounted for 18.86 million LVL. The total contribution of the game management to Latvia's economy in the 2009/2010 hunting season has been estimated at 22.52 million LVL. Among the game-related products the most significant product is the game meat total amount (sales and own consumption) of which has been estimated at 2.8 thousand tons, while total value accounted for 3.6 million LVL. Among the game-related services the most significant contributors are the following: sales of hunting equipment (6.7 million LVL) and game-related transportation costs (4.7 million LVL).
Key words: game management, game products and services, economical impact, market value.

Introduction

Game management is a system that is aimed at a balanced use of natural resources not only by engaging in acquisition of game products, but also ensures the permissible number of the game animals and preserves the natural habitats of such animals. Hunting, as well as game management is directly linked with other sectors of economy, such as forestry and agriculture, for instance, unlimited reproduction of the game animals may cause significant damages to the aforementioned sectors. Forests and forestry play an important role in Latvia's economy; however, the concept of "forest value" is often narrowed down to include only the wood (predominantly the amount of timber that can be cut and sold, and, on separate occasions also the wood yield in terms of the future value), sometimes the concept also includes the cadastral value or the market value of the land. The rest of the forest values, namely, the non-wood forest values (such as ecological and social values) are often disregarded, since there are methodological and practical difficulties in terms of determining the monetary value, in order to compare the non-wood value with the value of wood and land (Tuherm, 1997; Tuherm and Berņikova-Bondare, 2008). Therefore, in order to determine the role of game management in Latvia's economy, as well as to identify the areas of priority in cases where game animals cause damages to other sectors, it is important to be able to determine the volume and the monetary value of the game-related products and services. If the role of game management is evaluated in a manner that does not cover the whole country, the land owners and hunters tend to base their decision-making solely on their personal experiences or interests that have developed over time, while failing to match the actual situation (Mc Kinley, 1999).

In Latvia the revenues of the state treasury generated by the game management have been first evaluated by A.Kalniņš, who already at that time emphasised the role of appropriate game management in the national economy, and the net revenues from game management was estimated at 100,000 LVL a year. The revenues from renting the state-owned hunting grounds in 1922/1923 accounted for 19,282 LVL, while the hunting permit tax in the same period brought in 65,640 LVL (Kalniņš, 1943). On certain occasions the volume and value of some specific game-related goods and services have been estimated in the times of the Soviet Socialist Republic of Latvia (Avotiņš, 1980; Siliņš, 1984). For instance, the game management of the Latvian SSR in terms of ungulates (*Artiodactyla*) meat products accounted for 1,365 t in 1976, 1,588 t in 1978 and 1,714 in 1980. The total amount of meat products (including all the edible game species) obtained in 1980 was estimated at 2,000 t. The fur products produced in 1980 accounted for 71,000 roubles, while rawhide products for additional 60,000 roubles.

The analysis of the quantity of game animals traditionally is based on data regarding the counted and the hunted animals. For instance, in the Russian Federation there were 604.67 thousand elks in 2007, out of which 14.269 thousand were hunted (Lomanova, 2007). One of the methods used to estimate the volume of the game products includes expressing the volume of the hunted animals' biomass (kg x km^2). The biomass of the *Cervidae* family game animals hunted in the North America in 1996 was estimated at 110 kg x km^2 (Crete et al., 1998). The estimated volume of meat from the major game species in Europe was 43,122.320 kg, in 1960s and reached 91,002.400 kg in 1970s (Дёжкин, 1983).

Hunters have repeatedly pointed out that game management should be treated as a sector of Latvia's economy, yet since regaining independence there have been no studies on the total physical volumes and monetary value of game-related products and services.

The aim of this research is to determine the total contribution of the game management to Latvia's economy in 2009. In order to achieve the aim, the following tasks have been defined within the framework of this research: (1) to draft a list of game products and services; (2) to identify the potential sources of information required to determine the volumes of game products and services; (3) to develop calculation methodology in order to obtain the missing information; (4) to determine the physical volume and monetary value of game products and services in the hunting season 2009/2010, by providing a breakdown between the amounts of game products and services for sales and own consumption; (5) to estimate the game management's contribution to Latvia's economy in the hunting season 2009/2010; (6) to provide recommendations regarding further collection of information in order to determine the volume and value of game products and services.

Materials and Methods

The list of game products and services has been drafted based on the non-wood categories of forest goods defined in the preparatory guidelines for the report on the State of European Forests SoEF2011. The list of game species has been extracted from the current version of the Cabinet of Ministers Regulation No 760 "Hunting Regulations" of December 23, 2003. The list of game services has been drafted by including all the statutory fees payable by the hunters, as well as by identifying the services that are required to ensure appropriate process of hunting.

As a part of the research the primary sources of information have been identified, such as the state institutions that are required by the law to maintain information on game products and services, companies that are engaged in buying and processing of game products, service providers, as well as hunters and hunter organisations. In order to obtain general information on the types and volumes of game products and services, questionnaires have been drafted and distributed among hunter organisations (hunting clubs) and individual hunters. In order to acquire as unbiased information as possible, (the questionnaires contain questions regarding economic and financial performance of hunting clubs) the survey is anonymous. This type of survey is not compatible with quality control (identification of the hunting clubs that have not submitted their answers, repeated sending of the questionnaires, if required or adjustment of incomplete data); however, taking into account the short timeline of the project, this was deemed to be the most appropriate way of obtaining the necessary data.

The hunters' survey covered the whole territory of Latvia. The sample group consisted of 350 hunters. The sampling method was based on stratified random selection (the contact persons at each hunting district received questionnaires to be distributed among the hunters during the nearest driving hunt event). 284 valid questionnaires have been filled out and returned. It is assumed that the sample group is random and represents the general group (21469 hunters who have received the hunting permit from the State Forest Service for the hunting season 2009/2010). Taking into account the size of the sample group and the relevant assumptions, the survey error rate is ± 2.5%, with 95% probability. The questionnaires contained the following questions:

1. How much (LVL) did you spend during 2009 on the following items:
   - 1.1. Contributions to the hunting club budget (membership fees, rental, feeding etc.);
   - 1.2. Purchasing of hunting equipment (weapons, ammunition etc);
   - 1.3. Purchasing of hunting clothing and footwear;
   - 1.4. Transportation to the hunting venue and during the hunting;
   - 1.5. Keeping of hunting dogs;
   - 1.6. Hunting sports competitions;
   - 1.7. Participation in hunting trophy exhibitions;
   - 1.8. Other costs directly linked with hunting activities.
2. How many and what type of game animal furs/hides did you sell in 2009?
3. How many and what type of measures did you take to prevent game animals from causing damages in 2009?

The hunting clubs' survey covered the whole territory of Latvia. The sample group consisted of 100 hunters' clubs' (which is a representative sample of the general group). The sampling method was based on random selection. According to the data from the State Forest Service in 2009 there were 1319 hunting districts in Latvia. 84 valid questionnaires have been filled out and returned. Taking into account the size of the sample group, the survey error rate is ± 5.1%, with 95% probability.

The contact persons in each hunting district were approached based on the information from the State Forest Service. The survey was conducted by means of printed questionnaires in Latvian language. The questionnaires were delivered to the respondents. The questionnaires contained the following questions:

1. How much do you spend on the rent of the hunting grounds payable to the private owners of the land?
2. How many days in the hunting season 2009/2010 were dedicated to commercial hunting in your hunting club?
3. What was the volume of feeding the game animals in the hunting season 2009/2010?
4. How much and what type of game meat did your club sell in the hunting season 2009/2010?
5. How many and what type of measures has been taken by your hunting club to prevent game animals from causing damages in the hunting season 2009/2010?

The following formula has been used to determine the

interval of probability in the mean evaluation of the general group:

$$\bar{x} - z_\alpha \cdot \frac{s}{\sqrt{n}} \le \mu \le \bar{x} + z_\alpha \cdot \frac{s}{\sqrt{n}} \ , \quad (1)$$

where

z_α – Standardised critical value of normal distribution with 95% probability. It is assumed for the purposes of calculations that the value is 1.96

s – Standard deviation

n – Number of observations within the sample group

The following formula has been used to determine the interval of probability of the proportion of the indicator within the general group:

$$\bar{p} - z_\alpha \cdot \sqrt{\frac{p \cdot (1-p)}{n}} \le p \le \bar{p} + z_\alpha \cdot \sqrt{\frac{p \cdot (1-p)}{n}} \quad (2)$$

The following formula has been used to determine the error in the mean value of the indicator, which describes the general group and is expressed as an interaction between several indicators:

$$P_{ij} = \sqrt{P_i^2 + P_j^2} \ , \quad (3)$$

where

P_{ij} – Standard error in the indicator describing the general group expressed as a percentage from the mean value

P_i – standard error in the indicator "i" expressed as a percentage from the mean value

P_j – standard error in the indicator "j" expressed as a percentage from the mean value (Arhipova et al., 2003).

The probability interval of the mean assessment within the general group is set at 95%, assuming that z=1.96

The data on the quantities of the game animals hunted in 2009/2010 have been acquired from the official statistics maintained by the State Forest Service. In order to determine the volume of the game meat the game animal species have been divided in two groups – the edible game animal species and non-edible game animal species. In order to determine the physical volume of the hunted animals expressed in tons, the average weight (kg) of representatives of each edible game animal species has been used in accordance with the available reference data (Siliņš, 1984). In order to determine the volume of the game meat used for sale and own consumption, the data from the Food and Veterinary Service on the amounts of sold game meat (carcasses) have been used, while the data regarding the sold ungulate animal meat by different species have been acquired from the results of the survey conducted among the hunting clubs.

The quantity of furs, hides and trophies from the total number of the hunted animals is determined by experts. The data on the sold furs have been acquired from the results of the survey conducted among the hunting clubs, while data on trophies have been obtained from the trophy exhibition catalogues. The estimates regarding the trophies only include items that are awarded medals in accordance with the appraisal system adopted by the International Council for Game and Wildlife Conservation (C.I.C.) (Varičak, 2000).

Information regarding the price of furs has been acquired by surveying the buyers.

Results and Discussion

Game products

In accordance with the defined tasks within the framework of this research a list of game products in Latvia has been produced. In conformity with the preparatory guidelines for the report on the State of European Forests (SoEF2011) there are the following game product categories in Latvia:

- Game animals;
- Game animal meat;
- Hides, furs and trophies.

In accordance with the Hunting Law, the list of game animals is stipulated by the Cabinet of Ministers Regulation No. 760 "Hunting Regulations" of December 23, 2003. There are the following game animal species in Latvia (total of 46 species): moose *(Alces alces)*; red deer *(Cervus elaphus)*; roe deer *(Capreolus capreolus)*; wild boar *(Sus scrofa)*; lynx *(Lynx lynx)*; capercailie *(Tetrao urogallus)*; black grouse *(Tetrao tetrix)*; wolf *(Canis lupus)*; *(Tetrao tetrix x Tetrao urogallus)*; grey hare *(Lepus europaeus)*; mountain hare *(Lepus timidus)*; pine marten *(Martes martes)*; stone marten *(Martes foina)*; polecat *(Mustela putorius)*; muskrat *(Ondatra zibethicus)*; badger *(Meles meles)*; fox *(Vulpes vulpes)*; American mink *(Mustela vison)*; racoon dog *(Nyctereutes procyonoides)*; hazel grouse *(Bonasia bonasia)*; pheasant *(Phasianus colchicus)*; woodpigeon *(Columba palumbus)*; feral pigeon *(Columba livia)*; woodcock *(Scolopax rusticola)*; hooded crow *(Corvus corone)*; magpie *(Pica pica)*; bean goose *(Anser fabalis)*; white-fronted goose *(Anser albifrons)*; Canada goose *(Branta canadensis)*; greylag goose *(Anser anser)*; coot *(Fulica atra)*; teal *(Anas crecca)*; gadwall *(Anas strepera)*; shoveler *(Anas clypeata)*; mallard *(Anas platyrhynchos)*; garganey *(Anas querquedula)*; wigeon *(Anas penelope)*; pintail *(Anas acuta)*; pochard *(Aythya ferina)*; tufted duck *(Aythya fuligula)*; scaup *(Aythya marila)*; velvet scoter *(Melanitta fusca)*; common scoter *(Melanitta nigra)*; long-tailed duck *(Clangula hyemalis)*; goldeneye *(Bucephala clangula)*; beaver *(Castor fiber)*.

The product "game animal" includes several other products such as game animal meat, furs, hides and trophies, as well as various game services. Therefore, the product has only been accounted for in quantitative values, since it is impossible to precisely calculate the monetary value of the product. Contribution to the economy can only be determined in terms of the hunted animals therefore, the evaluation is based on the quantity of hunted animals. Data on the quantity of hunted animals have been acquired from

the official statistics maintained by the State Forest Service (SFS, 2010). The quantities of the game animals hunted in the hunting season 2009/2010 are included in Table No. 1.

Table 1

The quantities of the game animals hunted in the hunting season 2009/2010

Species	Quantity of hunted animals (number)	Species	Quantity of hunted animals (number)	Species	Quantity of hunted animals (number)
Moose	2,656	Racoon dog	4,376	Ducks	24,018
Red deer	5,226	Grey hare	246	Geese	2,001
Roe deer	30,619	Mountain hare	58	Woodcock	20
Wild boar	30,201	Pine marten	631	Hazel grouse	10
Wolf	175	Stone marten	64	Hooded crow	591
Lynx	140	Badger	108	Magpie	315
Beaver	15,456	Polecat	61	Feral pigeon	63
Capercailie	83	American mink	113	Woodpigeon	0
Fox	10,028	Muskrat	11	Pheasant, black grouse	0

Species of edible game animals and the average weights of their carcasses are included in Table No. 2.

Table 2

The average weight of edible game animal species' carcasses (Siliņš, 1984)

Species	Weight of carcass (kg)	Species	Weight of carcass (kg)
Moose	170	Hares	3
Red deer	85	Geese, capercailie	1.5
Roe deer	17	Ducks, woodcock, hazel grouse, pigeons, pheasant, black grouse	0.25
Wild boar	40		
Beaver	10		

The volumes and values of game animal meat produced in the hunting season 2009/2010 are included in Table No. 3.

Table 3

The volumes and values of game animal meat produced in the hunting season 2009/2010

Species	Meat (t)		Average price (LVL kg^{-1})	Total (LVL)	
	Sold	Own consumption		Sold	Own consumption
Moose	10.36	441.16	1.6	16,576	705,856
Red deer	28.9	415.31	1.3	37,570	539,903
Roe deer	20.54	499.99	2.0	41,080	99,998
Wild boar	16.96	1,191.08	1.6	27,136	1,905.728
Others		164.57	1.5		246,855
Sub-total:	76.76	2,712.11		122,362	3,498.340
Total:	2,788.87			3,620.702	

It is impossible to separately determine the value of game trophies in Latvia, since hunting is predominantly organised as a leisure activity or as a measure to control the game animal populations and prevent the game animals from causing damages to other sectors of economy, as well as a source of game meat. Game trophies are only regarded as a by-product that is treated as an element of the long hunting traditions. Therefore, it is proposed in this research to estimate only the quantities of game trophies, while the contribution to the national economy is examined as a part of game services or the commercial hunting. The data on the quantities of game trophies are based on expert's estimates acquired by means of analysing the game trophy exhibition catalogues (Anonymous, 2010). For the purposes of this research the estimates regarding the trophies only include items that are awarded medals in accordance with the classification of the International Council for Game and Wildlife Conservation (C.I.C.) As to the quantities of furs, only the items offered in the market are accounted for, due to the fact that the quality of furs differs depending on the season in which they are acquired. Therefore, the estimates do not cover all the hunted furs bearing animals. The data on the sold furs by species have been acquired by means of surveying hunters.

The quantities of game trophies and furs acquired in Latvia in 2009/2010 are included in Table No. 4.

Table 4

The quantities of game trophies and furs acquired in Latvia in the hunting season 2009/2010

Type of trophy	Distribution of trophies (%)	Quantity of trophies (pieces)	Type of fur	Quantity of furs (pieces)	Average fur price (LVL/ piece)	Total (LVL)
Moose antlers	1	26	Beaver furs	5,410	4	21,640
Red deer antlers	5	261	Fox furs	5,014	3	15,042
Roe buck antlers	1	300	Racoon dog furs	1,531	6	9,186
Wild boar tusks	1	302				
Wolves, lynx	30	95				
Total:		984	Total:	11,955		45,868

The total monetary contribution of game management to Latvia's economy in the hunting season 2009/2010 was 3,666.570 LVL.

Game services

The following list of game-related services has been compiled based on the official payments made by hunters, as well as the services required to ensure appropriate process of hunting:

- Rental of the state-owned hunting areas / Rental of privately owned hunting areas;
- Issuing of the seasonal hunting cards/ Issuing of hunting permits / Issuing of the seasonal hunting cards and hunting permits to foreign hunters / Issuing of trophy exporting permits / Issuing of hunter's certificates / Hunter's examination / Examination of the head of the hunt;
- Training courses for Hunters (applicant's) / Heads of the hunt;
- Organising of the hunt for foreign hunters / Organising of the hunt for local hunters;
- Administrative penalties for illegal hunting / Compensation of damages caused by illegal hunting;
- Feeding of game animals (costs of the feed and arranging for the feeding patches);
- Measures aimed at prevention of damages (repellents, fences, sound blasters, removal of beaver dams, hunting in the damaged areas etc.);
- Hunting infrastructure (tree-stands, shooting lanes, feeders, areas of preliminary processing of the hunted game);
- Transportation costs (fuel and maintenance of the vehicles);
- Retail trade of hunting equipment (weapons, ammunition, clothing);
- Hunting sports services (weapons, ammunition, rental of shooting ranges);
- Treatment of game trophies, taxidermist's services, participation in game trophy exhibitions;
- Keeping of hunting dogs.

The data on the state-owned hunting areas have been acquired from the Joint Stock Company „Latvia's State Forests", while the data on the rental of privately owned areas have been acquired by means of surveying the hunting clubs. The information regarding the statutory issuing of documents, examination of hunters and heads of the hunt, as well as the monetary penalties and compensations of caused damages has been acquired from the State Forest Service. The data on commercial hunting have been acquired from the results of the survey conducted among the hunting clubs. The data on the costs associated with the training courses to acquire the status of hunter of the head of the hunt have been obtained by surveying the trainers.

The rental fees applicable to the private hunting areas as well as the services under items 6 - 12 of the table No. 4 have been acquired by surveying hunters and hunting clubs. The estimates are based on the percentage of the respondents who use the aforementioned services and the average amounts spent on each type of service. The feeding costs are based on the average market prices of the products used in feeding in 2009. In item 13, namely, treatment of game trophies, taxidermist's services, participation in game trophy exhibitions the calculations are based on the results of the survey conducted among hunters as well as on the data provided by the trophy treatment and taxidermy service providers. The quantity of the training courses for hunters and heads of the hunt has been aligned with the number of hunters, who have passed a relevant examination conducted by the State Forest Service in 2009. The calculations regarding the revenues from examination of hunters, the number of hunters who have passed the examination has been increased by 30%, while the number of heads of the hunt has been increased by 10%. The numbers are adjusted due to the fact that according to the State Forest Service approximately 30% of the applicants for the status of hunter and 10% of the applicants for the status of head of the hunt fail the examination on the first attempt and they have to undergo examination once again. Since the fee for seasonal hunting cards is differentiated, namely, 3 LVL for students and retired persons and 10 LVL

for the able-bodied, it has been assumed that approximately 30% or 7000 hunters are either students or retired persons.

The physical volumes and monetary value of the game services are included in Table No 5.

Table 5

The physical volumes and monetary value of the game services in the hunting season 2009/2010

No.	Type of service	Volume / Price	Total (LVL) (± standard error with 95% probability)
1.	Rental of the state-owned hunting areas	1,594.000 ha /0.29 LVL ha^{-1}	467,000
	Rental of privately owned hunting areas;		35,828
2.	Issuing of the seasonal hunting cards	21,469 seasonal cards out of which 7,000 issued to students and retired people /3LVL; 14,469/ 10 LVL	165,690
	Issuing of hunting permits	119588 permits (elk, red deer, roe, wild boar) /1 LVL	119,588
	Issuing of the seasonal hunting cards and hunting permits to foreign hunters	69 x 20 LVL (1 day) 885 x 35 LVL (2-10 days) 143 x 80 LVL (season)	43,795
	Issuing of trophy exporting permits	50 permits/10 LVL	500
	Issuing of hunter's certificates	1,249 certificates/ 1 LVL	1,249
	Hunter's examination	1,249x30 = 37470 + 30% = 48,711 LVL	48,711
	Examination of the head of the hunt	101 x 10 = 1,010 + 10% = 1,111 LVL	1,111
3.	Training courses to acquire the status of hunter	1,249 / 100 LVL	124,900
	Training courses to acquire the status of head of the hunt	100 / 50 LVL	5,000
4.	Organising of the hunt for foreign hunters	1,097 / 500 LVL	548,500
	Organising of the hunt for local hunters	1,000 / 250 LVL	250,000
5.	Administrative penalties for illegal hunting		4,570
	Compensation of damages caused by illegal hunting		9,397
6.	Feeding of game animals (costs of the feed and arranging for the feeding patches)		1,384.950 ±48,581
7.	Measures aimed at prevention of damages (repellents, fences, removal of beaver dams, hunting in the damaged areas etc.)		524,706 ±44,688
8.	Hunting infrastructure (tree-stands, shooting lanes, feeders, areas of preliminary processing of the hunted game)		469,93 ±128,569
9.	Transportation costs (fuel and maintenance of the vehicles)		4,650.185 ±753,902
10.	Retail trade of hunting equipment (weapons, ammunition, clothing)		6,667.367 ±756,578
11.	Hunting sports services (weapons, ammunition, rental of shooting ranges)		1,790.684 ±264,017
12.	Keeping of hunting dogs		1,824.865 ±318,059
13.	Treatment of trophies, taxidermist's services, participation in hunting trophy exhibitions;		189,056 ±27,136
	Total:		18,857.056

The contribution of game services to Latvia's economy in the hunting season 2009/2010 has been estimated at 18.86 million LVL. A part of the amounts can be regarded as the direct hunting-related costs, while the rest can be regarded as the indirect costs (such as transportation and purchasing of hunting weapons) that for the purposes of statistics are accounted for as a part of other sectors of economy. However, in order to evaluate the total contribution of game management to Latvia's economy, it is important to take into account these costs. The total monetary value of game products and services in the hunting season 2009/2010 has been estimated at 22.52 million LVL.

Also in the future the information on rental of the state-owned hunting areas should be acquired from the Latvian Forestry Company AS LVM. The information on the rental fees of the private hunting areas can be acquired in two ways, namely, either by surveying hunting clubs or the land owners. The information regarding the issuing of statutory permits, examination of hunters and heads of the hunt, monetary penalties and compensations for caused damages can be acquired from the State Forest Service. The data on the stamp duties and state fees can also be obtained from the State Treasury.

The information on the commercial hunting, costs of the training courses for hunters and heads of the hunt, the costs of taxidermy services and trophy treatment services can be acquired by means of surveying the service providers.

The data regarding volumes and costs of the remaining game services (feeding, prevention of damages, hunting infrastructure, hunting equipment, transportation, hunting dogs, etc.) can be acquired by surveying hunting clubs.

Conclusions

1. The total value of game products in Latvia in the hunting season 2009/2010 was 3.66 million LVL. The largest part of the total value is constituted by the game animal meat (3.62 million LVL), a part of which has been sold for the total of 122 thousand LVL (76.76 tons), while the own consumption accounts for the total value of 3.5 million LVL or 2.7 thousand tons.
2. The total value of game products in Latvia in the hunting season 2009/2010 was 18.86 million LVL. The total value is constituted by the following most significant services in terms of their monetary value:
   - Services related to retail sales of hunting equipment: 6.67 million LVL;
   - Transportation services (fuel and maintenance of vehicles): 4.65 million LVL;
   - Costs associated with keeping of hunting dogs: 1.82 million LVL.
3. The total contribution of game management to Latvia's economy in the hunting season 2009/2010 is estimated at 22.52 million LVL.
4. In the future, by carrying out similar studies, information regarding the volumes and values of game products and services should be obtained from the state institutions responsible for accounting for the game-related resources, as well as by means of surveying the relevant service-providers, hunters and hunting clubs.

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THE ASSESSMENT OF CONTRIBUTION OF FOREST PLANT NON-WOOD PRODUCTS IN LATVIA'S NATIONAL ECONOMY

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Abstract

The forests in Latvia occupy 49.9% of territory and they have significant economic, ecologic and social functions. The notion 'forest value' is frequently understood as the value of wood only but non-wood values are often neglected because there are methodological and practical difficulties to estimate them in monetary terms. The list of forest plant non-wood product (FPNWP) groups potentially important for Latvia was made and the significance of them in Latvia's national economy was estimated. To obtain the information about FPNWP in Latvia (kinds, amounts, value, own-consumption) the public opinion poll was carried out. 77% of the residents of Latvia aged 18 - 74 have gathered the nature products in Latvia in 2010. The most significant FPNWP are mushrooms, wild berries of family *Ericaceae* - *Vaccinium myrtillus* L., *Vaccinium vitis-idaea* L., *Oxycoccus palustris* Pers. and birch sap. The contribution of FPNWP in the Latvia's national economy in 2010 was 66.8 million LVL, including 8.9 million LVL for the products sold in the market or exchanged among households.

Key words: non-wood products, mushrooms, wild berries, birch sap.

Introduction

According to the state cadastre data of real estate on 1st January, 2010 the type of land use – forest occupies 45.8% or 2 955.5 ha of the whole territory of Latvia (State Land Service, 2010). Estimating the situation in nature, the data of the first cycle (2004 - 2008) of the national forest inventory shows that 49.9% or 3220.9 ± 23.61 ha of the state territory corresponds to the definition of forest (Latvijas meža resursu statistiskā inventarizācija, 2010). Considering the territory covered and its proportion on the land, the forest is not only an important source of wood products but it also has significant ecological and social functions.

The value of ecosystems is formed by its primary value (the ability to exist in changeable circumstances) historical, cultural and symbolic value and also its secondary value – economic value (market and non-market value). Although historic, cultural and symbolic values are included in the group of non-market values, it is pointed out particularly to emphasize its importance for the local identity and culture which is hard to evaluate fully with the general methods of neo-classical economics (Willis et al., 2000). The notion 'forest value' is frequently understood as the value of wood only (most often it is the amount of wood which could be cut and sold, rarely as the perspective value of wood stock). Sometimes it is understood as the value of forest land cadastre or market value. Other forest values – forest non-wood values (all the ecological and social values are often neglected because there are methodological and practical difficulties to estimate these values in money expression to be compared with wood and forest land value (Tuherm, 1997; Tuherm and Berņikova-Bondare, 2008).

In 2008, forest contribution to the national economy value was 187 million LVL and its value to gross domestic product (GDP) was 1.2%, but wood production branches – wood processing, paper production and furniture production contribution was 410 million LVL, making more than 2% from GDP. The forest branch has an important role in the employment of the state inhabitants – more than 5% of the employed in the national economy (Meža nozare Latvijā, 2009).

In 1999 after the decision of Food and Agriculture Organization, it is defined in Forest Resources Assessment that non-wood forest products consist of goods of biological origin other than wood, derived from forests, other woodland and trees outside forests (Wong et al., 2001). But global forest resource assessment in 2005 and 2010 used the following non-wood product definition - products gained from forests that are tangible and physical objects of biological origin other than wood (Global Forest Resources Assessment, 2010). However, Integrated Environmental and Economic Accounting groups Forest plant non-wood products (FPNWP) for personal and production use in the following way: food (berries, fruit, mushrooms, nuts, plam oil, honey etc.), medicine, animal feed and industrial extracts (cork, indian rubber, resin, tar, chemicals) (Handbook of National Accounting - Integrated Environmental and Economic Accounting, 2003). The report guidelines about the state of European forests define the categories of FPNWP: Christmas/New Year trees; mushrooms and truffles; fruit, berries, edible nuts; cork; resins, raw material- medicine, aromatic products, colorants, dyes; decorative foliage, incl. ornamental plants, mosses, etc. (Reporting on sustainable forest management, 2011).

According to the statistic classification of economic activities, NACE division 'Forestry and logging' (code 02) includes the following classes: 'Silviculture and other forestry activities' (code 02.10), 'logging' (code 02.20)

and also 'gathering of wild growing non-wood products' (code 02.30) which includes mushrooms and truffles; berries, nuts; different kinds of tar; cork; shellac and resin; balsams; plant fibers; acorn, chestnuts; moss and lichen (Saimniecisko darbību statistiskā klasifikācija, 2010). According to the statistical classification of products by activity (Preču statistiskā klasifikācija pēc saimniecības nozarēm, 2008), forest products do not include only wood materials and trees but also wild growing non-wood products (code 0.2.30): natural gums (code 02.30.1); balata, gutta-percha, guayula, chicle and similar natural gums (code 02.30.11); lac, balsams and other natural gums and resins (code 02.30.12); natural cork, raw or simply prepared (code 02.30.2); parts of plants, grasses, mosses and lichens suitable for ornamental purposes (code 02.30.3); wild growing edible products (code 02.30.4).

There is no accepted and confirmed united list of forest non-wood products and services in Latvia. There is no detailed research of the gain of other national economy branches from the forests in Latvia.

The research aim is to carry out the estimation of FPNWP which are the most essential for Latvia's circumstances determining their gain in Latvia's national economy in 2010.

The following research tasks were put forward to reach the aim:

1. To make a list of FPNWP in Latvia;
2. To determine the significance of FPNWP in Latvia's national economy;
3. To collect information about the amount FPNWP and their monetary expression using the information from the state databases and sociological research;
4. To estimate the contribution of FPNWP in Latvia's national economy in 2010.

Materials and Methods

To determine whether the information of FPNWP and their stocktaking is collected and available the state institutions were interviewed by phone or in writing (Central Statistical Bureau, Nature Conservation Agency, State Revenue Service, State Forest Service), enterprises (JSC 'Latvijas valsts mezi'; Rigas mezi Ltd.; JSC Riga Pharmaceutical Plant, Latvia homeopathy chemists and other enterprises which are connected with the process and purchasing of herbs and food products) and non-governmental organization (Association of Latvia's Florists).

To obtain the information about FPNWP from Latvia (kinds, amounts, own-consumption) the public opinion poll was carried out in cooperation with media, market and public opinion research agency TNS Latvia. Latvia's representative sample population – 1000 residents in the age group 18-74 selected by multistage stratified random sampling method. The method of computerized telephone interview CATI (Computer Assisted Telephone Interviews) was used. Programming of the questionnaire was carried out before the research using BELLVIEW CAPI 5–00–23 which guarantees the range of technical procedures for carrying out the poll as well as successful interview and immediate data input.

The following questions were asked to determine the habits of respondents in using non-wood plant products:

What kind of forest goods did you gather in the forest last year?

How much forest products did you yourself gather this year? (liter or kg)

How much did it contribute in monetary terms to your household this year? (LVL) (please separate own-consumption and value of sold or given to other people/ companies?

The statistic methods were used to calculate the indicators of the general set. The indicators are based on the poll results.

The following connection was used to calculate the standard error of quantitative indications

$$\sigma_{\bar{x}} = \frac{s}{\sqrt{n}}, \quad (1)$$

where

σx^- – standard error;

s – standard deviation;

n – the number of observations in the sample set.

The following connection was used for calculating the standard error of the proportions

$$\sigma_{\bar{p}} = \sqrt{\frac{p(1-p)}{n}}, \quad (2)$$

where

σp^- – indicators proportion standard error;

p – proportion between the favourable events and total events within the sample group;

n – the number of observations in the sample set.

The probability interval of the average general set evaluation is determined using the following connection

$$\bar{x} - z_\alpha \times \frac{s}{\sqrt{n}} \le \mu \le \bar{x} + z_\alpha \times \frac{s}{\sqrt{n}}, \quad (3)$$

where

$\bar{x}$ – the average value of the sample set;

μ – the average value of the general set;

z_α – the standardized critical value of normal distribution with 95% probability;

s – standard deviation;

n – the number of observations in the sample set.

The probability interval of the proportion of the general set indicators was determined using the following connection

$$\bar{p} - z_\alpha \times \sqrt{\frac{p \times (1-p)}{n}} \le p \le \bar{p} + z_\alpha \times \sqrt{\frac{p \times (1-p)}{n}} \quad (4)$$

To calculate the average error value of the characteristic indicator of the general set which is formed as the correlation of several indicators the following connection was used

$$P_{ij} = \sqrt{P_i^2 + P_j^2}, \quad (5)$$

where

P_{ij} – the value error of the characteristic indicator of the general set % from the average value;

P_i – *i*-indicators standard error % from the average value;

P_j – j-indicators standard error % from the average value.

The probability interval of the general set average value is determined with 95% probability considering z=1.96 (Liepa, 1974).

It is supposed in the calculations that the general population in Latvia consists of 1 694 800 residents in the age group 18 - 74 (Iedzīvotāji un sociālie procesi, 2010). The value of FPNWP is calculated multiplying the amount and the average market price of the related product. This value is also referred to FPNWP used for own-consumptions. In calculations one liter of mushrooms weighs 0.4 kg and 1 liter of wild berries weighs about 0.7 kg. According to the opinion of the sociological research people, human habits do not change essentially throughout years.

Results and Discussion

The list of FPNWP for Latvia.

The list of non-wood plant product groups potentially important for Latvia was made using the European classifications and categories of FPNWP (Table 1).

Table 1

The list of FPNWP and the estimation of significance

No.	Plant product group	Plant products	Significance in national economy
1	Christmas/New Year trees	Christmas/ New Year trees	important
2	Mushrooms	*Boletus edulis*, *Cantharellus cibarius*	very important
		Other edible mushrooms	important
3	Fruit, berries, edible nuts	*Ericaceae* family (blueberries, bilberries, bog bilberries, cranberries)	very important
		Rosaceae family (raspberries, blackberries, drupes, strawberries, crab trees)	important
		Empetraceae family (crowberries)	not significant
		Cupressaceae family (junipers)	not significant
		Fagaceae family (oak-tree)	not significant
		Betulaceae family (hazel)	unimportant
4	Resin, medical raw materials, aromatic products, colorants	Pine, spruce tree resin	not significant
		Herbs	important
		Pigment plants	not significant
5	Decorative materials	Birch tree branches (oak, mountain ash, pine etc.)	important
		Moss, lichen, bilberry bush	unimportant
		Cones	unimportant
6	Other plant products	Sap (birch, maple)	important
		Brooms, sauna-brooms	unimportant
		Needles	unimportant

The evaluation of the essence of FPNWP in Latvia's national economy.

The list of criteria and indicators was made to evaluate the significance of FPNWP in Latvia's national economy. The criteria reflect the basic values in the conceptual level, but the indicators are the basic data which give the quantitative and qualitative characteristics of every criterion (position, changes and capacity).

The following indicators and criteria were determined to evaluate the significance of FPNWP in the national economy:

1st criterion – economical significance:

1st indicator. The amount of supply in the national economy in physical unit;

2nd indicator. The proportion of product supply in the product group;

3rd indicator. The material value (combined and separately for every unit);

4th indicator. Demand for such products;
5th indicator. The influence on other national economy branches;
6th indicator. The legacy of obtaining the product.
2nd criterion – social significance:
1st indicator. The number of inhabitants (proportion) getting personal benefit from the product;
2nd indicator. Employment in obtaining the product;
3rd indicator. Possible threats for society.

Every non-wood plant product has been given the evaluation of its essence according to its significance. There is a 4 point system, where 0 – not significant, 1 – unimportant, 2 – important on average, 3 – very important. The estimation of significance of the FPNWP relating to the worked out criteria and indicators is shown in Table 1. The most significance FPNWP are mushrooms (probably *Boletus edulis*, *Cantharellus cibarius* as they are commercially most important) and wild berries - *Vaccinium myrtillus* L., *Vaccinium vitis-idaea* L., *Oxycoccus palustris* Pers. of family *Ericaceae*.

The gain amount and monetary value of the FPNWP using the information from the state databases and sociological research.

The information about FPNWP is not available in the state institutions as it turned out during the research. Some information could be found from JSC 'Latvijas valsts mezi' and Rigas mezi Ltd. The members of the Association of Latvia's Florists acknowledge that they use the decorative materials from forests but they are not purchased, and there is no information about the amount. The enterprises connected with the purchase and processing of berries and mushrooms refused to give official information. Similarly the enterprises connected with purchase of herbs and the production of homeopathic goods refuse to give the official information about the purchased non-wood products (kinds, amount, the country of origin).

In total about 77.1% of respondents gained some forest non-wood products of plant origin. The data acquired at the sociological research show the following significance of the non-wood plant products: 67.6% of respondents gather mushrooms; 35.4% – wild berries, 27.5% cut Christmas and New Year trees, 25.9% gather birch and maple sap, 22.2% gather floristic decorative materials, 16.4% collect herbal plants, 14.4% collect branches for sauna-brooms, but 3.8% other non-wood products (nuts, branches, cones).

The estimation of definite FPNWP (mushrooms, berries, Christmas/New Year trees, birch juice) is done both in physical and monetary units. the calculation of gain amount of the other groups of FPNWP – decorative materials, medical raw materials in physical units (items, kg) is not rational because related products are too different, for example, decorative materials – cones, branches, lichens. The physical amount and monetary values of FPNWP have been summarized in Table 2.

Table 2

The physical amount and monetary value of the FPNWP in Latvia

Products	Totality		Own-consumption		Sold in the market or to other households	
	amount*	value, million LVL	amount*	value, million LVL	amount*	value, million LVL
Mushrooms	21.5±3.0	36.0±9.7	18.9±2.5	31.6±8.3	2. 7±1.1	4.4±2.0
Wild berries	6.1±1.3	11.9±2.9	5.0±0.9	9.7±2.0	1.1 ±0.6	2.2±1.2
Christmas/ NewYear trees	654.7±0.1	3.1±0.5	572.3±84.9	2.7±0.4	82.4±33.4	0.4±0.2
Birch sap	23.6±5.4	15.8±4.5	20.8±4.0	13.9±3.6	2.8±2.3	1.9±1.6
In total		*66.8*		*57.9*		*8.9*

*Measurement units: Mushrooms, Wild berries - million kg; Christmas/ New Year trees - thousand pieces; Birch sap - million liters.

The prices (LVL kg^{-1}) of the gathered mushrooms and wild berries are calculated using the information of those respondents who gather at least 10 kg wild berries a year and the information gained in the internet. 67.6 ± 1.5% of the respondents have gathered mushrooms, on average - 18.84 ± 1.29 kg. The average price of mushrooms is 1.67 ± 0.20 LVL kg^{-1}. Relating to Latvia, it means that 1.15 ± 0.04 million residents have picked mushrooms.

35.4 ± 1.5% of the respondents have gathered wild berries, on average - 10.2 ± 1.1 kg. The average price of wild berries is 1.96 ± 0.11 LVL kg^{-1}. Relating to Latvia, it means that 0.60 ± 0.05 million residents have picked wild berries.

27.5 ± 1.4% of the respondents have cut Christmas and New Year trees in the forest themselves, on average 1.41 ± 0.1 pieces. The average price of Christmas and New Year trees is calculated using the information of forest attendants, and it is 4.79 LVL. Relating to Latvia it means that 0.47 ± 0.05 million residents have cut Christmas and New Year trees.

25.6 ± 1.4% of the respondents have collected birch or maple sap, on average 53.6 ± 5.5 liters. The average price of sap is 0.67 ± 0.06 LVL l^{-1}. The prices are calculated using the information of forest attendants and the information gained in the internet. Relating to Latvia, it means that 0.47 ± 0.05 million inhabitants have collected birch or maple sap.

The evaluation of FPNWP in Latvia's national economy in 2010.

Non-wood plant product contribution in Latvia's nation economy in 2010 – the amount and value of the own-consumed and sold FPNWP has been summarized in Table 2.

67.6 ± 1.5% of the respondents have gathered mushrooms for self-consumption, on average 16.48 ± 1.04 kg. On the whole 18.9 ± 2.5 thousand tons of mushrooms were in the households. 8.7 ± 0.9% of the respondents have sold mushrooms to others, on average 17.98 ± 3.17 kg. Relating this information to the inhabitants of Latvia - they are 147.3 ± 29.6 thousand people. On the whole, 2.7 ± 1.1 thousand tons of mushrooms were in the market (sold or transferred to other households).

35.2 ± 1.5% of the respondents have picked wild berries for their own-consumption, on average 8.34 ± 0.64 kg. On the whole 5.0 ± 0.9 thousand tons of wild berries were in the households. 4.1 ± 0.6% of the respondents have gathered berries for selling purposes, on average 16.33 ± 3.73kg. Relating this information to the inhabitants of Latvia - they are 69.4 ± 20.8 thousand people. On the whole, 1.1 ± 0.6 thousand tons of wild berries were in the market (sold or transferred to other households).

27.5 ± 1.4% of the respondents have cut Christmas and New Year trees for self-consumption, on average 1.23 ± 0.07 items/ units. On the whole 572.3 ± 84.9 thousand of trees were in the households. 3.0 ± 0.5% of the respondents have sold trees to others, on average 1.62 ± 0.17 trees. Relating this information to the inhabitants of Latvia - they are 50.8 ± 17.9 thousand people. On the whole, 82.4 ± 33.4 thousand of trees were in the market (sold or transferred to other households).

25.6 ± 1.4% of the respondents have collected birch or maple sap for their own-consumption, on average 48.0 ± 4.0 liters. We assume that majority of sap collected is birch sap as maples are rarer and are not so popular in Latvia. On the whole 20.8 ± 4.0 million liters of birch sap were in the households. 3.7 ± 0.6% of the respondents have sold birch sap to others, on average 44.9 ± 17.4 liters. Relating this information to the inhabitants of Latvia - they are 62.7 ± 19.8 thousand people. On the whole, 2.8 ± 2.3 million liters of birch sap were in the market (sold or transferred to other households).

On the whole, the contribution of non-wood products in Latvia's national economy was 66.8 million LVL, from it 8.9 mill. LVL – the value of the products for sale in the market or exchange with other households.

Systematic bias is possible in the evaluation because considering the labour market opportunities in foreign countries, there are less inhabitants in Latvia than shown in the database of statistics. In an ideal case it would be necessary to calculate the product price at the forest. But in this case the market prices found in the internet as well as given by the respondents were included in the evaluation. The market prices also include the product gathering and transportation costs.

Unfortunately, it was not possible to obtain information about the amount of the purchased nature products grown in Latvia for the comparison and checking. To get more credible information about the gain of FPNWP in Latvia's national economy, it is necessary to estimate the inclusion of such information in the state statistic programme.

Conclusions

1. 77% of the residents of Latvia aged 18 - 74 have gained the forest plant non-wood products (FNNWP) in Latvia in 2010.
2. The most significant FPNWP are mushrooms, wild berries and birch sap.
3. The contribution of FPNWP in the Latvia's national economy in 2010 was 66.8 million. LVL, including 8.9 million. LVL for the products sold in the market or transferred to other households.

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MONETARY VALUE AND SOCIAL ROLE OF FOREST RECREATION SERVICES IN LATVIA

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Abstract

Recreation services are the forests' non-market goods which constitute a substantial part of the total economic value and are important for the choice of multi-functional forest policies. However recreational services do not always have a market price and comparatively less literature applies value orientations to examine issues concerned with recreational use of natural resources. This research reports on the findings of the comprehensive, national-level study about the contribution of forest recreational services to Latvia's national economy in 2009 and about the respondents' declared choices, travel costs and willingness to contribute some money for improvement of amenities in a forest. Two general information sources were used to obtain the information - available statistical data and the contingent valuation survey to estimate the respondents' choices and habits for recreation activites in the forests. Results show that forest recreation is very popular and highly valued in Latvia. The statistical analysis confirms that the significant differences exist between varied respondents' socioeconomic groups in their objectives, choices and preferences to use the forest recreational services.

Key words: forest recreational service, economic value, contingent valuation.

Introduction

Forests are the source of a wide range of services (Stenger et al., 2009; Bestard and Font, 2009; Kőchli and Brang, 2005; Termansen et al., 2008; Tahvanainena et al., 2001) and include indirect use values (waste protection, watershed services and carbon storage); non-use values (wildlife habitat and diversity preservation) and direct use values (recreational opportunities) (Barrio and Loureiro, 2010). Over the last two decades an increasingly diverse range of social and cultural values associated with forests (Edwards et al., 2011; de Vries and Goosen, 2002), and studies across Europe show that forests are among the most popular settings for outdoor recreation (Nielsen et al., 2007; Mann et al., 2010). People needs for outdoor recreation refers to innate desire to re-establish the severed links with nature in settlements, as expounded by the biophilia concept of Wilson in 1984. The attitude toward forest resources and services predicts four types of people's environmental value orientation ('sentiment', 'ecology', 'utilitarian', 'negativity') (Li et al., 2010) which include stress recovering (Guilio et al., 2009; Kőchli and Brang, 2005), improving of mental and physical health, satisfaction with natural aesthetics (Barrio and Loureiro, 2010), acknowledging of historical and cultural importance and providing of commodity benefits (Li et al., 2010). Recreation services are the forests' non-market goods (Chen et al., 2004; Termansen et al., 2008) which constitute a substantial part of the total economic value of forests in modern society (Bartczak et al., 2008; Turväinen, 2001). However many of the forest goods and services do not have a market price (Stenger et al., 2009), the monitoring of recreational visit numbers to forests is patchy and inconsistent (Edwards et al., 2011) and comparatively less literature applies value orientations to examine issues concerned with recreational use of natural resources (Li et al., 2010; Nielsen et al., 2007). The demand for non-market benefits is increasing faster than the demand for most wood products in many parts of the world (Stenger et al., 2009) and the diverse range of social and cultural values associated with forests has come to be recognised by the European forestry sector (Bernath and Roschewitz, 2008; Roovers et al., 2002). It is now widely acknowledged that the taking into account the forests' recreational services and an understanding of residents' recreational habits have implications for forest management and land use policy more generally (van der Horst, 2006; Bartczak et al., 2008; Turväinen, 2001). Moreover, projecting the multiple benefits of greenspaces in monetary values provide a universal language to justify the expenditures, and permits fair competition with other demands for policy and financial support (Jim and Chen, 2006).

Given the complexities of forest ecosystems and their environmental features, many different valuation methods can be used to get at different facets of the non-market goods and services provided by forests (Eberle and Hayden, 1991; Turväinen, 2001). The fundamental assumption is that the value of all goods can be expressed in money equivalent terms and that value is based on a goods' utility to humans. These value rankings of non-market goods can be empirically identified by: the indirect revealed preference methods - Travel-Cost Method (TCM) and the stated preference method - Contingent Valuation Method (CVM) (Whitehead, 2000; Faber et al., 2002).While applications of TCM and CVM to value recreation services are quite common in Western Europe and USA, their use in transition economies in Central and Eastern Europe is in its infancy (Bartczak et al., 2008). The primary reason seems to be the absence of a legal obligation to require a monetary evaluation of environmental policies (Tyrväinen and Väänänen, 1998).

Forests in Latvia are an important part of people's everyday life and their everyday landscape – 56% of total area is covered by forest (33% in Europe average) or 1.3 ha per capita. The majority – 59% are conifer forests (in 2006). The state owns 50.2% of Latvia forests, but the access is available to the public for recreational purposes in 99.5% of Latvia forests (United Nations Economic Commission for Europe, 2005). One of the aims in the social sphere of Latvia Forest policy is to balance the interests of society and forest owners in using the social values of forest. Every year more and more inhabitants in Europe and also in Latvia go to the forest to relax – pick mushrooms and berries, observe nature, go fishing, hunting, ride a bike, go on a hike or simply for a walk, have a picnic or participate in different sports activities. The Joint Stock Company "Latvijas Valsts Meži" (Latvia's State Forests) (hereafter also JSC) actively participates in organizing the recreation opportunities in the state forests. The inhabitants of Latvia are interested in using the recreational opportunities in the forest however the current economic situation, when the level of unemployment is 17.2% (Central Statistical Bureau, December 2010), the picking of berries and mushrooms is not a recreation any more, but it has become a source of well-being.

The main goal of this study is to analyze the date, obtained in the national-level study estimating the amount and monetary value of the forest recreational services and the respondents' declared choices and willingness to contribute some money for a well organized forest with amenities in 2009. The research also discerns whether the differences exist between varied respondents' socioeconomic groups in their objectives, choices and preferences to use the forest recreational service.

Materials and Methods

In 2010 - 2011 in the framework of the project 'Additional research for the development of integrated forest accounts model in Latvia' (agreement No. 51110/C-116, Ministry of Agriculture of Latvia Republic) the research document about the contribution of forest non-market services in the national economy in 2009 was worked out. To obtain the information about forests recreation services, amounts and offering we used available statistical data and the internet resources. The data about the number of people visiting the territories with admission fees and/or other paid services connected with tourism are obtained from JSC (information about 2009) and Nature Conservation Agency (in connection with the reorganization - information about period 01.01.2009. - 31.05.2009.) The data about the number of nature trails and recreational areas with definite admission fees are obtained from the internet but are not sufficient, because they do not show the cases of repeated visits and total incomes in 2009. According to the available information, 33 nature trails and objects have admission fees and guided tour fees or payment for car parks, but the visit of 120 nature trails and objects are free of charge. The data about the organized and charged orientation sport events in the forests were obtained from the internet resources, but they are not sufficient. In Latvia there are 38 sport clubs, but only 15 of them have homepages with available information about participation fees and number of participants. To obtain the additional data about the residents' habits, choices and preferences to use the forest recreational service as well as the payment for transport to get to the forest and willingness to contribute some money for improvement of amenities in a forest in 2009, the contingent valuation survey (hereafter CVS) was used.

The CVS's questionnaire was designed based on the research of Turväinen (2001), Mayor et al. (2007) and Zandersen et al. (2007) about the economic valuation of recreational resources. The first section of the CVS's questionnaire introduced with the purpose of the study and instructions to help respondents understand the questions. The second section included questions about actual recreational experiences and activities through the following questions: what management regime is the most appropriate for recreational use, what the purposes of recreational activities are, and when the respondent usually visits the forest – in working days, at weekends or in vacations/holidays. Depending on the answer about frequency of visits, we asked about the distances travelled to the site, mode of transport and travel cost for one person in both directions. The third section contained the description of the hypothetical scenario and the valuation question. The open-ended payment card approach (Jim and Chen, 2006) was adopted in this study because this technique provided direct prompts, clarified their willingness-to-pay, and allowed them to express their preferred amount if they were not satisfied with the given choices (Henemann, 1994; Turväinen, 2001; Venkatachalam, 2004). Besides that we asked about the payment per year for entrance in the forest with amenities. The last section of the questionnaire provided the general socioeconomic information.

The public opinion poll in Latvia (December, 2010) was carried out in cooperation with the LTD SKDS. The methodology of estimation based on the assumption that sociological research would contain representative information about the contribution of forest recreational services was worked out. The quantitative Omnibus poll method was used – the representative selection, at least 1000 respondents at the age of 18-74 (the general selection representing the totality the whole territory of Latvia). The common error of the research with such selection amount is ± 3.1%, with 95% probability level. The total number of 'face to face' interviews in the dwelling-places of the respondents was 1003. The Statistical Package for Social Science (SPSS V.19) was used to analyze the collected data. A series of Chi – square ($\chi 2$) tests to determine differences at 0.01significance level in order to find out the possible differences or similarities between the answer of different groups of respondents were applied.

Results and Discussions

The main forest recreational services having impact on Latvia's national economy were identified: firstly, educational services (the incomes from admission fees and/or other paid services connected with tourism in protected natural areas and recreational areas in the state forests); secondly, sport and adventure activities in the forests (the participation fees); thirdly, others with recreation connected services (the sum/per year of inhabitants individual choice to pay for transport to visit the forest, for entrance fees in different object of recreation and amusement in the forests, and the willingness to contribute some money for improvement of amenities in a forest). In Latvia there are a lot of privately owned forests and the information about the incomes and number of visits to the different recreational and amenity objects in those forests is not available. The total sums of the available data about the forest recreational services are shown in Table 1.

Table 1

The amount and monetary value of the forest recreational services in 2009

No.	Recreational service	Number of visits	Sum (LVL)
1.	The organized sport activities: 15 orienteering sport clubs (total number – 38) which have available information in internet about participation fees and number of participants	15 sport clubs with total number of participation – 51 930	121 028
2.	The number of people visiting the territories with admission fees and/or other paid services connected with tourism (information about 01.01.2009. - 31.05.2009.)		
2.1.	Gauja National Park	6463	4 097
2.2.	North Vidzeme Biosphere Reserve	180	55
3.	The number of people visiting the recreational areas in Latvia State forests in 2009		
3.1.	Tervete Nature Park	75 000	103 000
3.2.	Pokainu forest	11 300	10 700
4.	Number of natural trails with admission fees and guiding service – 33; trails for free -120	Information is not available	Information is not available
		Total	~136 000 LVL (194 000 EUR)

The first question of the public opinion poll asked to rank the given forests with different levels of management in four ranks from the most suitable for recreational use (rank No.1) till the least suitable (rank No.4). The results are shown in Table 2. The natural forest was mentioned as the most appropriate forest for recreation, but the least appropriate – the forest with intensive management. In comparison, in 2008, the forest with recreational amenities and the forest with intensive management were mentioned as the most appropriate forests for recreation, but the least appropriate – the natural forest and the forest – park (Donis, 2008). In this survey, the differences between those forest types were not defined. The people's perception differs from their education level, experience and expectations (Faber et al., 2002) and in this case the respondent's understanding was subjective and spontaneous. It is partly the reason why so great contradictions among respondents' choices in 2008 and in current survey exist. However, in further researches those definitions to obtain the more equitable results have to be clarified.

The vast majority of respondents (83%) visited the forest during 2009. To the question how often the respondent usually visits the forest for recreational activities obtained following results were obtained: 17% of respondents did not use the forest for recreation, 57% of respondents usually visited the forests at weekends, 16% of respondents - in working days and 10% - in vacations/holidays. As the most popular recreational activities the respondents mentioned walking, picking the berries and mushrooms (respectively - 50%, 43% and 69%). However, these rates show both – those who go to forest for recreational purposes and also people who pick berries and mushrooms for selling them to gain additional income. In comparison with Poland, the vast majority (85%) go to forests for walking, though berry and mushroom picking is considered almost as important (80%) (Bartczak et al., 2008). The survey results showed that 44, 8% of respondents use the transport (private or public) to go to the forest, and we calculated that the average sum for a round trip per person is 1, 33 LVL (1.9 EUR). The obtained data were proportionally related to the total number of Latvia's inhabitants in the age group 18 - 74 (Table 3).

Table 2

The forest suitability for recreational use

Landscape's description	Rank				Mean	Position
	1	2	3	4		
Natural forest	589	85	147	46	1.6	1
Forest with intensive management	18	115	139	595	3.5	4
Forest with recreational amenities	162	357	271	77	2.3	2/3
Forest - park	97	309	310	151	2.6	2/3

Table 3

The respondents' declared choices and willingness to contribute in 2009

No.	Payment	Rate (%)	Amount (LVL/ EUR)
1.	The total transport cost for one trip (for each person in both directions)	44.8	1 009 830/ 1 436 867
2.	The total sum of using the amenities in the forests with admission fee	17.2	1 107 720/ 1 576 152
3.	Willingness to contribute some money for amenities' improvement in a forest	26.2	3 065 893 / 4 362 397
		Total	5183443 LVL/ 7375417 EUR

Using the amenities in the forests with admission fee is quite rare – only 17.2% of respondents choose such service and the monetary value of contributions is 1 107 720 LVL (1 576 152 EUR) in 2009 (Table 3).

Prior to asking the question: '*Would you agree to contribute some money for a well organized forest with all amenities? If yes, what amount of money per year are you ready to pay for this purpose'* it was explained that the well organized forests can provide the recreation service for a lager number of people. The literature studies show if the stated willingness-to-pay is too high (exceeding stated income by 5%), the questionnaires are discarded as outliers (Turväinen, 2001; Jim and Chen, 2006). We decided to discard 20 questionnaires where the stated willingness-to-pay was more than 5% of income to one member of family. 27.0% of respondents answered 'yes' and mean willing to contribute was estimated 6.7 LVL (9.5 EUR). The monetary value of contributions 3 065 893 LVL (4 362 397 EUR) was estimated relating to the total set (Table 3).

Through the series of statistical analysis it became clear that there exist variances between opinions of different respondents' groups and their choices (Table 4). The greatest significance ($p<0.01$) shows: the number of members in families in relation to frequency of visits and the choice of natural forest for recreational activities; the ages in relation to frequency of visits and with choice of forest with different levels of management for recreational activities; the education in relation to frequency of visits, the choice of natural forest for recreational activities and willingness to contribute; the nationality in relation to choice of natural forest for recreational activities; the occupation in relation to frequency of visits, the choice of natural forest and forest – park for recreational activities; the incomes to one member of family in relation to willingness to contribute.

The significance $p<0.05$ shows the relation between: the nationality and choice of forest with intensive management and forest – park for recreational activities; the occupation and willingness to contribute; the incomes to one family member and frequency of visits and the choice of forest with intensive management and the forest – park for recreational activities.

The significance $p<0.1$ shows the relation between the education and the choice of forest with intensive management for recreational activities and the nationality and the choice of forest with amenities for recreational activities (Table 4).

We also tested the answers of respondents' groups from different socioeconomic groups to the questions about travel cost and using the amenities in the forests with admission fee. The significant differences were not found except in the respondents' group with different number of members in a family in relation to using the amenities in the forests with admission fee ($p<0.05$).

Table 4

Results of contingency tables analysis

No.	Socio-economic groups/variables	Number of members in family	Ages	Education	Nationality	Occupation	Incomes to one member in family
1.	Frequency of visits	0.002***	0.000***	0.000***	0.820	0.000***	0.033**
2.	The forest suitability for recreational use						
2.1.	Natural forest	0.004***	0.000***	0.002***	0.000***	0.005***	0.168
2.2.	Forest with intensive management	0.217	0.001***	0.066*	0.021**	0.076*	0.048**
2.3.	Forest with recreational amenities	0.168	0.004***	0.134	0.076*	0.055*	0.355
2.4.	Forest – park	0.509	0.003***	0.761	0.025**	0.006***	0.015**
3.	Willingness to contribute	0.583	0.815	0.004***	0.047**	0.037**	0.000***

Designations: * - $p<0.1$; ** - $p<0.05$; *** - $p<0.01$

Conclusion

This research aimed to provide an insight into the monetary value of forest recreational services and obtain the results about the use of these services by varied respondents' socioeconomic groups in Latvia, in 2009. The results of the research show that:

1. The national annual forest recreational value in 2009 was estimated around 136 000 LVL (194 000 EUR) to the total area of forests;
2. The respondents' declared choices and willingness to contribute in 2009 was estimated around 5 200 000 LVL (7 400 000 EUR);
3. The significant differences exist in answers of respondents' socioeconomic groups about the frequency of visits to the forest for recreational activities, the forest suitability for recreational use and willingness to contribute;
4. No significant differences exist in the answers between respondents' socioeconomic groups about the travel costs and using the amenities in the forests with admission fee;
5. The contribution of this study has covered some of the last research and application in forest valuation in Europe, but for further construction of the hypothetical market of forest recreational service in Latvia, the obtained data have to be proceeded by methods of TCM and WTP to become comparable with results in other countries.

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MANAGEMENT COMPETENCES ASSESSMENT IN SMALL AND MEDIUM-SIZED FOREST ENTERPRISES

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Abstract

The role of small and medium-sized enterprises (SME) in the development of economics becomes more important, as they can quickly re-orientate in the rapidly changing economic situation, and they are the main guarantee of wellbeing on the regional scale. Although these enterprises are different, still the SME in the European Union meet several similar difficulties. One of the main problems of the SME is lack of management competences that causes difficulties in ensuring efficient management of the enterprises.

The aim of the research was to investigate the competences that are necessary for the employees to carry out their duties from the point of view of small and medium-sized forest enterprises (SMFE). The task of the research was to identify problems faced by the SMFE management in daily business. To get results, the qualitative interview method was used as well as, survey was carried out, and the obtained data from well-established methodology and criteria were evaluated.

The research results show that the distribution at the SME is specific professional competence with 40%, social competence with 23%, methodical and individual competence with 19% and 18%. The results show that necessary management competences in SME and large enterprises are equal, but the kind of their application and topicality differ; therefore, it is essential to organize activities of professional development concerning the definite model and type of business. The professional teaching models for SMFEs should be according to enterprises management specifics, focusing on the fact that managers of SMFEs to combine the competences.
Key words: competences, small and medium-sized forest enterprises.

Introduction

The role of small and medium sized enterprises (SME) in the development of economics, irrespective of the expressed globalization trends, in the forest sector is considered to be more important and their efficiency is counted as a significant factor of survival and success (Loan-Clarke et al., 2002). The importance of the SME in the society today becomes more and more notable, as they can in the quickly changing economic situation rapidly re-orientate and they are the main guarantee for ensuring of wellbeing on the local and region al scale (Mazo…, 2008).

Based on the size of the SME they are divided into three categories: microenterprises with less than 10 employees, small enterprises with 10 to 49 employees and medium size enterprises with 50 to 249 employees. The SME in Europe from 99.8% of all European enterprises and 67.1% of private-sector jobs, but more than 80% of employment in some industrial sectors such as the manufacture of metal products, construction and furniture (Mazo…, 2008).

SMEs offer very traditional services or craft products, many others are fast growing high-tech companies. Although these enterprises are different, still in the European Union they have many similar difficulties. The most essential problems the SME face within the EU are administrative and regulatory burden, access to finance, taxation and lack of competences (Mazo…, 2008, Table 1).

Table 1

Most essential problems SME are facing in Europe

Most important problems	Place
Administrative and regulatory burden	1.
Access to finance	2.
Taxation	3.
Lack of skills	4.
Access to public procurements	5.
Unfair/too strong competition	6.
Labour law	7.
Access to Single Market	8.
Access to EU programs	9.
Late payments	10.
Access to international markets	11.
Access to information and advice	12.

It can be concluded that one of the most essential problems is lack of management competences that causes difficulties in ensuring SME efficient management. The government initiatives the aim of which is to develop the competitiveness of the SME should be intensified in the spheres promoting the development of the enterprise management competences (Smith and Whittake, 1998). By now the role and development of the management competences in SME are insufficiently investigated and the previous research shows that factors influencing the SME operation are not completely understood (Smith et al., 1999).

Latvia is one of the most forested EU member states. The forest sector has convincingly demonstrated its strategic importance to Latvia's national economy. Of all the companies registered in Latvia, 8% are linked to the forest sector, which employs around 5% of the labour force. The forest sector share of Latvia's gross domestic product is about 5% (in 2009). The forest sector is Latvia's most important export industry, historically having contributed as much as one third of national export revenues and about 70% of forest sector output is exported (Forestry…, 2009). Therefore, the management competences assessment of the SMFEs can increase the total forest sector competitiveness at both national and global level.

The present article describes the opinion of the authors on the efficiency of the SMFE, teaching models of professional growth as well as the competences necessary for SMFE management. Today different development programs for the improvement of the competitiveness of enterprises and the economics in total become more topical. Training to improve the competences of the enterprise managers implemented before was aimed mainly at the development of skills that are applied in large enterprises, but with the increase of the understanding about the needs of the SME, the necessity for corresponding education and training arises. Programs for the development of SME management competences are efficient if the main gain promotes survival and development, decreases failures and shows improvement in performance (Fuller-Love, 2006).

The competitiveness of the enterprise is determined by the employees who are not only qualified professionals but also can solve the problems caused by external influences that become more complicated. By the notion "competence" a totality of factors characterizing a person for carrying out successful duties at work or knowledge, experience, skills, abilities in a definite field are understood.

In literature sources two kinds of competence groups are distinguished - specified competences and generic competences (Gonzalez and Wagenaar, 2003).

Development of the competences of the employees is a progressive trend more and more chosen in the educational establishments in Europe.

As it is mentioned above, competences are formed as a combination of definite skills and abilities. In order to determine the competences, the following interrelated competence groups were defined and specified as professional competence, methodical competence, personal (individual) competence and social competence (Knauf and Frühwald, 2001; Figure 1).

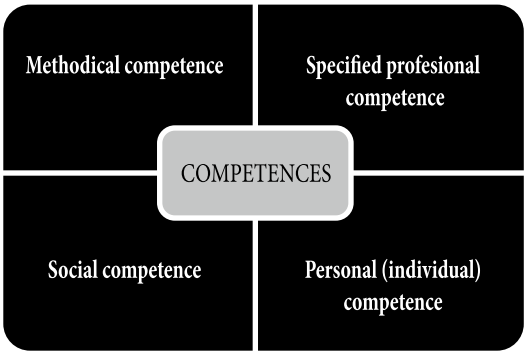

Figure 1. Competence groups in SME.

Applying the elaborated classifier of competences they were divided into skills and habits that form them (Table 2)

Table 2

Skills and abilities included in competences in SME

Specific professional competence	Methodical competence
1. Professional experience in product/service 2. Theoretical knowledge on product/service	1. Process planning 2. Project development and implementation 3. Application of management and control mechanisms 4. Calculation of costs 5. Signing contracts 6. Documentation of work 7. Work with computer
Social competence	**Individual competence**
1. Formation of relations with clients/suppliers 2. Organization of structural unit and personnel management 3. Work with foreign co-operation partners 4. Team work ability 5. Solving of conflicts, taking decisions 6. Collection and processing of information	1. Introduction of new technologies and processes 2. Independent setting and achievement of aims 3. Ability to work individually 4. Good language knowledge 5. Foreign language knowledge (Russian, English, German etc.)

In addition, it should be taken into account that every competence forms accumulating theoretical knowledge of a definite field and skills for application. Depending on the kind of enterprise operation, the proportion of practical application of these two elements of competences essentially changes. This is the main difference between the competences necessary for the management of the SME and the definite competence elements necessary for the management of the large enterprises (Figure 2). Formally the same competences are needed, but the kind of their application is determined by the kind of operation at a definite enterprise (in large enterprises it is determined by the post of the employee).

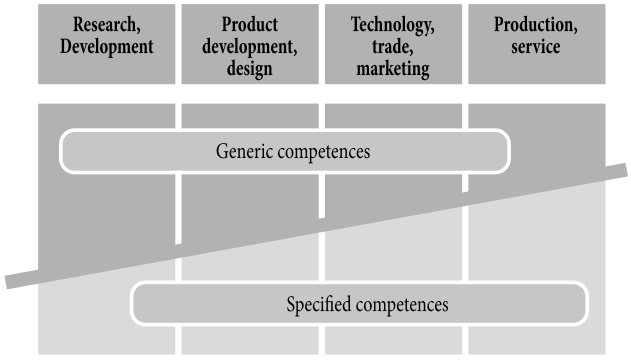

Figure 2. Proportion of theory and practice of the demanded competences in SME.

In acquisition of competences, formal education plays an important role. The main problem stressed by businessmen is that employees are not trained to be sufficiently competent for business. Therefore, it is important to offer education adequate to business needs. The necessity for different education methods for small and large enterprises becomes more topical. Today, according to the opinion of the authors, in the conditions of business development different education models would be necessary for small and large enterprises, and there should be the transition marked from the entrepreneurship model for small enterprises to the entrepreneurship model for large enterprises (Figure 3). Also, in fast changing economic situation the type of enterprise operation can quickly change.

Successfully developing a specific product in a micro or small size enterprise, as well as a demanding large production capacity and with this – corresponding competences of business organization can occur.

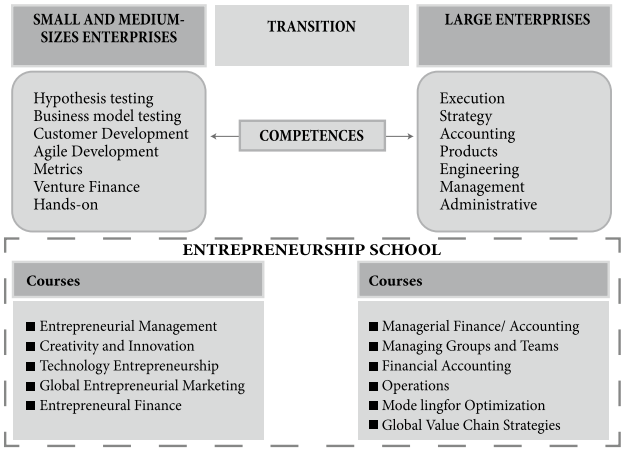

Figure 3. Training model in small and large enterprises.

The necessary management competences in SME are the hypothesis testing, business model testing, customer development, agile development, metrics, venture finance and "hands-on", which developed the following courses – the entrepreneurial management, creativity and innovation, technology entrepreneurship, patent law for entrepreneurship, global entrepreneurial marketing and entrepreneurial finance. But in large enterprises necessary management competences are the execution, strategy, accounting, products, engineering, management and administrative, which developed the following courses – the managerial finance and accounting, managing groups and teams, financial accounting, operations, modeling for optimization and global value chain strategies (Figure 3).

Materials and Methods

In the research on the competences of specialists and managers (skills and abilities), the qualitative interview method – inquiry of experts – was applied. This method is used to obtain the opinion of a definite group more deeply about the proposed question (Brunsemann et al., 1997). The selected experts are as follows: enterprise managers, personnel department managers, managers of the most important units and target group specialists.

The aim of this method was to state the general situation in the researched matters and not to get a representative and statistically processed result. By using the obtained information, it is possible to get more complete insight in the significance of the situation in relation to the qualification and skills of the employees, position of a definite enterprise represented by the expert in these matters as well as the reasons and barriers for the development of the qualification of the specialists.

The task of the research was to identify problems faced by the SMFE management in the daily business. In the research actively working wood processing, forestry and furniture production enterprises in Latvia were included. The research was performed from September till December, 2010. Out of 150 randomly selected SMFEs, 47 enterprises

confirmed their participation in the project, the operation of which corresponds to the NACE classifier is forestry and logging in NACE Rev. 2 A 02, manufacture of wood and wood products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials in NACE Rev. 2 C16) and furniture production in NACE Rev. 2 C31 (NACE…, 2006).

Systematization of the obtained results according to the qualitative content analysis model of Mayring (Mayring, 2002; Figure 4) was done.

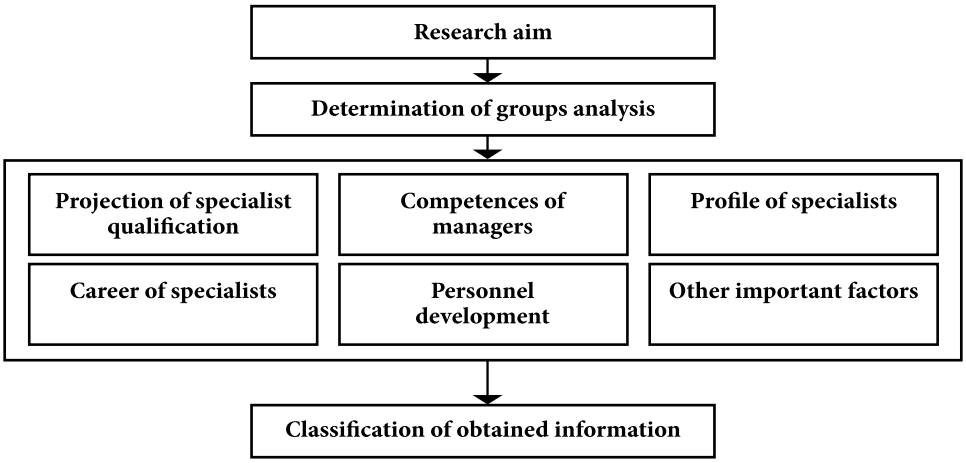

Figure 4. Diagram of information collection and processing.

If during the interview a skill or ability was mentioned that could not be classified as related to any of the competences in Table 2, they were classified in a separate group – other skills and abilities.

Evaluating every separate skill in the corresponding group of competences, the experts were asked to evaluate every skill according to its importance. The Likert scale that allowed to evaluate every skill in the range of four points - not essential, less essential, essential and very essential was applied.

Evaluating every skill and ability that from the corresponding competence, the respondents were asked to express their opinion and evaluation. It helped to identify and evaluate main reasons why definite skills are essential or not essential for the manager.

Results and Discussion

The research results show that in SMFE ~83% managing employees have special education in forestry sector. With this, determining the management competences, it was possible to determine skills and abilities that are necessary in SMFE. The results also show that ~60% SMFE are located in Riga and Riga region. It is related to higher economic activity compared to other regions in the territory of Latvia.

Analyzing the qualification of employees in the labour market, the following factors with which the SME confront at work are mentioned most often (Table 3).

Table 3

Main labour market influencing factors in small-size and medium-size enterprises

Factors	Medium	Small
Increase of the demand of enterprises for highly qualified specialists that can deal with complicated processes and equipment	X	X
Difficulties to attract specialists with higher education and necessary management skills	X	X
Lack of good managers with leadership abilities and ability to take decisions, create conditions and organize processes for the enterprise to get income and profit	X	
Employees leaving the enterprise to get higher salaries in other places		X

Characterization of management competences

In the SMFE in total all offered competences were considered to be necessary, still, evaluating every separate competence. The research results show distribution among the competences as follows: specific professional competence with 40%, social competence with 23%, methodical competence with 19% and individual (personal) competence with 18% (Figure 5).

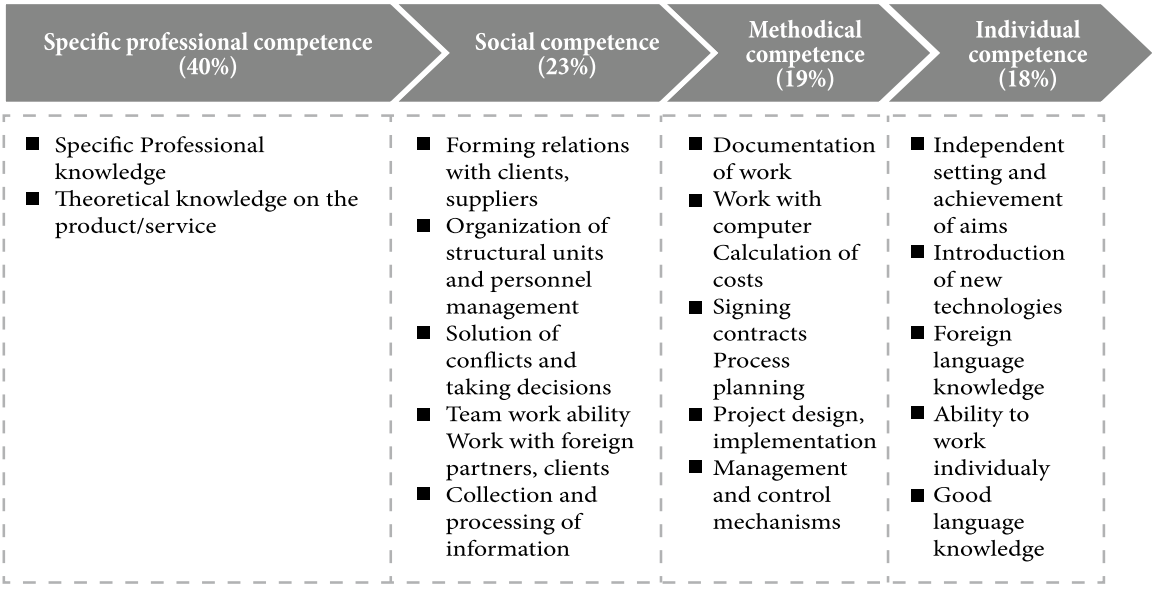

Figure 5. Characterization of management competences in small and medium size enterprises.

Specific professional competence

The obtained results show that in SME the specific professional competence plays an important role. In total the respondents think that the professional competence is very significant, in particular (Figure 6):

1. theoretical knowledge about the product / service sales – if market conjuncture is stressed, then knowledge on different ways of usage of the product is necessary in order to offer alternatives (42 respondents of the total number) to the clients;
2. specified professional knowledge - the task is related to highly technological processes – production, design (42 respondents of the total number).

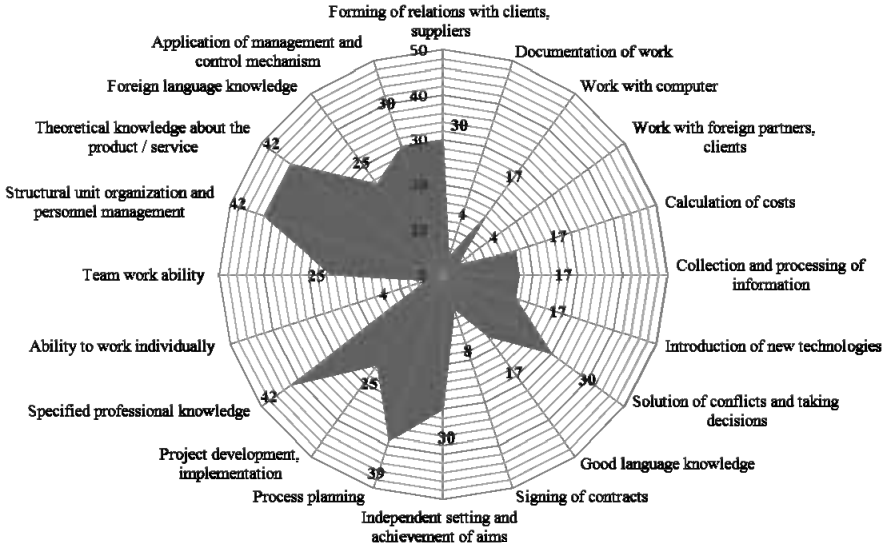

Figure 6. Necessary management competences in small and medium size enterprises, number.

It was stressed that employees without special branch education have to spend comparatively longer time to understand the processes at the enterprise than those who have the mentioned education, so the latter have much more possibilities to develop at the enterprise.

Social competence

The social competence at the SMFE is evaluated as the next most significant with the following necessary skills and abilities (Figure 6):

1. Structural unit organization and personnel management (42 respondents of the total number);
2. Solution of conflicts and taking decisions (30 respondents of the total number);
3. Forming of relations with clients, suppliers (30 respondents of the total number);
4. Team work ability (25 respondents of the total number);
5. Collection and processing of information (17

respondents of the total number);
6. Work with foreign partners, clients (4 respondents of the total number).

Depending on the specificity of the SMFE production is organized in shifts that can be treated as a team. The main task is to create the state when employees are motivated coperate and reach the set aims. In order to ensure it, it is necessary to maintain good atmosphere solving the conflicts quickly and finding individual approach to every employee.

Methodical competence

It can seem strange that the methodical conference at the SME is evaluated only as the third with the following skills and abilities (Figure 6):
1. Process planning (39 respondents of the total number);
2. Application of management and control mechanism (30 respondents of the total number);
3. Project development, implementation (25 respondents of the total number);
4. Computer literacy (17 respondents of the total number);
5. Calculation of costs (17 respondents of the total number);
6. Signing of contracts (8 respondents of the total number);
7. Documentation of work (4 respondents of the total number).

In the inquiry among the respondents it was stated that the employees should not know that many definite methods (for instance, documentation of work, signing of contracts) as they should be able to co-operate with the workers who have these skills. Here it should be stressed that separate skills such as project development and implementation are evaluated as essential.

Individual (personal) competence

The individual competence in SMFE according to its relevance is evaluated close to the methodical competence with the following necessary skills and abilities (Figure 6):
1. Independent setting and achievement of aims (30 respondents of the total number);
2. Foreign language knowledge (25 respondents of the total number);
3. Introduction of new technologies (17 respondents of the total number); Proper language knowledge (17 respondents of the total number);
4. Ability to work individually (4 respondents of the total number).

According to the evaluation of the respondents, the employees need to develop this competence, otherwise, it is not possible to co-operate successfully with colleagues and participate in formation of the team.

As it was mentioned above, the competences are formed as a combination of definite skills and abilities. Evaluating the skills and abilities individually, information is obtained about skills and abilities of the managers that are evaluated as essential (See figure).

Besides the skills depicted in the graph, the respondents mentioned the following skills that are essential for a good employee:
1. readiness to learn continuously and acquire new knowledge, skills and solutions – the present market development is so dynamic that the employees must be able to take new technological, cultural challenges;
2. ability to argue and defend the opinion – the manager should be convinced about proposal and solution offered by him/her;
3. ability to understand him/herself and others – employees should be able to work with themselves, answer the question why in definite situations definite emotions occur and how they influence the staff;
4. ability to evaluate critically him/herself, productive attitude and value orientation; personal competences;
5. ability to be active, creative based on self-organizing – be reflective, to treat the surrounding conditions technically and methodically and communicate with other people;

Conclusions

1. The research results prove that the efficiency of the SME operation in the Latvian forest sector also is influenced by the same factors as researchers of other countries mention in their publications. Therefore, the recommendations of these researchers can be used for evaluation of the necessary management competences in Latvian SME.
2. The necessary management competences are equal in the SMFE and large enterprises but the kind of their topicality and application differs, therefore, it is very important to organize professional development activities that are aimed at the definite model and kind of business.
3. The efficiency of introduction of the statements obtained in the result of the research in planning of activities for professional development is closely related to academic or professional education in the corresponding field. The professional teaching models for SMFEs should be according to enterprises management specifics, focusing on the fact that managers of SMFEs combine several competences. Therefore, in future research it is necessary to broaden the research field also including the evaluation of influence of formal education.

Acknowledgments

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USE OF TIMBER RESOURCES FOR DEVELOPMENT OF WOOD PROCESSING INDUSTRY

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Abstract

Forest industry consists of two related industries forestry and wood processing. Wood processing industry, which is a direct consumer of timber resources generated by forestry sector is eager to search for an answer about kind and amount of round wood they can count on in long term period. In Latvia for every five years State Forest Service calculates cutting volumes for the state owned forests based on models which do not guarantee safe long term income maximization. Long term cutting volumes and assortments in privately owned forests have not been analyzed very deeply. The aim of the research was to estimate the hypothetic amount of different timber resources available in the territory of Latvia for wood processing industry within next hundred years and look at geographic location of timber resources and woodworking companies. Research results showed that forests in Latvia are not being depleted and current annual cutting volumes could be increased. Geographic observation of primary wood processing companies showed that most of them are located close to large cities or near main roads of Latvia. This location makes easier round wood deliveries to factory and facilitates transportation of produced goods to an end customer. To clarify where and what profile (softwood or hardwood) production volumes should be increased, model of timber resource demand indicator was implemented.
Key words: primary wood processing, timber resources, geographic location, timber cutting volumes.

Introduction

In Latvia, timber resources have significant economical, social and ecological value as forests cover 54% of territory and timber stocks are slightly increasing year by year. Forest industry consists of two important sectors – forestry and wood processing industry both working closely together. Together with connected sectors (transport, building, power industries, science, etc.) forest industry employs around 14% of employable population from which most are employed in rural areas of Latvia. Total value of produced goods by wood processing industry in 2010 reached one million LVL. During last ten years annual cutting volume of timber resources have been 10 to 12 million m^3 (State Forest Service, 2010). In society discussions occasionally raise whether current level of cutting is not too high to maintain sustainable forest industry and biodiversity.

Every five years the State Forest Service calculates cutting volumes for state owned forests for the next five year period. Five year cutting volumes for state forests are calculated by using tree growth models (Ozolins, 2002) and models of forest operation management simulation (Dagis et al., 2006). The aim of this model is to even timber stock of each tree species in a long term period. Drawback of the method used by the State Forest Service is that it does not take into account net present value of forests and does not try to increase this value for a long term period. Thus, it is not guaranteed that the owner (state) will get maximum long term income. Anyway, if the state forest cutting volumes are determined by some kind of sustainable model, then sustainable timber cutting volumes of privately owned forests have not been analyzed very deeply. But wood processing industry, which is a direct consumer of timber resources is eager to find the answer about the kind and amount of round wood they can count on in a long term period (Robinson, 1987).

The aim of the research was to estimate the hypothetic amount of different timber resources available in the territory of Latvia for wood processing industry within next hundred years and look at geographic location of timber resources and woodworking companies. Reflection of future timber resource availability is given for next 30 years. A separate task of the research was to model timber resource demand indicator in each county of Latvia.

Materials and Methods

Research work was carried out in the autumn 2010 within the frame of the project „Substantiation of deciduous trees cultivation and rational utilisation, new products and technologies" in Latvia University of Agriculture Forest faculty. To reach the aim of the research, State Forest Service data and questionnaire of woodworking companies were used as well as specialized forestry management planning software, developed by Latvia University of Agriculture researchers, "Forest expert" (Dagis, 2007).

The first step was to calculate timber ready for cutting and timber in stock within next hundred years and divided in ten year periods. These calculations were done using the State Forest Service data. In these calculations growth models of different tree species as well as their cutting age according to legislation of Latvia was taken into account. Tree growth models are dependent on parameters like species, growth conditions, quality of locality and stand age. While in the simulation models of forest management basic actions of forestry like final felling, thinning, stand regeneration and tending of young stands are included (Ozolins, 2002). During simulation of each planning period the outcome of timber assortment and its market value is calculated. In calculation costs of logging, real estate taxes and other forest management costs are taken into account.

The next step was to optimize timber cutting volumes and stocks so that net present value of timber resources would not decrease and cutting volumes would be balanced with increase of forest value (Dagis et al., 2006). Thus, sustainable timber stock and cutting volumes were found. For forest capital value calculations price monitoring of timber resources was used. Price monitoring was done in autumn 2010 at Latvia University of Agriculture Forest faculty.

Cutting volumes were calculated in different sections – state or other owned forests and softwoods or hardwoods. Other forests mainly consisted of privately owned forests and small percentage of municipality owned forests. For further research forecasted cutting volumes were divided into round wood dimensions – large, middle, small, pulpwood, firewood and residues. In our further analysis timber residues were extracted as this assortment does not make interest for wood processing industry. Additional forecast of cutting volumes and available round wood dimensions in the period 2010 to 2039 by counties in Latvia were made.

Questionnaire of woodworking companies was carried out in the year 2009. From surveyed 778 woodworking companies, 380 acknowledged themselves as primary wood processing companies. For better visualization of primary wood processing companies' location on the map of Latvia, companies were divided in groups according to their round wood processing volumes:

- large - above 50'001 m^3 annually;
- middle - 10'001-50'000 m^3 annually;
- small - 1'001-10'000 m^3 annually;
- micro - below 1'000 m^3 annually.

Additionally companies were divided by tree species they process – softwood, hardwood or both.

For modelling timber resource demand indicator in each county, previously calculated sustainable timber cutting volumes were applied to annual processing volumes of primary wood processing industry. In response to these calculations, a use of linear optimization method was applied. The target of the use of this method was to find timber resources for each woodworking company at minimum distance between company and timber resources. Timber resource demand indicator allows evaluating potential demand for timber resources within certain territory and implies to counties with larger demand of resources which can mean larger value of resources in this territory. Unlike small resource demand indicator could mean that demand for resource in this county is smaller, and it could be more difficult to find customer for it. Small resource demand indicator shows that in this territory it would be useful to develop processing of round wood.

Results and Discussion

Timber resources in Latvia available for sustainable use

Calculations of timber ready for cutting, which includes all mature and overgrown stands, shows that cutting volumes vary between decades with the largest amount of timber to be cut in the first decade (Figure 1).

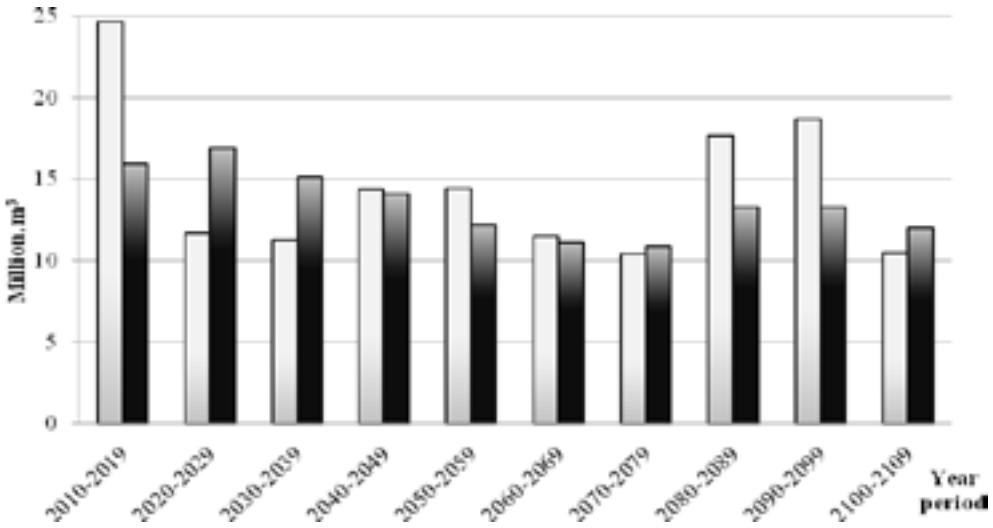

Figure 1. Forecast of annual cutting volumes (without residues) in Latvia within next hundred years before and after optimization, million m^3: □ before optimization; ■ after optimization.

This scenario of timber use is not good for sustainable wood processing industry as in the first decade to consume large amounts of supplied timber, woodworking companies will have to make significant investments in production. They will have to double timber processing capacities compared with current facilities. But in the second, third and further decades when supplied timber volumes are only half of first decade, most of woodworking companies

will have to reduce their production capacities twice and at the same time will have fierce fight for existing timber resources on the market. In this situation many companies will not survive and many will work with minor profit margin as raw materials they will have to buy for too high prices. After optimization, when net present value of timber would not decrease and cutting volumes would be balanced with increase of forest value, cutting volumes are more even distributed between decades and wood processing industry will have minor shifts in timber supply from forest owners.

To increase capital value of forests, in the first few periods' significant cutting volumes should be focused on overgrown aspen (*Populus tremula* L.), black alder (*Alnus glutinosa* (L.) Gaertn.) and grey alder (*Alnus incana*) stands with smaller cubic meter values than main species used in wood processing industry – pine (*Pinus sylvestris* L.), spruce (*Picea abies* (L.) H.Karst), birch (*Betula pendula* Roth). Felled little value stands should be regenerated with species demanded by wood processing industry. As newly regenerated species pine, spruce and birch have longer growth period compared to aspen and alder, then total timber stock in first four decades are slightly decreasing and stable increase starts after middle of this century.

Cutting volumes and available round wood dimensions in period 2010 to 2039

In the first decade softwood timber should be used in amount of 7.3 million m^3 and hardwood timber 8.6 million m^3 annually if the target of forest management is the increase of NPV and timber cutting volumes balance with increase of forest value (Table 1). From extracted growing stock 7.8 million m^3 of round wood should come from state owned forests, but 8.1 million m^3 from other forests.

Table 1

Forecast of annual cutting volumes in state and other forests in period 2010 to 2039, m^3

Annually	Year 2010-2019	Year 2020-2029	Year 2030-2039
Dimension softwoods / hardwoods			
Softwoods	7.3	8.0	7.9
Hardwoods	8.6	8.9	7.1
Dimension state forests / other forests			
In state forests	7.8	8.2	6.9
In other forests	8.1	8.7	8.1
Total	15.9	16.9	15.1

Assuming that in the first decade use of timber resources will be according to sustainable forestry principles, in the second decade use of softwood timber could be increased by 0.3 million m^3 in state forests and by 0.4 million m^3 in other forests annually, while hardwood timber use would increase by minimum amount. In the third decade use of softwood timber would be almost the same as in the second one, but the use of hardwood timber would decrease by 1.2 million m^3 in state forests and by 0.6 million m^3 in other forests annually. Previous statement would come true if in the first two decades felling volumes would have been concentrated on mature and overgrown hardwood stands whose value under time influence decreases faster than value of softwood stands. If forecasted available annual cutting volumes are compared with annual cutting volumes during last ten years, which have been 10 to 12 million m^3, then one has to conclude that annual cutting volumes could be increased. To identify for what species cutting volumes could be increased, closer look at the balance of consumed round wood in Latvia should be done. Round wood consumption balance shows that softwoods (Figures 2) are being used more intensively than hardwoods (Figure 3). If hardwoods are used only in amount of 56% from sustainable cutting volumes, then softwoods are used at 85 - 90% intensity from maximum available. It means that at the moment consumption of softwood timber in Latvia is close to maximum to perform sustainable forestry, but consumption of hardwoods is possible to increase at least by 30 - 35%. However, to implement larger cutting volumes than current ones, more detailed research should be done about availability of each single forest stand – how far it is from forest road, time of year stand could be felled, interaction with by standing mature or young forest stands, intensity of surrounding clear cuttings, etc.

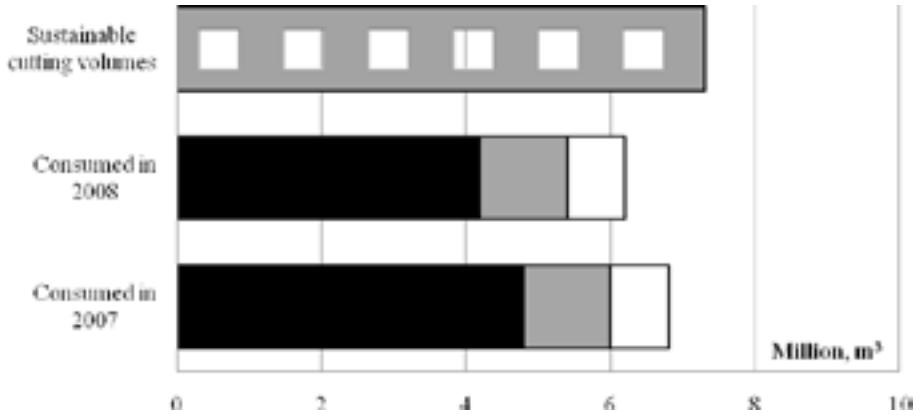

Figure 2. Balance of consumed softwood timber in Latvia during years 2007 and 2008, million m^3: sustainable annual cutting volumes, primary wood processing, export saldo of round wood, firewood.

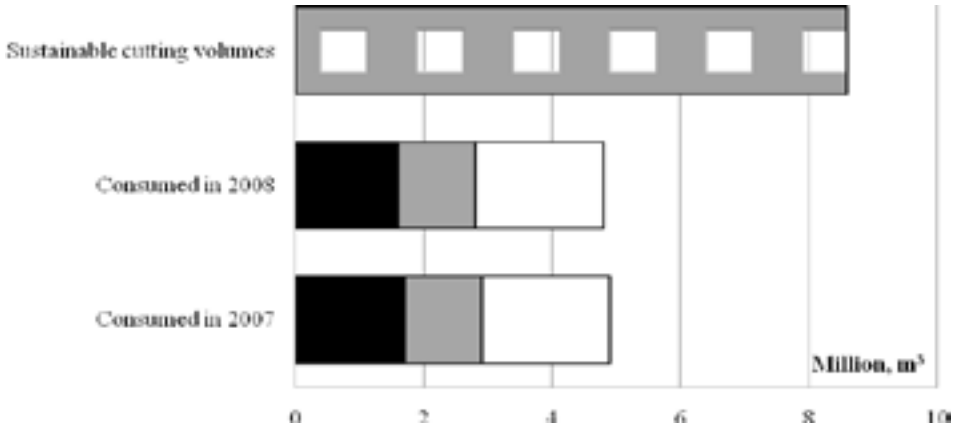

Figure 3. Balance of consumed hardwood timber in Latvia during years 2007 and 2008, million m^3: sustainable annual cutting volumes, primary wood processing, export saldo of round wood, firewood.

In state forests the largest softwood cutting volumes in the first decade are forecasted to be in Ventspils, Talsu, Kuldigas, Tukuma, Gulbenes and Aluksnes counties. In the second decade potential softwood cutting volumes would increase in Talsu, Kuldigas, Daugavpils, Madonas and Valkas counties, but would decrease in Tukuma, Jelgavas and Aluksnes counties.

In other forests the largest softwood cutting volumes in the first decade are forecasted to be in Amatas, Madonas, Aluksnes, Gulbenes, Pargaujas and Rezeknes counties. In the second decade potential softwood cutting volumes would increase in Ventspils, Pavilostas, Talsu, Kuldigas, Rezeknes, Gulbenes and Valkas counties, but would decrease in Madonas, Aluksnes, Amatas and Pargaujas counties.

In state forests the largest hardwood cutting volumes in the first decade are forecasted to be in Saldus, Jelgavas, Jekabpils, Daugavpils, Madonas, Gulbenes, Aluksnes and Viļakas counties. In the second decade potential hardwood cutting volumes would increase in Karsavas county, but would decrease in Jelgavas, Jekabpils, Daugavpils, Madonas, Aluksnes and Viļakas counties.

In other forests the largest hardwood cutting volumes in the first decade are forecasted to be in Limbažu, Madonas, Aluksnes, Gulbenes, Rezeknes, Dagdas and Kraslavas counties. In the second decade potential hardwood cutting volumes would increase in Kuldigas, Saldus and Rezeknes counties, but would decrease in Limbažu, Aluksnes, Dagdas and Kraslavas counties.

Geographical location of primary wood processing companies

Most of large and middle scaled primary wood processing companies are located close to large cities or near main roads of Latvia (Figure 4). Thus, it makes easier round wood deliveries to factory and facilitates transportation of produced goods to the end customer. Important factor in successful woodworking company operation is availability of skilled and qualified workers. From this point of view factories close to large cities are more privileged. But

from other point of view in cities there are higher average salaries and here woodworking companies have to offer competitive salaries to their workers which are higher than in the countryside.

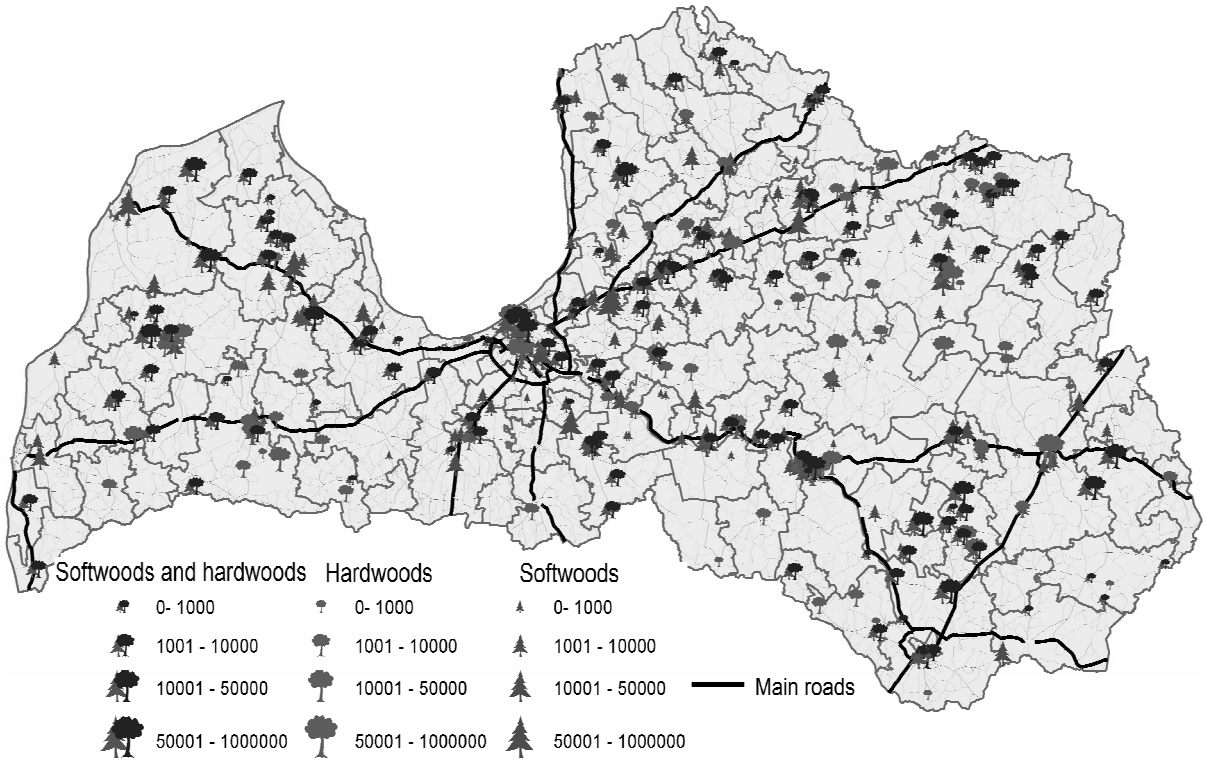

Figure 4. Geographical location of primary wood processing companies and their annual round wood processing volumes, m^3.

Out of 390 primary wood processing companies, Gulbenes, Kuldigas, Saldus, Aluksnes, Talsu and Ogres counties each having 14 to 16 companies and altogether in these six counties are located 20% from total number of primary wood processing companies. In half of Latvian counties there is one or two primary wood processing companies.

Processing volume of primary wood processing companies located in Riga in the year 2008 was 1.33 million m^3 of round wood, which makes around 20% of total annual round wood processing volumes in Latvia. It is because large companies like Latvijas Finieris, Bolderaja Ltd. and BSW Latvia are located in Riga. In Incukalna county 0.57 million m^3 of round wood are processed annually, and this amount is generated mainly by two large companies - Rettenmeier Baltic Timber and Swedwood Latvia Ltd. In Talsu county there are processed 0.56 million m^3 of round wood annually and most of this volume is made by company Vika Wood. In Smiltenes county every year are processed 0.43 million m^3 of round wood (the largest company is Stora Enso Timber), in Ventspils county – 0.33 million m^3 (mainly by company Kurekss), in Gulbenes county – 0.27 million m^3 (the largest company is Gaujas Koks) and in Aizkraukles county – 0.23 million m^3 (the largest company is AKZ) of round wood. In each county - Rezeknes, Saldus, Aluksnes, Vecumnieku and Kuldigas, 0.1 to 0.14 million m^3 of round wood are processed every year. In total from 94 Latvian counties and 7 largest cities, Riga and 11 counties with largest round wood processing volumes altogether constitute 75% from annual round wood processing volume in Latvia.

Figure 4 demonstrates that in regions with weak infrastructure (Vidzemes central highland, Eastern Latgale), despite availability of forest resources, still there is a small number of wood processing companies. Therefore, these regions have not completely used potential of primary wood processing. To clarify where and what profile (softwood or hardwood) production volumes should be increased, it is necessary to make detailed analysis in each county on available timber resources for sustainable use and compare them with existing round wood processing volumes.

Modelling timber resource demand indicator for each county in Latvia

Timber resource demand indicator allows evaluating potential demand for timber resources within certain territory and implies to counties with higher demand of resources which can mean larger value of resources in this territory. Unlike little resource demand indicator could mean that demand for resource in this county is smaller, and it could be more difficult to find customer for it. Little resource demand indicator shows that in this territory it

would be useful to develop processing of round wood. Values of timber resource demand index (Figures 5 and 6) represents share of round wood potential demand in each county. For example, if demand index in county is 35%, then it means that wood processing companies, which are located in this county, consumes only one third of counties available timber resources.

Calculations made on basis of developed timber resource demand model shows that there is high demand for softwood timber in North Kurzeme, Vidzeme and surroundings of Riga (Figure 5). It can be explained by the fact that in these regions and their surrounding counties wood processing companies with large and middle softwood processing volumes are located. In some Latgale counties with small amounts of available softwood resources, high softwood demand indicator could be observed. It is due to the fact that small or middle sized softwood processors are located there.

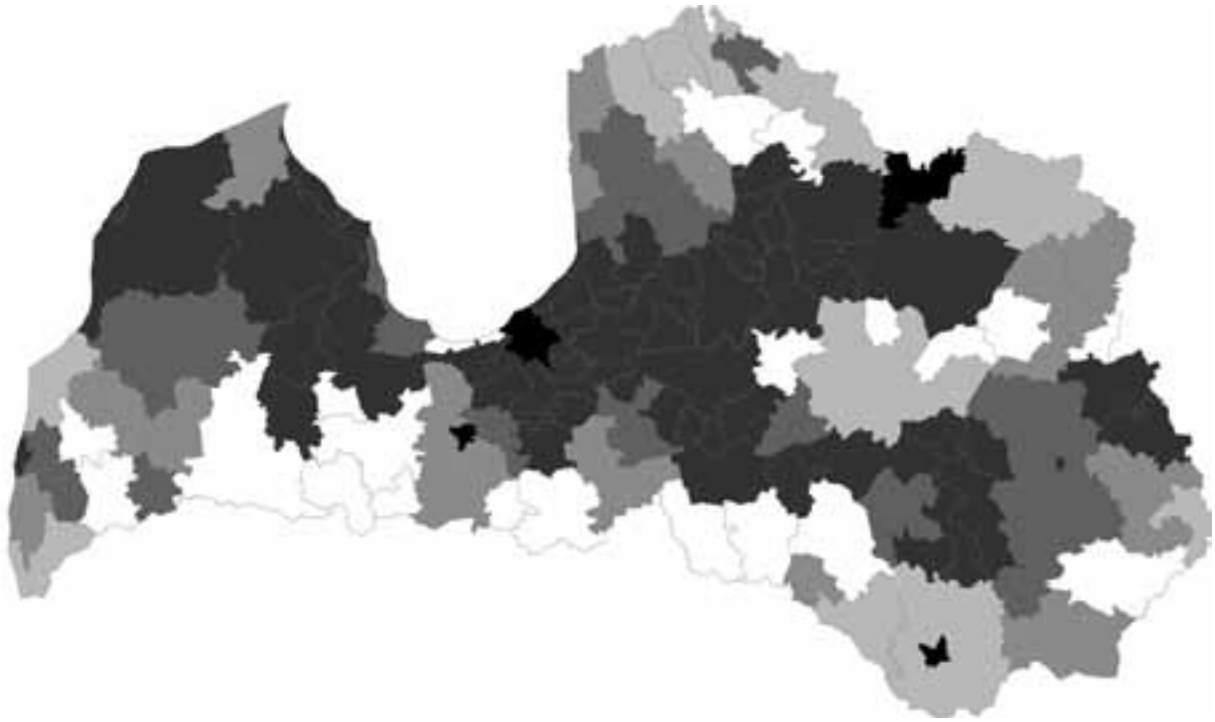

Figure 5. Softwood timber demand indicator in counties of Latvia: 0%-5%, 6%-14%, 15%-29%, 30%-51%, 62%-100%, no data.

Hardwood resources 100 and more kilometres around Riga mostly are used to satisfy large consuming volumes from primary wood processing companies Latvijas Finieris and Bolderaja Ltd (Figure 6). High hardwood timber resource demand is observed also in Smiltenes, Aluksnes, Gulbenes, Rezeknes, Preilu, Krustpils and Salas counties, where large and middle sized hardwood processors are located. Hypothetically we can assume that hardwood timber prices in these regions are a little bit higher than in other places where in average only 15% of available sustainable hardwood timber used. In counties with small softwood timber demand indicator, setting up new hardwood processing plants or increasing production power of existing companies should be promoted.

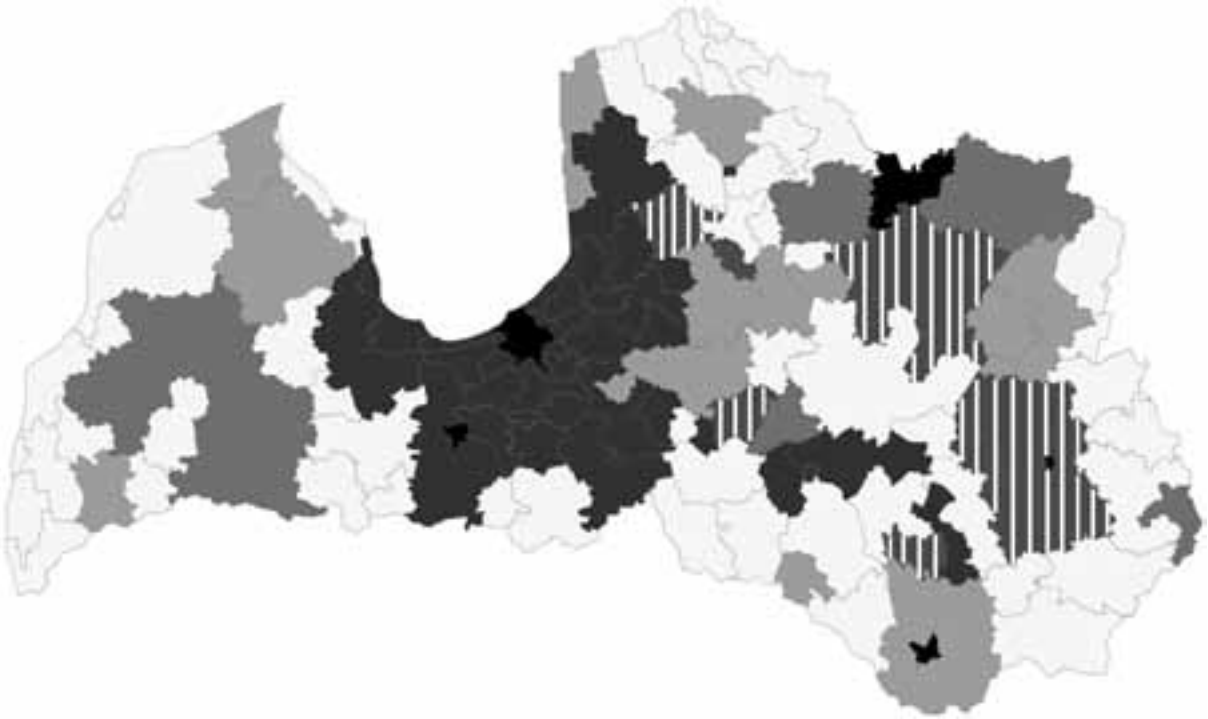

Figure 6. Hardwood timber demand indicator in counties of Latvia: 0%-5%, 6%-14%, 15%-29%, 30%-51%, 62%-100%, no data.

Model of timber resource demand indicator was implemented to give general insight in country's timber resource hypothetic demand in different regions. Currently this model could be used as an instrument for strategic planning. However, if more detailed solutions are needed, this model should be improved with indicators like price dependence from timber transportation distance, precise involvement of road network and other important indicators. In addition, for more precise timber flow and consumption analysis, export of round wood through every port in Latvia as well as firewood used for production of thermal energy should be taken into account.

Conclusions

1. Use of net present value method for timber resource forecast calculations guaranties minor shifts of timber supply for wood processing industry if compared to calculations based on timber ready for cutting method. With NPV method annual timber supply would be 11 to 16 million m^3, but with timber ready for cutting method it would be from 10 to 25 million m^3 annually.
2. Consumption of softwood timber in Latvia is close to maximum to perform sustainable forestry, but consumption of hardwoods is possible to increase at least by 30 - 35%. However, before implementation of larger cutting volumes more detailed research should be carried out .
3. Most of large and middle scaled primary wood processing companies are located close to large cities or near main roads. Thus, it makes easier round wood deliveries to factory and facilitates transportation of produced goods to an end customer.
4. Model of timber resource demand indicator gives general insight in countries timber resource hypothetic demand in different regions and discovers places where new timber processing plants could be set up or production power of existing companies could be increased.

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EVALUATION OF BENDING PROPERTIES OF THREE LAYER CELLULAR WOOD PANELS USING SIX DIFFERENT STRUCTURAL MODELS

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Abstract

Invention of light weight panel with a trade mark of Dendrolight is one of the most distinguished wood industry innovations of the last decade. At present three layers cellular wood panels have wide non structural application. The aim of the research is to evaluate the bending properties of three layer cellular wood panels for structural application. There were 8 specimens manufactured with thickness 136 or 152 mm, width 300 mm and length 2,500 mm of each of the six horizontal load bearing panel structural models. Scots pine (*Pinus sylvestris* L.) cellular wood and solid pine wood ribs were used as internal layer of the structural panels. Cellular wood core was placed in horizontal or vertical direction. Scots pine solid wood panels and birch plywood were used as top layer material. Applied glue was polivinilacetate Cascol 3353. The most common stress type in structural subflooring panels is bending; therefore, the influence of the cellular material orientation, ribs and top layer material on the sandwich type structural panel bending strength (MOR) and stiffness (MOE) were evaluated according to LVS EN 408:2011. Extra parameters like moisture content and apparent density were determined. Cellular wood in vertical direction can be used as raw material for structural panel production. Panels with solid timber external layers, with ribs and with vertical orientation of the cellular material showed the highest MOR (35.2 N mm^{-2}) and MOE (11,500 N mm^{-2}) values. The influence of the solid wood ribs on the bending properties is directly dependent on external layer material.
Key words: light weight panels; cellular wood; bending strength; bending modulus of elasticity.

Introduction

The reduction of manufacturing, transportation, assembling and exploitation costs of the structural building elements is important theme due to both ecological and economical aspects. Several researchers (Skuratov, 2010; Voth, 2009) are looking for new light weight constructions for wooden house manufacturing and cost effectiveness of sandwich materials (Pflug et al., 2003). One way how we can reduce the weight of the structural elements during manufacturing process is by modifying their structure by replacing high density material of the members with lower density material. Invention of light weight panel with trade mark of Dendrolight in Austria by inventor Johann Berger is one of the most distinguished wood industry innovations of the last decade. At present three layers cellular wood panels have wide non structural application in furniture, internal cladding, door production and transport manufacturing industry. During the manufacturing process due to the sawn longitudinal grooves solid timber becomes by 40% lighter, and it is possible to produce cellular wood material with lower density. Non structural cellular wood material initial research (Iejavs et al., 2009) and start-up of the new industrial plant in Latvia with manufacturing capacity of 65 thousand m^3 cellular wood panel material per year lead down to the necessity to use cellular wood material in building as a structural element.

The aim of the research is to evaluate the bending properties of three layer cellular wood panels for structural application. Industrially produced Scots pine (*Pinus sylvestris* L.) cellular wood material was used to produce internal layer of the structural panels. There are several structural materials (fibreboard, chipboard, strand board, plywood and solid timber panels) that can be combined with cellular material to produce structural panels. In this research only solid Scots pine timber panels and birch (*Betula pendula* L.) plywood were evaluated as external layer material. Wooden ribs were made of Scots pine solid timber and two different directions of the cellular wood material were used. In total six different structural models were designed to evaluate bending properties of panels. Bending is the most common stress type in subfloor panels (Heikila and Herajarvi, 2008); therefore, the essential importance of the research is to evaluate the influence of the cellular material orientation, solid timber ribs and top layer material on the sandwich type structural panel bending strength and stiffness properties. Stiffness and strength were tested in static bending test according to LVS EN 408:2010. Extra parameters like moisture content and apparent density were evaluated.

Materials and Methods

Manufacture of the Scots pine cellular material

As a raw material for cellular wood material production Scots pine (*Pinus sylvestris* L.) timber was used with nominal dimensions: thickness – 32 mm, width – 112 mm and length – 4,200 mm, and the total amount of 6.2 m^3. Cellular material was manufactured industrially on the automatic production line of the company Dendrolight Latvija Ltd. Schematic illustration of the cellular wood material production is given in Figure 1.

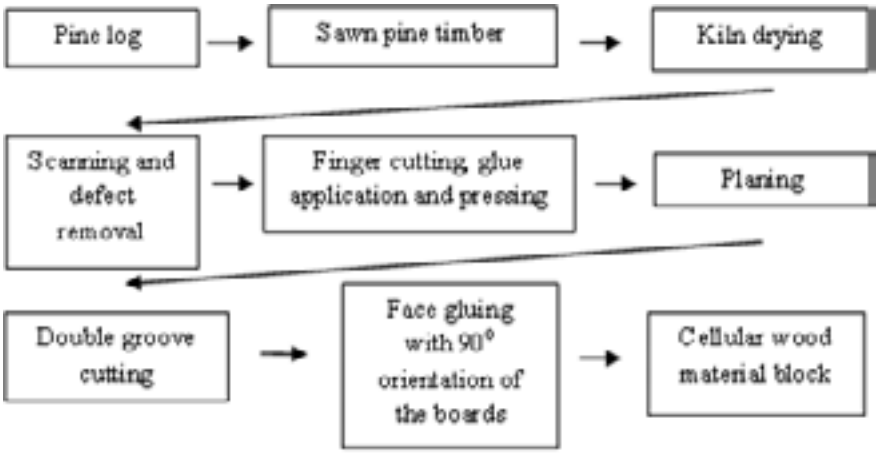

Figure 1. Schematic illustration of the cellular wood material manufacturing process.

All significant defects were removed before timber finger jointing. Technical data of the finger jointed pine wood: finger length - 10 mm, finger pitch - 4 mm, tip gap - 1 mm. Finger joint end pressure 12 N mm^{-2} was applied at least five seconds. The average moisture content of the boards was 12%. One component polivinylacetate (PVA) adhesive Cascol 3353 was used for all gluing operations in cellular wood material and panel production. According to the standard LVS EN 204:2002, the moisture resistance class of adhesive Cascol 3353 is D3. Technical information of the resin: specific gravity 1,080 kg m^{-3}; viscosity 8,000 m Pa s (Brookfield, 25 °C); spreading amount 60 - 200 g m^{-2}; open and close assembling time 5 and 8 min; press time 3 - 6 min at 60 - 75 °C; end pressure 15 N mm^{-2}; plane pressure 0.1 - 1.0 N mm^{-2}; dry matter 52% and wood moisture content 5 - 15%. After finger jointing fingers are visible on the flat face of the timber. During manufacturing process and before testing all materials were kept in constant atmosphere at 20±3 °C temperature and relative humidity of 65±5% to prevent wood material moisture changes. The thickness 28 mm and width 106 mm were obtained after four side planing operation. After the planing operation all boards were cut to 2,010 mm length. After that 8 double faced grooves were cut into longitudinal direction in the flat faces of boards with the following dimensions of the grooves: depth of 24 mm, pitch of 6.4 mm and width of 3.2 mm. Adhesive Casco 3353 were used in face gluing of grooved boards. Four layers of grooved boards were used to produce cellular wood material blocks. Each layer was aligned horizontally in 90 degree direction against the previous layer. Cellular material blocks were produced with steadily working heated press. Oscillation method was used to ensure glue spread from 200 to 300 g m^{-2} between block layers. Pressing was carried out with pressure 0.2 N mm^{-2} at 60 - 75 °C temperature and pressing time was 6 min. After pressing pine cellular wood material blocks with dimensions: thickness 112 mm, width 1,350 mm and length 2,500 mm, and total volume of 4.03 m^3 were obtained.

Manufacture of the structural panels

Twelve millimetres thick 9 layer birch plywood was used as two sided external layer material for structural models A, C and E (Figure 2). Solid pine flatwise glued planed boards with 20 mm thickness were used as two sided external layer material for structural models B, D and F. External layer material dimensions in all structural models were 300 by 2,500 mm. Two solid planed pine ribs with strength class C24 in edgewise direction were installed in structural models A and B. The dimensions of the ribs were: thickness - 20 mm, width - 112 mm and length - 2,500 mm, pith was 112 mm. After cellular wood material block cutting in certain dimensions the cellular wood material was glued in panels in two directions. Cellular wood material was installed in vertical direction in structural models E, B, E and F, and in horizontal direction (as produced) in structural model C and D. Illustration of the panels are given in Figure 2.

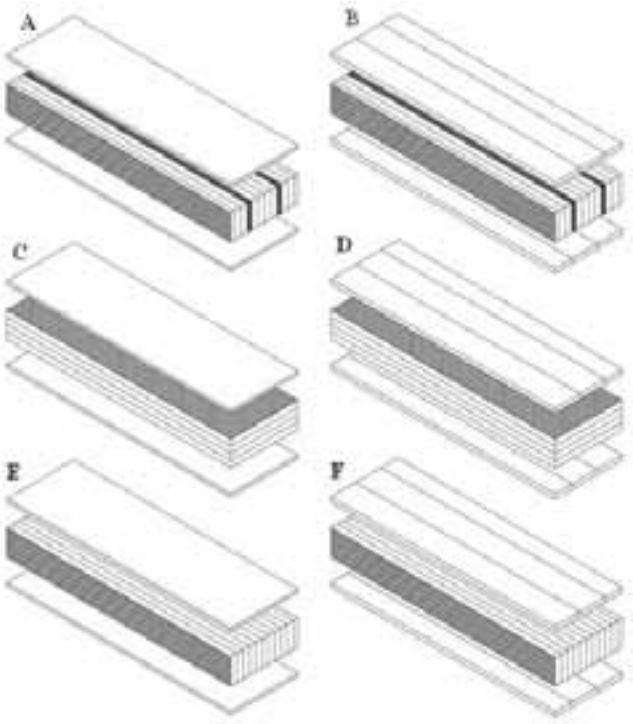

Figure 2. Illustration of the panel structural models A - F:
A - vertical direction of cellular material, with ribs and external layers of plywood;
B - vertical direction of cellular material, with ribs and external layers of solid timber;
C - horizontal direction of cellular material and external layers of plywood;
D - horizontal direction of cellular material and external layers of solid timber;
E - vertical direction of cellular material and external layers of plywood;
F - vertical direction of cellular material and external layers of solid timber.

In total six cellular wood material panels structural models (A - F) were manufactured. Eight samples for each model were used to determine and compare physical and mechanical properties. Characteristic of the panels are given in Table 1.

Table 1

Characteristic of panel structural models

Structural model	Panel dimensions			Internal layer			External layer	
	dept, mm	width, mm	length, mm	cellular material direction	thickness, mm	with wooden ribs	material	thickness, mm
A	136	300	2,500	vertical	112	yes	plywood	12
B	152	300	2,500	vertical	112	yes	pine	20
C	136	300	2,500	horizontal	112	no	plywood	12
D	152	300	2,500	horizontal	112	no	pine	20
E	136	300	2,500	vertical	112	no	plywood	12
F	152	300	2,500	vertical	112	no	pine	20

Rib gluing to cellular material and cellular material covering with external layers were carried out with adhesive Casco 3353. Adhesive in these operations were applied manually with a hand roller, and the average glue spread measured by weighing method was 200 g mm^{-2}. The cold setting hydraulic press was used in panel manufacturing with plane pressure 0.2 N mm^{-2} and pressing time of 20 min. In further panel development process non-structural adhesive Casco 3353 will be replaced by structural adhesive to provide necessary heat resistance and delamination properties.

Test methods and data processing

The apparent densities of the panels were determined after the bending tests by measuring their masses and dimensions of the full cross section specimens with

specimen length of 50 mm in the longitudinal direction of panels. Moisture content of wood and plywood has a considerable effect on its mechanical properties; therefore, the moisture content of the panels was controlled from the same density specimens and calculation was made according to standard LVS EN 13183-1:2003. Bending tests were carried out in Forest and Wood Product Research and Development Institute on the Instron 600 kN material testing device. The panels were tested in bending flatwise according to the standard LVS EN 408:2011. Bending modulus of elasticity (MOE) and bending strength (MOR) were determined in a static bending test. The distance between the span in bending test was reduced to 16 depths of the panel because of limited length of specimens. All panels were stressed until rupture. All specimens before testing were conditioned in the standard atmosphere to the constant mass according to the standard LVS EN 408:2011. Only the mean values of the panel's moisture content and apparent density were evaluated. According to initial compression and shear tests of the cellular material when significant amount of samples were tested distribution of mechanical properties comply with normal distribution function. Therefore, in order to compare the mean values of the different structural model MOE and MOR, independent sample t-tests were used with 95% confidence level.

Results and Discussion

The average apparent densities of panels varied from 363 kg m^{-3} to 404 kg m^{-3}, the highest values being in structural models A (404 kg m^{-3}) and B (400 kg m^{-3}). The lowest apparent densities were observed in model D (363 kg m^{-3}). For structural models E and F average apparent density was equal to 389 kg m^{-3}. Average apparent density 382 kg m^{-3} was achieved with structural mode C. The average panel moisture content varied from 12.2% to 12.5% after conditioning and the difference was not significant. The initial research shows that different structural models have a great effect on the cellular wood material panel MOR. The structural models influence on the cellular wood material panels MOR is given in Figure 3. Figure 3 presents mean values and 95% confidence interval of the MOR mean.

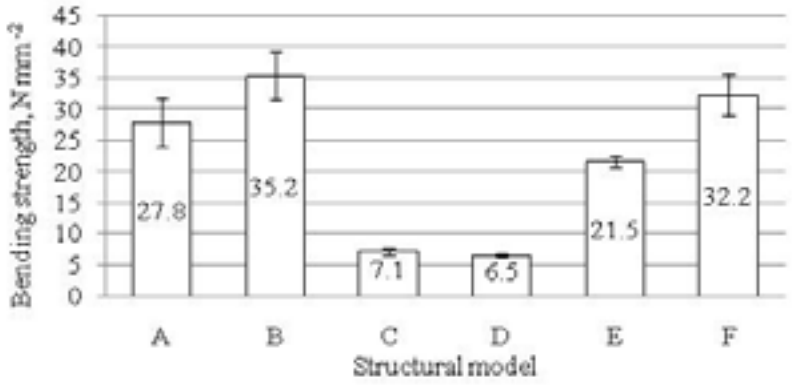

Figure 3. The influence of cellular wood material panel structural model on the panel bending strength – MOR (mean values and 95% confidence interval for mean):
A - vertical direction of cellular material, with ribs and external layers of plywood;
B - vertical direction of cellular material, with ribs and external layers of solid timber;
C - horizontal direction of cellular material and external layers of plywood;
D - horizontal direction of cellular material and external layers of solid timber;
E - vertical direction of cellular material and external layers of plywood;
F - vertical direction of cellular material and external layers of solid timber.

The highest MOR was achieved with structural model B (vertical direction of cellular material, with ribs and external layers of 20 mm solid timber) with 35.2 N mm^{-2} bending strength. The influence of the external layer material on the panels MOR were observed when structural model B indicated significantly higher MOR values than the structural model A (vertical direction of cellular material, with ribs and external layers of 12 mm birch plywood). Structural models C (horizontal direction of cellular material and external layers of plywood) and D (horizontal direction of cellular material and external layers of 20 mm solid timber) with horizontally installed cellular wood material show several times lower MOR values compared with structural models A, B, E (external layers of 12 mm plywood) and F (external layers of 20 mm solid timber) with vertically installed cellular wood material. The wooden ribs did not influence MOR in case of structural models B and F with 20 mm solid pine external layer because mean bending strength did not differ significantly ($p=0.173$). In case of structural models A and E when as external material was used 12 mm plywood structural model A with ribs has significantly higher bending strength compared with structural model E without ribs.

The initial research shows that different structural

models also have a significant effect on the cellular wood material panel MOE. The influence of the structural model on the cellular wood material panel's modulus of elasticity is given in figure 4. Figure 4 presents mean values and 95% confidence interval of the MOE mean.

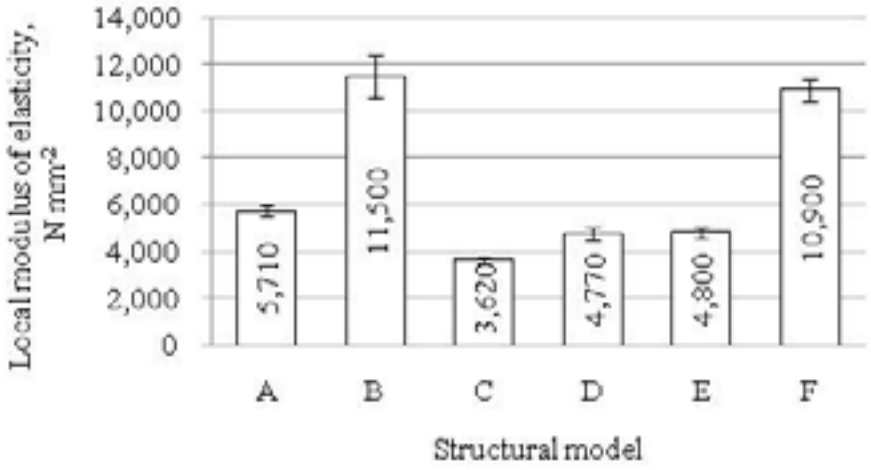

Figure 4. The influence of cellular wood material panel structural model on the panel bending modulus of elasticity - MOE (mean values and 95% confidence interval for mean):
A - vertical direction of cellular material, with ribs and external layers of plywood;
B - vertical direction of cellular material, with ribs and external layers of solid timber;
C - horizontal direction of cellular material and external layers of plywood;
D - horizontal direction of cellular material and external layers of solid timber;
E - vertical direction of cellular material and external layers of plywood;
F - vertical direction of cellular material and external layers of solid timber.

The MOE values significantly vary between the models. The highest average MOE value 11,500 N mm^{-2}, but also the highest standard deviations were observed in panel with solid pine external layer and solid wood ribs look at structural model B (Figure 4). Like with MOR the wooden ribs did not influence MOE in case of structural models B and F with 20 mm solid pine external layer because mean modulus of elasticity did not differ significantly (p=0.201). Mean MOE of structural models B and F are comparable with structural timber bending modulus of elasticity. Structural models B and F with vertically installed cellular wood material and external layer of solid timber show two times higher MOE values compared with structural models A, C, D and E. Structural models C and D with horizontally installed cellular material show the lowest MOE values. In case of structural models A and E when as external material was used 12 mm plywood structural model A with ribs have significantly higher MOE compared with structural model E without ribs. Generally, we can say that cellular wood material in vertical direction can be used as raw material for structural panel production from point of bending strength and bending modulus of elasticity. The influence of the solid wood ribs on the bending strength and bending modulus of elasticity of panels are dependent directly of external layer material properties. Solid 20 mm thick pine wood as panel external layer material provided significantly higher MOR and MOE if compared with 12 mm thick birch plywood external layer when cellular wood material was installed in vertical direction. The cellular material installation directions significantly influence the character of the panel failure. For structural models A, B, E and F failure mostly occurred in the middle of the panel under top supports, but in structural models C and F failure occurred in the ends of the panels in core cellular material layer. The panel failure mostly occurred in cellular material or external layer; therefore, the influence of non-structural adhesive on the panel MOR and MOE were not observed.

Conclusions

The results of this preliminary study showed that the structural model has a significant effect on the bending properties of panels with cellular wood material core. Panels with 20 mm thick solid timber external layers with vertical orientation of the cellular material showed the highest MOR (35.2 N mm^{-2}) and MOE (11,500 N mm^{-2}) values. The significant influences of the solid ribs on MOE and MOR in structural models with solid timber external layers were not observed because mean modulus of elasticity and mean bending strength did not differ significantly. The model F with solid timber external layer, without ribs and vertical direction of the cellular material will be used for further development of structural panels. The results indicate that further development is required related to other structural properties of panels. In future, innovative products and production strategies might be developed based on the promising cellular wood material.

Acknowledgements

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RESEARCH ON FORMATION OF COMPOSED WOOD BASED BIOFUEL

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Abstract

Due to currently aggravating problems of global warming, more and more alternatives are being developed using a mixture of different fuels. The rapid development of science and engineering solutions can be the most efficient burning of the local biofuels to a minimum harmful substances from combustion process - including the CO_2 emitted into the atmosphere.

The research concerns fuel problem of choice between cost-effective, but environmentally harmful fuels. Research data will help further studies on the fuel in order to increase energy efficiency and rational use.

The research was done in 2010, in Riga Technical University laboratories. An aspen wood and hard coal was used to create this fuel mixture. During the research, sampling, grinding, sifting and blending of different proportions, moisture and calorific value determination were carried out. It was determined that the calorific value of the mixture would increase linearly, exactly in the proportion of coal quantities added.

Key words: calorific value, chopped wood, hard coal.

Introduction

Wood, like the majority of plant material, in contrast to minerals, is not monolithic - a homogeneous substance. These are individual cell structures composed of various elements (Zaķis and Neiberte, 2003). Currently, throughout the European Union reduction of dependence on fossil fuels is being sought, and renewable energy is becoming an important policy. In addition, Latvia acceded to the Kyoto Protocol, which aims to reduce harmful emissions, including gas, having a greenhouse effect in 2005. Energy crops for energy purposes is one of its components since in the process of wood burning, released carbon dioxide does not affect the environment because during the process of photosynthesis oxygen is released, that binds the same CO_2, emitting combustion (Plāte et al., 2006). Entrepreneurs have begun to invest considerable financial resources in economic activity and in the field of energy supply. But it is often done under conditions of insufficient information, and a lot of time and money resources are spent inefficiently (Vides projekti, 2007). Due to currently aggravating problems of global warming, more and more alternatives are being developed using a mixture of different fuels. In literature there are no exact data on the soft hardwood thermal compound. The rapid development of science and engineering solutions can make the most of local burn biofuels, resulting in a maximum heat output. This heat output can be increased through a variety of biofuel blends, thus maximizing the use of natural resources, minimizing the harmful substances from combustion process - including the CO_2 emitted into the atmosphere. We will be able to compare and summarize the obtained results. Research data will help us to select an effective mix of biofuels, as well as help to carry out further research on fuels to increase energy efficiency and rational use. The aim of research is to create the fuel mixture whose calorific value would be higher than mixture`s base timber, but the amount of emissions would be less than pure coal harmful emissions.

Materials and Methods

The research was done in 2010, in Riga Technical University laboratories. An aspen wood and hard coal were used to create fuel mixture. During the research, sampling, grinding, sifting and blending of different proportions, moisture and calorific value determination were carried out. The study selected a sample heat capacity determination made in accordance with LVS standard LVS CEN / TS 14918:2005 'Solid Biofuels - Method for the determination of calorific value' (LVS Standard, 2005). This standard sets down the maximum amount of solid biofuel heating method for bomb calorimeter, which is calibrated with benzoic acid. The experimental results underline the sample examined calorific value. Net calorific value and net calorific value at given humidity are calculated at the standard formula set out.

During the experiment, different equipment and reagents were used

Ignition wire may be of chromium-nickel alloy with a diameter of 0.16-0.2 mm, platinum, 0.05 to 0.10 mm in diameter, or other material conductive wire with well-defined thermal properties of the combustion process.

Pure oxygen (99.5%) free of contaminants, which does not contain flammable substances at a pressure that is adequate to fill the ball with a 2MP lot of pressure from the burner

Cotton wick consisting of cotton fibres, or similar.

Burning equipment with a determined calorific value, composition and purity, for example: benzoic acid, paraffin oil, if necessary, the burning bags or capsules.

Benzoic acid the quality of which is up to calorimetric standards, and it is certified by the relevant authority.

Crucible must be of chromium-nickel alloy, platinum, or similar material that will not engage in chemical reactions. It should be about 20 mm deep and with diameter of 15 - 20 mm. Metal cup preferred thickness is 0.5 mm.

Scales for weighing the sample to measure with an

accuracy of at least 0.1 mg, the weighing less than 0.5 g, the recommended weight accuracy of 0.01 mg.

Calorimeter bomb designed to withstand the gas pressure, which occurs during sample combustion. The construction of the bombs in order to be completely empty of liquids or partially burnt particles of the sample. Producing material has to be designed to withstand the acids that might be produced by burning biofuels in the samples. According to the standard (LVS Standard, 2005), the test pieces have to be crushed and screened through a 1.0 mm sieve. This is necessary to promote more complete combustion of the sample and increase the reproducibility of results as much as possible.

First, coal samples were mechanically crushed and ground in a grinding mill. Similarly to wood, coal was passed through the sieve mesh. By the ground wood and coal, necessary proportion model mixtures were established:

Aspen (*Populus tremula L.*) 95% - Coal 5%
Aspen (*Populus tremula L.*) 90% - Coal 10%
Aspen (*Populus tremula L.*) 85% - Coal 15%
Aspen (*Populus tremula L.*) 80% - Coal 20%
Aspen (*Populus tremula L.*) 75% - Coal 25%
Aspen (*Populus tremula L.*) 65% - Coal 35%
Aspen (*Populus tremula L.*) 55% - Coal 45%

Mixtures were prepared in a porcelain vessel weighed sample of the required quantity and mix well. The required amount of crushed coal was added to the sample timber and two components of the mixture were immediately mixed thoroughly with a metal spoon and weighed. The established mixture was placed in tightly -sealable plastic bag until further measurements. Each compound was prepared in the amount of about 10 g. mixture. This quantity is sufficient for moisture and calorific value determination, even if it is necessary to carry out another experiment measurements. Until the beginning of the experiment all the mixture samples were stored in air-tight plastic bags tightly sealed so that ambient humidity would not affect the model and thus the experimental results.

The sample moisture determination is made according to the standard LVS CEN/TS 1477-3:2004 'Solid biofuels, Moisture content determination method Oven dry method, Part 3. part analysis sample moisture' (LVS Standard, 2004) This standard defines the method of the moisture test sample by drying it in an oven. Since the split wood is highly hygroscopic and moisture content can easily vary the atmospheric humidity, the sample is weighed, and moisture analysis must be carried out in parallel with other tests, for example, calorific value determination.

After determination of moisture sample examined by the masses (1 ± 0.1) g compacts dense, a hard tablet and place it calorimeter bomb. The whole bomb, pressurized with excess pure oxygen at 30 Pa and containing a determined mass of sample and a small fixed amount of water (to absorb produced acid gases), is submerged under a set volume of water (before the charge is ignited). The energy released by the combustion raises the temperature of the steel bomb, its contents, and the surrounding water jacket. The temperature change in the water is then accurately measured. This temperature rise, along with a bomb factor is used to calculate the energy given out by the sample burn. A small correction is made on account to the electrical energy input, the burning fuse, and acid production (by titration of the residual liquid). After the temperature rise has been measured, the excess pressure in the bomb is released.

According to the standard, each test of sample mixtures is carried out twice on condition that difference between these test results should be insignificant. The average value was determined for each sample of model mixtures.

In that way results were calculated to all proportion samples.

Results and Discussion

The highest determined calorific value of the mixtures is noted in Fig. 1 where the calorific value determined by calorimeter bomb was recorded. Looking at the estimated mixture calorific schedule it can be seen that even at low concentrations of coal, thermal joint compound will significantly increase. For example, even 10% of coal mixed with the mixture, increases calorific value from 18.2 MJ kg^{-1} (pure wood) to 19.4 MJ kg^{-1}, and at 20% concentration of the mixture it reaches 20.38 MJ kg^{-1}. As it is seen from the graph, the trend is almost linear, and each of 10% of coal admixture increases calorific value for 1 MJ kg^{-1}. Wood is not a homogeneous material and the calorific value of different parts of the trunk is different. The coal structure is not homogeneous either, so the heating schedule is not completely linear. However, taking this as a basis, it is possible to calculate the required presence of coal in mixture to achieve the required calorific value. This coherence could be used, for example, in energetic.

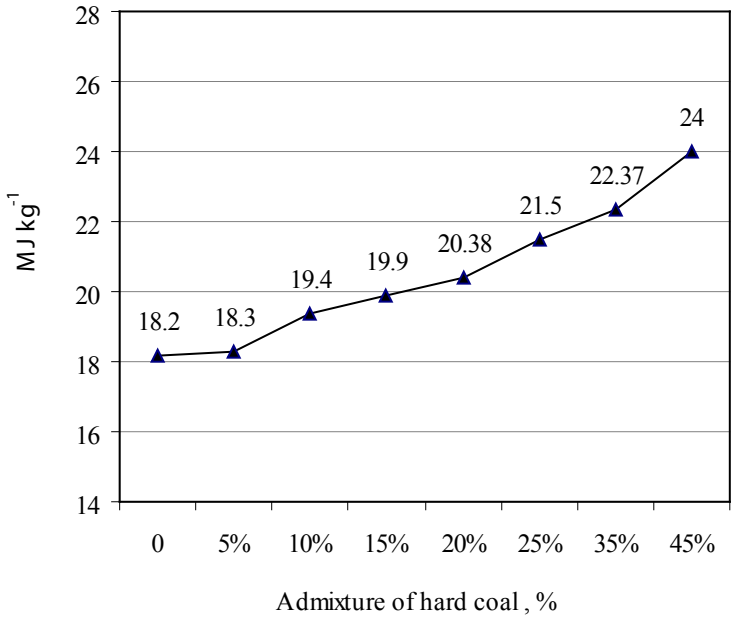

Figure 1. Determined calorific value of the mixtures.

Conclusions

In this research, aspen wood and coal thermal compound different concentrations are defined and calculated.

It was proved and there is strong evidence that calorific value of the mixture increases if compared to pure aspen wood.

It was determined that the calorific value of the mixture increases linearly, exactly in the proportion of coal quantities added. This makes it possible to calculate the required admixture of coal in the mixture to achieve necessary heating value. It can be used for energy and production of wood pellet. By adding a small portion of coal dust to manufacturing waste of softwood, pellets with greater calorific value than pure softwood pellets can be produced.

Recommendations and Proposals

Woodworking companies should set up a pellet plant and start producing pellets from wood waste mixed with coal for their own consumption.

One should establish a powerful pellet boiler plant for energy supply.

The optimal granular mixture ratio, considering coal CO_2 and SO_2 emissions should be determined.

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THE COMPARATIVE ANALYSIS OF STRATEGIES OF LOCAL WORK GROUPS

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Abstract

The theoretical part of the paper presents an overview of trends in the solution of economic and social problems in rural areas and rural development. It also makes an inventory of modern theories on European rural development and analyses aspects of strategic management of the activities of regional and rural communities.

The documentary part of the paper analyses the EU and Lithuanian regional and rural development policy, the developments in the implementation of the EU *LEADER* programme in Lithuania in 2003 – 2010 and opportunities for its improvement, the establishment of local action groups (LAGs) and their key activities.

The empirical part of the paper examines the activities of LAGs in Ukmerge and Radviliskis regions and offers a comparative analysis of the content of five strategies produced by the two LAGs for the period between 2003 and 2013. The research has demonstrated that the five rural development strategies of both LAGs are based on the principles of collaboration among the representatives of local authorities, businesses and rural communities, continuity and consultations with local population.

The discussion part focuses on the guidelines for the improvement of the strategic management of rural development. The conclusions present an overview of the typical features, priorities, aims and objectives of the strategies of both LAGs.

Key words: rural development, strategic management, local action group (LAG), regional policy.

Introduction

The importance of the research

In the end of the 20th century rural places of the European Union (EU) countries experienced similar difficulties as the current Lithuania – great disjuncture between city and countryside, ageing of rural places' residents and the decline of the rural places. In 1991 the European Commission announced *LEADER* initiative, which was aimed at the involvement of all interested in rural place's welfare partners (business and local government representatives) into the rural development process.

In 2004 when Lithuania became the EU member, possibilities to use the EU structural funds' support for countryside development opened and together with other members of the EU to seek for one of the most important EU aims – economic and social cohesion. *LEADER+* nature means methodology is meant for preparation and implementation of countryside development strategies. In Lithuania, in order to implement this means, from 2001 – 2009 51 local activity groups were formed (henceforth – LAGs). Most LAGs encompass particular districts' territories of municipalities rural places and towns and join most particular districts' rural places' communities.

The area of activities "Acquisition of Skills" of *LEADER+* type measure is aimed at providing support for the study of rural areas, preparing and developing pilot strategies and improving rural population skills. Between 2004 and 2006, 27 pilot integrated strategies were produced in Lithuania. Funds were allocated for the implementation of 10 strategies. The total of 320 local projects received financial support.

Lithuanian researchers (Atkociuniene and Bartkute, 2004; Tamosiunas and Liubomirskiene, 2009; Tamosiunas and Siaulianskiene, 2010) have examined the activities of LAGs exclusively in the context of the implementation of *LEADER+* programme in Lithuania. The activities of LAGs have been analysed from the aspects of the activating of the rural communities and assimilating EU funds. Little attention has been paid to the examining of the importance of the activities of LAGs in the context of rural development and management.

The **novelty** of the present paper is the analysis of the elements of strategic management of rural development in concrete areas, when strategic management of the development processes is used for purposeful coordination and realisation of different attitudes and needs. The article analyses the development strategies of the two concrete areas; it foresees prospects of the activities of the two LAGs and presents their analysis.

The research subject is the activities of two LAGs in preparing and implementing development strategies.

The research purpose is to analyse five strategies of two LAGs and to substantiate promising directions for the activities of LAGs.

The research methodology. The following research methods were used to investigate the problem: the analysis of research literature, generalisation, systemisation, document analysis, the analysis and synthesis of initial and secondary information sources; also contrasting, systemisation, logical and graphic modelling. A qualitative research into the content of strategies, visions, priorities, aims and actions has been performed.

Theoretical aspects of the research

Regional development. Research papers give different definitions of a region. Tamosiunas (2004) views the region as an independent territorial and administrative unit. The

region is a territorial entity, in which policy, corresponding to the needs, is carried out with the view on the achieving wellbeing of the whole structure.

The idea of a region as a unit of political and administrative management is now new. Most European states are not unitary. European regional institutions haven't escaped variety, determined by their different origins and roles. Most European states view regional authorities as an important element of the system of management. The expansion of the EU only highlighted this variety (Marcou, 2000).

Julien and Lachance (2001) singled out three regional development stimuli: natural advantages, investment attractiveness, the flow of foreign investment. Natural advantages increase the investment attractiveness of the region and generate profits. The two advantages stimulate the third one – a huge flow of investment.

Strategic management of regional development. Various researchers (Christensen et al., 1973; Mintzberg, 1991; Lynch, 1997) in their works give very different definitions of a strategy. One of the most precise and simple definitions was proposed by Hofer and Schendel (1978): a strategy is a plan of measures, agreed with the budget and necessary for the implementation of the mission and strategic aims of an institution. Lorange (2005) analysed its possible meanings in a new way. Mintzberg (1991) analysed the processes of strategic management in great detail, while Bryson (1988) emphasised strategic planning in the sector of public administration.

Sustainable development is sparing and balanced development. The main provisions of sustainable development are legalised as a long-term society development ideology, while three equal components are set on its basis: environmental protection, economic and social development. Tamosiunas (2009) has described sustainable regional development by means of the system of the three components.

Two methods predominate in regional development planning: correspondence and conversion. By using the method of correspondence, the aims and objectives of a strategy are formulated by focussing on the strengths and opportunities of the region in order to make use of them. The method of conversion aims at decreasing the weaknesses of the region and avoiding threats.

Rural development. A lot of attention has been paid to the analysis of the processes of rural development by Ploeg et al. (2002). They provided detailed analysis of the situation in the rural areas in Western Europe and other countries of economic wellbeing. Terziev (2005) has analysed institutional structures of rural areas and their development tendencies. Malecki and Oinas (1999) have emphasised the importance of new technological processes, innovative methods, and technological literacy of the rural population to the regional economy and especially rural development, technological changes in production and services. Garvin (1993) has focused on the importance of the implementation of the concept of a learning organisation in rural areas to the development of intellectual potential of rural communities. Kanter et al. (1992) have dwelled upon education of the population of problem regions, remote and rural areas; he emphasised the importance of their ability to change and improve for the company indicators and education of leadership.

In Europe, two groups of theories on rural development predominate: multifunctional agricultural development theories and new institutional economy theories (see Table 1).

Table 1

Modern Theories on Rural Development in Europe

Theories	Key features of the theories
Multifunctional agricultural development theories (Belgium, the Netherlands and other West European countries) represented by Ploeg et al. (2002).	Infrastructural, interrelated positive qualitative and quantitative changes on the level of the economy stimulate the development of rural areas. Traditional economy can be transformed in **quantitative** terms by diversifying economic activities, unrelated with the production of goods – rural tourism, production of alternative energy, etc.; by protecting natural resources or by managing the countryside; by receiving income from activities. Traditional economy can be also transformed in **qualitative** terms: a change in the chain of offered agricultural and food products by developing ecological or biodynamic economy and producing quality goods, including those recycled inside the economy; by stimulating greater direct sale of products with surplus value to the customer to ensure greater income to the farmer.
New institutional economy theories on rural development (Central and East European countries – Bulgaria, Hungary, Czech, Slovak Republics, Rumania, etc.), represented by Terziev (2005), Delgado et al. (2003).	A rural area is a system in the wide sense of the word from geographical and territorial point-of-view. The theories single out the following six special functions oriented towards the processes of rural development: 1. Agricultural: private areas, strengthening the farmer's identity. 2. Environmental: preservation and adjustment of the forms of landscape and old settlements. 3. Cohesion: communication, citizenship, community spirit and social capital. 4. Recreational: preservation of public spaces for all. 5. Residential: accessibility of public and private services. 6. Cultural: improvement of rural environment from the cultural aspect. The links among these functions provide liveliness to the rural area; they unite individual and community attitudes to the rural development.

In Lithuania, rural development dimensions are defined by an integrated rural development conception, uniting the ideas of agricultural multifunctionalism and traditional economy transformation as well as the development of rural areas. An integrated approach to rural development is based on the following statements and principles: the foreseen activities are geared towards society, economy and environment; the development should be organised both "from top to bottom" and "from bottom to top" at all levels; the development should involve all sectors – public, private and non-governmental, while economic activities and development should be based on partnership and collaboration among areas, activities and sectors.

Atkociuniene and Bartkute (2004) argue that integrated rural development depends on 4 factors: economics, ideas and institutions, environment and people (see Fig.1):

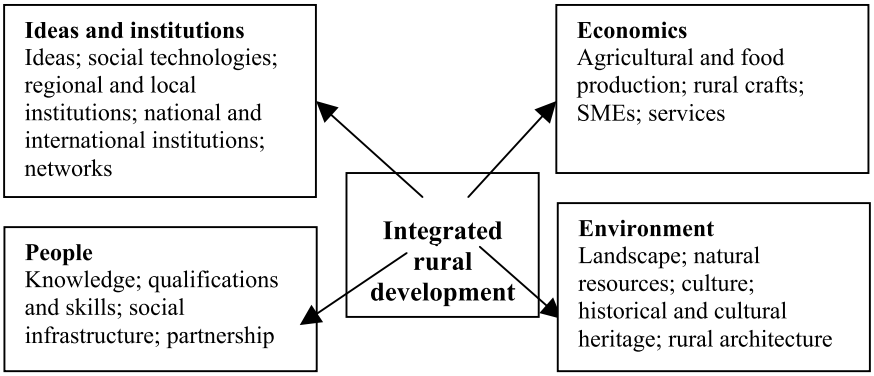

Figure 1. The structure of the concept of "Integrated Rural Development".

Compiled by the author of the paper on the basis of the following source: (Atkociuniene and Bartkute, 2004).

In 2004, in Lithuania *an integrated rural development conception* was formulated. It combined the ideas of agricultural multifunctionalism, traditional economy transformation and development of rural areas. The essence of this conception could be summarised as follows: a fair distribution of natural resources among generations; an opportunity to use all the main natural, social and economic services for all without causing threats to the viability of ecological and social systems. This concept requires integrating the opinions of people and different business philosophies, which would aim at improving the environment (Atkociuniene and Bartkute, 2004).

The strategic management of rural development. In the public life of Western European countries, the principle of partnership was implemented at the end of the 20th century, when a reform in public administration took place. The aim of the reform was aimed at an interaction between the state and the civic society. This gave a rise to a "new management", which used the modern management models and "self-regulating" social systems. The new model was characterised by a wider orientation to the market and de-centralised public administration; the hierarchical model of management has been complemented by democratic horizontal relationships.

In Lithuania, a similar rural development process has been going on since 2003. Rural development in Lithuania is characterised by the following: the managing body is an organisation compiled on the principle of territorial partnership, which is a local action group (LAG); particular attention is paid to the involvement of the local population (rural communities) and their participation in the preparation of the development strategy; rural development is carried out via the integrated development strategies, prepared by LAGs.

LAGs, having been functioning in Lithuania since 2003, have designed and implemented pilot integrated local development strategies for the years 2004 – 2006. The new informal formations of local authority (LAGs) accepted great challenges and directed their human resources to the application of the strategic management system. LAGs have analysed local situations, assessed them, set forth priority spheres, established indicators to measure the implementation success, calculated the beneficiaries and administered the implementation of the strategies. In 2006 – 2007, Lithuanian LAGs formulated rural development strategies for the years 2007 – 2013. During the period between 2003 and 2007, the number of LAGs has grown considerably, some LAGs managed to produce up to three rural development strategies during the mentioned period.

The European Union and Lithuanian regional and rural development policy

EU and Lithuanian regional policy. At present, EU consists of 27 very different states. That is why in order to achieve economic aims, a more compatible structure – regions – has been chosen. Regional policy is not only a priority area of the EU, it is also the main means of stimulating economic development and high living standards. The EU regional policy requirements for the member states are strict and clearly defined. One of them is to have regions and regional policy even in small states. Regional policy in the EU context is understood as the development of social, economic, environmental, technological, cultural and recreational aspects. Regional problems became another area where joint EU solutions are more efficient than efforts of separate states.

The EU sees Lithuania as a solid region and doesn't assess differences between Lithuanian regions inside the state. That is why centralisation inside the country increases. All decisions concerning the priorities of distributing EU funds, distribution methodology and evaluation of the produced projects are made by the national government. EU funds strengthen the central government in Lithuania. A disproportionally large part of the EU support is allocated to Vilnius. EU funds, meant to decrease developmental differences within the EU, in Lithuania have increased regional differences. While distributing funds, it is necessary to foresee greater proportions for the regions to ensure an even economic and social development of the whole country.

The EU and Lithuanian rural development policy. The Lithuanian rural development programme for years 2007–2013 foresees ensuring growth by increasing the competitiveness of agricultural, food economies and forestry, by providing opportunities for diversifying economic activities and improving the quality of life in rural areas, at the same time fostering the existing natural, human and other resources, by decreasing differences between rural and urban areas as well as those among separate regions. In Lithuania, the newest EU experiences in rural development are being analysed: multifunctional agriculture (Belgium, the Netherlands), village multifunctionalism (Spain), and new institutional economics (Hungary, Slovak Republic, Rumania).

To implement the multifunctionality of rural development, the LEADER programme, started in the EU in 1991, is of paramount importance. It supports implementation of integrated rural development strategies. With Lithuania joining the EU, *LEADER*+ type measure started to be implemented. Its aim is to master LEADER methodology in implementing rural development strategies. To implement the measure, LAGs were founded, and rural communities started appearing. Other aims of the programme are to activate people in rural areas, to promote innovations, to strengthen competitiveness and decrease the gap between rural and urban areas.

Activities of local action groups in Lithuania. Between 2001 and 2004, 3 LAGs were registered in Lithuania; in 2006 another 35 LAGs appeared; in 2008 47 LAGs were functioning in the country, covering almost all rural areas in Lithuania. Five LAGs included more than one municipality; however, since 2007, LAGs have mostly been formed on the municipal basis. European Commission encourages LAGs to include more than one administrative unit. In 2009, 51 LAGs were active in Lithuania.

At the end of 2007, 23 active LAGs joined into a network. In 2010, the network covered all 51 LAGs. The following working groups were founded in LAGs network: legal, public relations, collaboration and strategy implementation. LAGs network is entitled to receive support for its international projects according to the rural development programme in Lithuania for years 2007–2013 Objective 3 measure "*Diversification of the Quality of Life in Rural Areas and Rural Economics"*.

The analysis of the local development strategies of Ukmerge and Radviliskis region LAGs

Research methodology. Three local development strategies prepared by Ukmerge LAG were chosen: A Strategy for Decreasing Poverty and Social Seclusion in Rural Areas for Years 2003-2004; Ukmerge Region LAG Pilot Integrated Rural Development Strategy for Years 2004-2006; Ukmerge Region Local Development Strategy for Years 2007-2013.

The research has also analysed two rural development strategies, prepared by Radviliskis region LAG: Radviliskis Region Pilot Integrated Rural Development Strategy of the LAG for Years 2004–2006; Radviliskis Region Rural Development Strategy "Improvement of the Quality of Life in Radviliskis Region Rural Areas".

All five strategies were analysed from a few aspects. First of all, the methodological quality of their content was identified: the volume of the strategy, the structure, preparation process, analysis of the situation and the research of the population needs, analysis of the outcomes of implementation were examined. The links between LAGs and rural communities were described, strategic directions of rural development in the region were investigated. The qualitative research focused on the analysis of the content of strategies, priorities and activities. Figure 2 presents a logical structure of the qualitative research, involving the stages of the strategy:

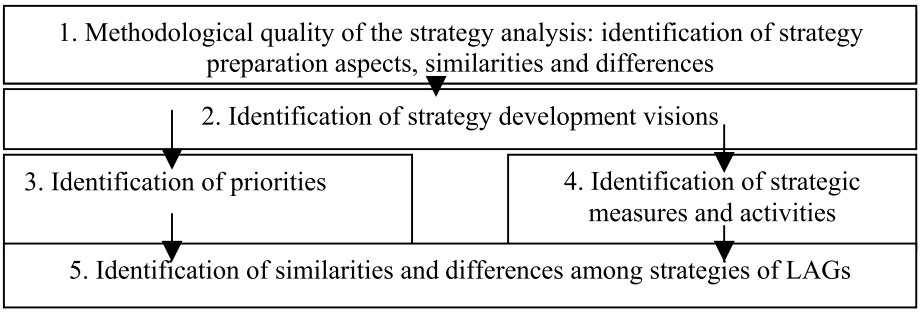

Figure 2. Logical structure of the qualitative research.

Essentially analogous subjects participating in the strategy preparation processes were identified in both LAGs: LAGs administration, consultants, rural community leaders, representatives of the administration of elderships. The objective factors having an essential influence on the identification of strategies of both LAGs are as follows (see Fig. 3):

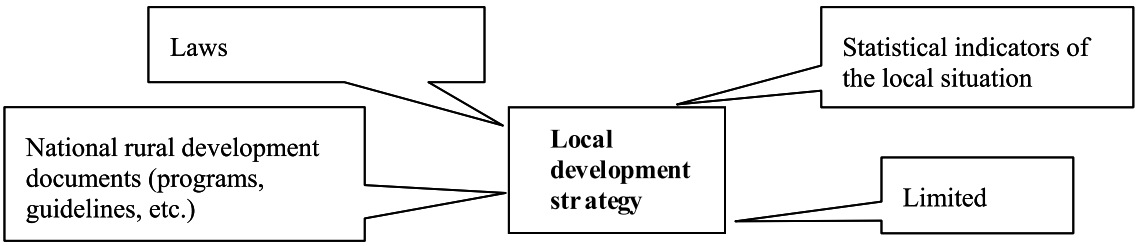

Figure 3. Factors having an essential influence on the process of preparation of local development strategies.

The main outcomes of the research. Table 2 gives an overview of the preparation stages of three strategies of Ukmerge region:

Table 2

Strategy Preparation Stages

Stages	2003-2004 strategy	2004-2006 strategy	2007-2013 strategy
I	Analysis of the situation and the needs	Analysis of the situation and the needs	Preparation of a plan of action for LAGs
II	Vision, mission	Establishing values and rules	Analysis of the situation and the needs
III	Strategic priorities	SWOT	Values and rules
IV	Measures	Vision	SWOT
V	Actions	Establishing strategic directions	Vision
VI	Consulting services	Establishing priorities	Strategic directions
VII	Implementation	Mission identification	Establishing priorities
VIII	Community projects	Aims, measures and activities	Mission identification
IX		Strategy implementation plan	Aims, measures and activities
X			Strategy implementation plan

Strategy 1 is more similar to an action plan, because its strategic period covers only one year. It has 3 strategic aims and 3 priorities, activities to implement them. Strategy implementation, finance, management and control procedures are foreseen. The strategy is implemented via community projects and 2 target programmes.

Strategy 2 is wider in scope, consisting of 8 parts. Much bigger funds are foreseen for its implementation (508,804 Lt, the first strategy was allocated only 160,000 Lt). The strategy has a more complicated administration and control mechanism. An exhaustive actual analysis of the local situation is carried out, strategic development directions are identified more precisely, 5 aims are set and 41 community projects are foreseen to be financed and implemented to achieve those aims; target programmes are declined. The strategy is prepared in a detailed and consistent way, however, its volume is too big both visually (125 pages with annexes), and from the point-of-view of strategic viability (5 aims and 41 projects in 2 years).

Strategy 3 both in its volume (156 pages with annexes), funds (7,730.000 Lt) and strategic period (6 years) is the largest among LAGs strategies prepared so far in Ukmerge region. This strategy has been produced as a continuation strategy on the basis of the previous. It consists of 8 parts and identifies one common strategic aim.

The qualitative analysis of the content of the three LAGs strategies of Ukmerge region allowed identifying the following similarities: the constituent parts of the strategies are essentially the same, with marginal and insignificant differences; the procedure of strategy preparation is the same and covers the same stages.

The following differences among the strategies were identified: the first strategy has even 3 long-term aims to be implemented within a year. The second strategy is a quality result of team work, having received positive responses beyond the limits of Ukmerge region. The third strategy is largest in terms of its volume and continues the activities foreseen by the previous rural development projects.

The analysis of the strategies of the LAG "*Radviliskio lyderis*" (Radviliskis Leader) allowed distinguishing the following key features: Strategy 1 "Radviliskis Region Pilot Integrated Rural Development Strategy of the LAG for Years 2004–2006" is an example of the new practice of public life. It is prepared on the basis of the innovative strategy production methods and is based on the collaboration among the partners by actively involving local population in the strategy development process. The strategy has as many as 6 strategic aims for the period of 3 to 5 years. The strategy is characterised by continuity because a lot of its measures are planned for the next planning

period. This is a document with long-term priorities; however, it is meant for too short strategic period of time. To implement the pilot strategy, 69,881Lt were allocated.

Strategy 2 (Radviliskis Region Rural Development Strategy "Improvement of the Quality of Life in Radviliskis Region Rural Areas") was prepared by a group of 27 people. 9.59 million Lt was foreseen for the implementation of the strategy. The planned outcomes are trend-setting: sorting out the existing public infrastructure and creating a new one, building structures important for the rural area, their reconstruction and repairs; adjustment and maintaining of immovable objects of cultural heritage; renewal of the infrastructure of recreational territory, creation of crafts centres; creation of businesses in rural areas; stimulation of rural tourism; establishment and development of campsites in rural areas. The key areas of implementation, corresponding to the Lithuanian Rural Development Programme for Years 2007 – 2013, are foreseen (see Fig.4).

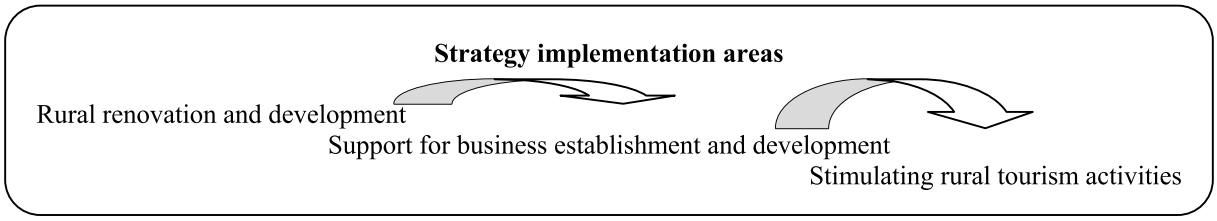

Figure 4. LAG strategy implementation directions.
Compiled by the author of the paper according to the LAG strategy "Radviliskis Leader".

Both strategies have two priorities. Both emphasise the priority of creating an environment motivating to live in the country, aiming at developing better living conditions in rural areas, at renewing and adjusting premises for community needs, at installing and managing public infrastructure. The second priority is dedicated to the improvement of the quality of life of rural population and strengthening rural economy.

Promising directions for the activities of LAGs: activating rural population and stimulating community spirit; preservation of the exceptionality of the locality and ethno cultural heritage; search and initiation of new economic activities in the country; education, informing and counselling of the members of rural community.

Results and Discussion

So far there has been no actual system for strategic management of rural development processes in Lithuania; however, the necessity of such a system is obvious. Rural development strategies are prepared exclusively on the basis of the general strategy preparation methodologies, by supplementing the process with the principles of the LEADER method. Strategic planning processes are based on the enthusiasm of the community leaders; however, a lack of planning skills, experiences and competence is often obvious; while the process of planning and strategy implementation is often achieved by the method of trial and error. Because rural strategies are geared towards the quality of life of the community members, people's health, culture and intellect, implementation mistakes sometimes incur incalculable losses, are indefensible and cause people a lot of moral and material damage. A national strategic management system of rural development processes would allow uniting the 51 LAGs of the country and sometimes chaotic efforts of rural communities, it would help making solutions based on the national and international experiences and would develop competence of leaders.

Conclusions

1. The strategies of both LAGs are prepared on the basis of methodological requirements for the strategic management. SWAT and LAG analyses of external and internal factors were carried out, a vision, mission and rural development priorities were formulated, strategic aims and means of their achieving were foreseen as well as the strategy management and implementation monitoring system. A number of projects prepared by rural communities were produced for the implementation of the strategies. All the strategies were confirmed, they correspond to the strategic provisions of the EU, national and regional municipality documents. Financing for the implementation of the strategies was allocated from EU structural, governmental and municipal funds.
2. The priorities, means and activities foreseen to achieve strategic aims can be viewed as complex activities of rural communities, which encompass changes in the spheres of transformation of traditional agricultural economy sector and social life. In the local development strategies of LAGs, the responsibility for the implementation is with the local rural communities, which are committed to producing projects.
3. Both LAGs under investigation give priority to the efficient use of EU support and aim at strengthening the sustainable development. LAGs pay a lot of attention to the creation of a learning community. Attempts are made to learn from good experiences abroad, inter-territorial and international cooperation is being expanded.
4. Local development strategies are similar in the following aspects of strategic activities: strategy preparation organisation principles and methods; innovative problem solution methods, allowing flexible manifestation of the initiatives of the local population; strategic aims and priorities, which

preserve the prospects of the local activities and stimulate the motivation for the local communities to feel responsible for the changes in the local conditions, encouraging their independence and self-expression. In all the strategies, multi-sector rural development means were identified, promoting ecological and alternative activities for agriculture.

5. Besides strategy preparation, LAGs are engaged in search for the competitive advantages of the locality; they perform a comprehensive analysis of the situation, which allows for the opportunity of an objective evaluation of the situation and setting strategic trends. LAGs have an actual opportunity to manage local human resources, to activate entrepreneurial initiatives of the population, their civic responsibility, their self-expression, to initiate new economic, social, cultural and environmental activities in the countryside, to carry out the monitoring of the changes, to publicise innovative activities and to strengthen the viability of rural areas.

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INFLUENCING FACTORS OF SOCIAL ENTREPRENEURSHIP IN LATVIA

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Abstract

The social enterprise features are well known in the world history while in Latvia there is a lack of studies and understanding about it. The aim of the research paper is to study the influencing factors of social entrepreneurship in Latvia. In the research the essence of social entrepreneurship and the main principles for definition of social enterprises – social mission, business orientation and involvement of marginalized groups are described. The analysis to determine the most important internal and external factors influencing development of social entrepreneurship was carried out. It was found out that the main external factors are political and legal environment, lack of knowledge about significance of social entrepreneurship, dominating values in society and such internal factors as access to finances, recruitment of professional and well motivated personnel.

Key words: social entrepreneurship, social enterprises, external factors, internal factors.

Introduction

Nowadays the concept of social economy is well-known concept. It has been mentioned as one of the basic tools of the Lisbon objectives. In the European Parliament resolution of 19 February 2009 on Social Economy it was emphasized that social economy has one of the main senses of the European economy because it combines profitability and solidarity, creates quality jobs, promotes economic, social and regional cohesion, enhances social capital, as well as promotes the sustainable development of economy. The social economy is carried out in social entrepreneurship.

The terms 'social entrepreneurship' and 'social entrepreneur' are relatively new, but the social business features have been well known already in ancient history. The first examples are identifiable in the 18th century when private health and social care institutions were set up. Since the second half of the 20th century in economy such phrases as 'social economy', 'social entrepreneurship' and 'social enterprise' were increasingly used, but a special urgency and practical applications they are beginning to experience only recently, driven by the social entrepreneur Bill Drayton and Charles Leadbeater. The most outstanding example of social entrepreneurship is a professor Muhammad Yunus, who in 1976 launched the Grameen bank project and started to provide banking services to poor rural inhabitants. Nowadays there are more than 60 new global social enterprise establishments, including several social business schools in Britain (Martin and Osberg, 2007) following the principle he established.

It is believed that social enterprises are the economic future because they promote employment (especially for marginalized groups), reduce poverty risk, solve social and economical problems and enhance entrepreneurial skills. But in Latvia there are only few social entrepreneurs and the concept of social entrepreneurship is still very new. According to Global Entrepreneurship Monitor in 2009, the social entrepreneurship rate in Latvia was 1.9% which is significantly smaller than in such European countries as France, Switzerland, Norway and Hungary. Furthermore, in Latvia there are economical, legal and political obstacles that hinder social entrepreneurship development.

In Latvia there is a lack of scientific researches about social entrepreneurship in general. First time some data about social entrepreneurship were presented in Global Entrepreneurship Monitor in 2009. Latvian researchers (A. Petersons, L. Pavare and A. Viksne) have paid more attention to corporate social responsibility; however, it is not the same. Companies which are characterized by corporate social responsibility focus on profits and they only engage in philanthropy but for social entrepreneurs the priority is social mission rather than profit. Significant contribution to social entrepreneurship gave the first Latvian social entrepreneurship forum organizer T. Cvetkova as well as a director of 'Idea Partners Fund' S. Sile (Žagare, 2010). Thus, it is essential to start research about social entrepreneurship in Latvia by explanation of the term 'social entrepreneurship' and analysis of factors that influence the development of social entrepreneurship.

The **aim** of the research paper is to study the influencing factors of social entrepreneurship in Latvia. The following **tasks** are advanced to achieve the set aim:

1. to study the essence of social entrepreneurship;
2. to determine factors influencing social entrepreneurship.

Materials and Methods

The main research methods applied: monographic descriptive method, logical, comparative analysis, method of analysis and synthesis, induction and deduction method. Method of analysis and synthesis was used to study the problem elements and to synthesize coherence. Induction method was used for summarising individual facts in general statements but deduction method - for theoretical explanations and logical synthesis of the empirical study. A graphical method for statistical display of data was used.

The research was made in Latvia from the year 2009

– 2010. Research is based on the analysis of information published by the Central Statistic Bureau (CSB), Global Entrepreneurship Monitor 2009 and scientific literature. Because of a lack of scientific literature in Latvia, the author bases the study on researches made by foreign scientists and social entrepreneurs.

Results and Discussion

1.The concept and essence of social entrepreneurship

Definition of the term 'social entrepreneurship' must start with the word **'entrepreneurship**' because the word 'social' modifies entrepreneurship. In the 19th century, entrepreneurs were the 'captains of industry', the risk takers, and the decision makers. They were individuals who aspired to wealth and who gathered and managed resources to create new enterprises. Early French, British and Austrian economists wrote about entrepreneurs as the 'change agents' of progressive economies (Holt, 2006). For example, French economist Jean-Baptiste Say described the **entrepreneur** as one who 'shifts economic resources out of an area of lower and into an area of higher productivity and greater yield', thereby expanding the literal translation from the French, 'one who undertakes', to encompass the concept of value creation (Dees, 2001). Austrian economist Joseph Schumpeter identified in the entrepreneur the force required to drive economic progress, without it economies would become static and structurally immobilized (Schumpeter, 1975). According to J. Schumpeter an entrepreneur is one who applies 'innovation' within the context of the business to satisfy unfulfilled market demand. On the other hand, Peter Drucker sees entrepreneurs as canny and committed exploiters of change. According to P. Drucker, 'the entrepreneur always searches for change, responds to it, and exploits it as an opportunity' (Drucker, 1993). It can be concluded that theorists universally associate entrepreneurship with opportunity, value creation and innovation. Entrepreneurs are believed to have an exceptional ability to see and seize upon new opportunities, the commitment and drive required to pursue them, and an unflinching willingness to bear the inherent risks.

Social entrepreneurs act similarly, tapping inspiration and creativity, seize opportunities that challenge and forever change established but fundamentally inequitable systems. But at the same time entrepreneurship and social entrepreneurship cannot be understood equally. There are several components that distinguish social entrepreneurship from its for-profit 'relative'.

There can be found various definitions for the term **'social entrepreneurship'**. Experts from different countries and organizations actively discuss and still cannot agree on the best possible definition of social enterprise. At the broadest level, a social entrepreneur is someone driven by a social mission and a desire to find innovative ways to solve social problems that have been neglected by either the market or the public sector. In other words, the role of a social entrepreneur is to identify societal problems and offer innovative solutions to them.

According to J. Mair and I. Marti (2006) social entrepreneurship definitions can be divided into 3 groups based on their focus to: economic entity (a social enterprise), the individual (social entrepreneur) or the process. For example, when the focus is on the organizational entity, the issue of profit allocation has been widely debated as a defining attribute of social enterprise. As S.L. Wallace (1999), J. Emerson and F. Twersky (1996) pointed out that social purpose enterprises are enterprises that trade like any other commercial establishment but return the profits to a social organisation. A lot of researchers by defining social entrepreneurship are focusing on the person – the individual social entrepreneur (Bornstein, 2007, Dees et al., 2001, Seelos and Mair, 2005, Vega and Kidwell, 2007). The third definition group focuses on process which involves either people, activities or organising process (Austin et al., 2006, Mort et al., 2003).

There are elaborated different **criteria** based on which it is possible to define a social enterprise. The UK-based Social Enterprise Coalition provides the following three characteristics that social enterprises display: enterprise orientation, social aims and social ownership. Enterprise orientation means that social enterprises are directly involved in producing goods or providing services to a market. Social aims mean that they have explicit social and environmental aims such as job creation, training or the provision of local services. And many social enterprises are also characterized by their social ownership. They are autonomous organisations whose governance and ownership structures are normally based on participation by stakeholder groups (employees, users, clients, local community groups and social investors) or by trustees or directors who control the enterprise on behalf of a wider group of stakeholders.

K. Alter (2004), on the other hand, provides the following nine characteristics of social enterprises:

- they use business tools and approaches to achieve social objectives,
- blend social and commercial capital and methods,
- create social and economic value,
- generate income from commercial activities to fund social programs,
- they are market-driven and mission-led,
- they measure financial performance and social impact,
- meet financial goals in ways that contribute to the public good,
- enjoy financial freedom from unrestricted income,
- incorporate enterprise strategically to accomplish mission.

J. Pearce (2003) has found out six common elements for social enterprises: having a social purpose, engaging in trade (at least in part; delivering services to clients which are paid for by a third party, sales to a customer, etc.), non-distribution of profits, holding assets in trust for community benefit, democratic ownership and accountability to a range of stakeholders. Similar determinants for social enterprise are described by J.L. Thompson and B. Doherty (2006).

The author combines previously mentioned characteristics of social enterprise and highlights one more - involvement of marginalized or excluded people (Figure 1).

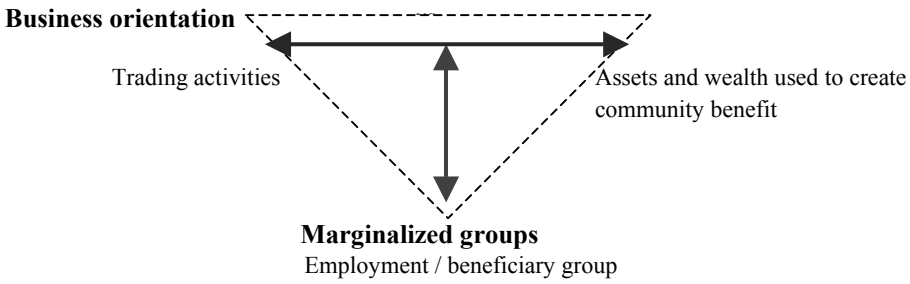

Figure 1. Characteristics of social enterprises.

Source: Made by the author

The author emphasises that, firstly, social enterprises have a **social purpose** or purposes such as job creation, training or the provision of local services. Secondly, it is achieving the social purpose by, at least in part, engaging in trade in the marketplace. It means they are **run as a regular business** just with a social purpose. Organizations are directly involved in business activity, supplying goods or services to the market and earning incomes as a result. Sometimes it is very hard for social entrepreneurs to find the balance between these two categories – business orientation versus (vs.) social purpose. That's why M. Yunus (2010) distinguishes two types of social businesses - non-loss, non-dividend companies (companies devoted to solving social problems and owned by investors who reinvest all profits in expanding and improving the business) and profit making companies (owned by poor people, either directly or through a trust that is dedicated to a predefined social cause). Thirdly, it is significant to employ a certain number of **marginalized people** or give them benefit of trading activities – provide them with cheaper products and services they can afford.

Based on the previous findings, the author defines the **social enterprise** as a practical, innovative and sustainable business creating primarily social value, as well as economic value by employing (or making them as a major beneficiary group) marginalized or excluded people in business where income generation has an important supporting role. By working this way such businesses can solve particular social and economical problems.

2.External and internal factors influencing social entrepreneurship

M. Bull et al. (2008) analyses factors and barriers influencing social enterprise in different organisation life cycles – from courtship to organisations death. According to his research, there can be determined different factors influencing social enterprise – the size of the enterprise, lack of resources, finance and funding, etc. All factors are related to one or another stage of the organisation life cycle. S. Grant (2008) analyses four influencing factors in New Zealand – socio-cultural norms, political reforms, legislation and international culture introduced by international citizens.

The author in the research emphasises external and internal factors influencing social entrepreneurship development in Latvia. **External factors** are opportunities and threats outside the business that it cannot control directly. For example, political and legal factors, cultural values in society, economical and technological factors, etc. **Internal factors** are opportunities and threats inside the business it has to compete with (Figure 2).

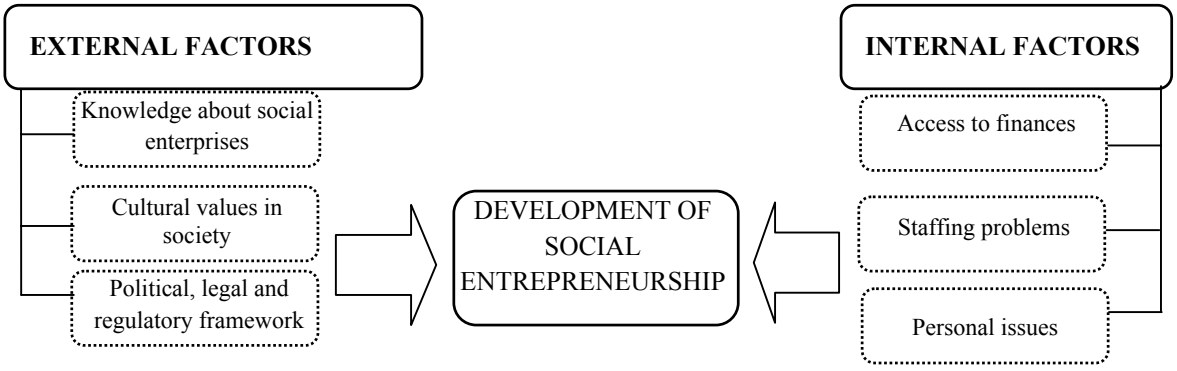

Figure 2. Factors influencing the development of social entrepreneurship in Latvia.

Source: Made by the author

Firstly, there is a **lack of understanding about social entrepreneurship** as a term. Even entrepreneurs who act as social entrepreneurs sometimes don't know that they are social entrepreneurs. According to E. Žagare (2009) research, only 37% of Latvia residents have heard the term 'social entrepreneurship' and have some understanding about it. But the understanding of this term should be strengthened by the explanation of benefits and functions that social enterprises fulfil in society. For example, social enterprises have a high potential to create and maintain a stable level of employment. According to the data of the CSB (Central Statistical Bureau, 2011) in 2009 employment rate significantly decreased compared with 2008 (for 7.4%) and unemployment rate increased (for 9.4%) because of economical crisis. Based on Government employment agency data unemployment rate is still very high - in January 2011 it was 14.3%. Furthermore, social enterprises can create jobs and provide support to socially vulnerable (marginalized) groups, for example, the disabled, pre-staff, etc. In Latvia last 15 years there have been no significant changes in employment terms for disabled people. In 1995 there were 4109 workers with disabilities in the country and almost twice as many (7895) unemployed people with disabilities. After the latest available data of CSB (Central Statistical Bureau, 2011) the author concludes that there have been no significant quantitative changes (in 2008 there were 7313 disabled unemployed people). Establishment of social enterprises is important for employment of socially vulnerable groups. In Latvia there are several such companies - the Business Opportunities Fund and the Short-term employment agency that offer job for people with disabilities, Mammu! - employing mothers for handicraft development, Tac-Osona Work Center, where most of the workers are people with intellectual disabilities and other disabilities, ziedot.lv - social enterprise that provides a variety of services, the Idea Partners Fund charity shops etc. Also it is essential to emphasize that social entrepreneurs create social innovation in various areas and promote development of entrepreneurial skills. According to the Global Entrepreneurship Monitor 2009 study, 69% of respondents noted that they lack entrepreneurial skills and knowledge, which makes business environment in Latvia look poor compared with other European countries.

Secondly, the economist and social entrepreneur Marcello Palaci (Unused Potential for Social Entrepreneurship in Latvia, 2009) highlights that a huge obstacle for development of social entrepreneurship in society is **'architecture of capitalism'** where the main focus is on profit making. And the performance of business which is coordinated alongside with society aims is not so important. D. Bornstein and S. Davis (2010) emphasize that thinking of society has to be moved from 'me' to 'us' and, eventually, to 'all of us'. But this is important to make a step forward of changing the way of people thinking and understanding of social enterprises significance.

Also, the way of thinking should be changed for some society groups that are used to receive support but not to earn it. That is why charity programs (also lead by Nongovernmental organizations (NGO)) have the inevitable effect on taking away the initiative of those who receive the benefits. Poor people who become dependent on charity do not feel encouraged to stand on their own feet. By contrast, as M. Yunus (2010) and D. Bornstein and S. Davis (2010) noted people who pay a fair price for the goods and services they receive are taking a giant step toward self-reliance. Thus, social enterprises lead more directly to genuine, long-term solutions to such problems as poverty, inequality and oppression.

Thirdly, social entrepreneurship is influenced by **political and legal framework** in Latvia. For example, in the UK political climate is one which visibly supports the development of social enterprises but in Latvia the great obstacle is that social entrepreneurship is not legally introduced in legislation and is not accepted as the form of entrepreneurship. Also, there are several prejudices from governmental institutions against NGO who are establishing social enterprises and also other forms of entrepreneurship that has a social purpose. J. Bland (2003) describes the importance and difficulty of choosing the best legal structure to fulfil a social enterprise's multi-faceted aims. According to Global Entrepreneurship Monitor 2009, there can be distinguished different social entrepreneurship types in Latvia. Some of those social enterprise types don't generate incomes - traditional NGOs who has purely social goals and not-for-profit status and not-for-profit social enterprises. But hybrid social enterprises purely social goals and some complementary economic activity), for profit social enterprises and social activities for profit motives are able to generate profit by themselves (Figure 3). Unfortunately, it is not possible to make comparison of quantitative changes during longer period as there were no previous findings about it.

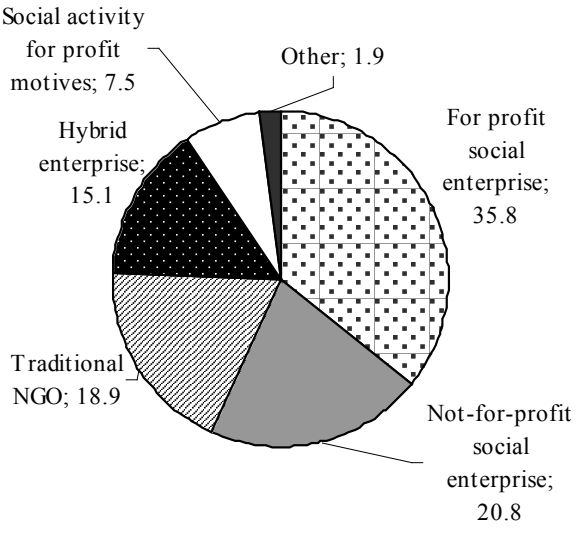

Figure 3. Social entrepreneurship by type of activity in Latvia in 2009 (%).
Source: Global Entrepreneurship Monitor 2009

R.L. Martin and S. Osberg (2007) hold the view that the government needs to provide an enabling legal and regulatory environment for social enterprises to thrive. Furthermore, social and environmental issues should be given a political priority. In Great Britain there are set four areas where the role of the government is most important: foster a culture where there is a complete information about the potential of social enterprises, ensure that the right information and advice is available to those running social enterprises, enable social enterprises to access appropriate finance and ensure that social enterprises are able to do business with the public sector and work with government to achieve shared objectives. According to K. Alter (2004), the law in many countries does not make neither provision nor recognition of a social enterprise as a legitimate legal entity. However, some countries have made special provisions in their law and tax codes for social enterprises. While the legal environment varies from country to country, a general lack of clarity in the law about the legality and tax treatment of enterprises engaged in commercial activities in emerging market countries results in a variety of practical and ethical challenges.

Fourthly, there are problems with **access to finance and investment**. R.L. Martin and S. Osberg (2007) and J. Brown (2002) say that social enterprises have lack of consistent, flexible and long-term financing. B. Hynes (2009) research revealed that social entrepreneurs face with funding problems which prevent establishment and development of social enterprises. Financing enables social entrepreneurs to hire talented employees, find a market, rent a space, pursue pilot projects, and carry out other activities related to growing their enterprises. K. Alter (2006) stresses that social enterprises are capitalized through a variety of different instruments such as grants, loans and charitable contributions. Unfortunately, it doesn't work well in Latvia. The high cost of credit and loans and collateral requirements is a problem in accessing funds for social enterprises. Also, in Latvia there is no specific venture capital fund where social entrepreneurs can borrow from. Social entrepreneurs are treated on the same level as other commercial organisations when seeking funds. There is no government support and there is a lack of links with foreign partners on sources of finance. A. Westall (2007) recommends that banks and community development finance institutions should be encouraged to work together and coo-finance social enterprises wherever it is appropriate. Governments may also need to extend the availability of support, for example through matched funding or tax relief on investment in social enterprises. So far in Latvia there have only been possibilities to apply for Soros Foundation - Latvia announced programmes which promote social entrepreneurship development in regions for a short period. It can be concluded that in Latvia social entrepreneurs act like enthusiasts and they seek to find funding from the different sources in the same way as mainstream entrepreneurs.

Fifthly, in social enterprises **problems with recruiting and retaining staff** can occur**.** C. Leadbeater (1997) and B. Imperatori, D. Ruta (1996) suggest that success of the firm is its ability to attract and retain employees with the right skills and knowledge. According to R.L. Martin and S. Osberg (2007), social enterprises lack the ability to attract the talent and commitment needed to expand their impact. Developing and retaining talent and balancing professionalism with entrepreneurialism and passion for the mission is also difficult. Whereas some have the social skills to work in social enterprises, they lack the entrepreneurial skills necessary to blend entrepreneurship with social missions. This lack of blended skills impacts negatively on the ability of the firms to achieve greater benefits to the target communities. Retaining staff in the social enterprise may not always be an easy task also because of a lack of financial resources, inability to guarantee job security or provide attractive salaries (Bornstein, 2007). It is a challenge for social entrepreneurs to incentivise staff through non - financial awards. A. Amin (2009) states that there are different category employees with diverse motivation. The first category employees have ethical reasons. Those can be university graduates who want to obtain a career opportunity and a space of ethical practice. The second category of employees is the individuals who have 'fallen' into the social enterprise – sometimes after personal mishap or due to forced exit from mainstream employment. Sometimes work in social enterprises change their value preferences and they stay there for a longer time than previously expected. The third category is the individuals for whom working in social enterprise is a matter of earning income or gaining experience before moving to other job. According to CSB data, in Latvia in 2009 there were 12% people without work experience (Central Statistical Bureau, 2011). It means that social enterprise can be a way how to get working experience which is very important for university graduates and students. Also, in social enterprises individuals with limited skills, experience or knowledge, frequently from socially disadvantaged backgrounds can be involved.

Finally, there are some **personal issues** that affect social enterprises. B. Hynes (2009) stressed that there are personal challenges for social entrepreneurs in growing their business. They have to do different tasks which are sometimes completely different from their previous experience. Also, social enterprises are founded by one or a number of people and when they retire, those below them may not be able to carry on with the vision.

It can be concluded that there are several factors that hinder the development of social entrepreneurship in Latvia. It should be overcome by disseminating information about significance of social entrepreneurship and by active discussions with municipality and government specialists to solve legal and political problems related to social enterprise issues.

Conclusions

1. Social business is a new kind of business which is quite distinct from a traditional profit-maximizing business. The goal of social enterprise primarily is to solve a social problem by using business methods, including the creation and sale of products or services.
2. There are various definitions of the term 'social enterprise' but the explanation of it has to be based on three main characteristics – social purpose, business orientation and employment or making benefit to marginalized groups.
3. Significant external factor influencing social entrepreneurship development in Latvia is a lack of knowledge about social entrepreneurship and its importance in social and economical problem solving, as well as cultural values in society. The main external factor that hinders extension of social enterprises is political and legal environment because in legislation it is not recognized as a legal entity. Also there isn't any support from government for establishment and development (funding, tax reliefs) of social enterprises in Latvia.
4. Substantially social enterprises are affected by internal factors – recruitment and retention of qualified staff and access of finances. It is hard to compete with a level of salaries offered by traditional profit making businesses, but social enterprises can offer meaningful job with provision of great experience. Access of finances is usually solved by investing capital from family, friends or taking a bank loan with the same requirements as traditional businesses do.

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METHODOLOGICAL PROPOSALS TO COMPARE BUSINESS CONDITIONS IN DIFFERENT ECONOMICAL SYSTEMS: CASE OF LITHUANIA

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Abstract

The comparison of business and taxation conditions in several countries is one of the main tasks of each investor who claims to start a new business. The same problem is significant for state authorities responsible for attraction of investments as well as for scientists who analyse problems related to investment attraction. The aim of the research is to propose the methodological model to compare taxation conditions of various business forms. The taxation of six different business forms was compared. As the examples for research object, the smallest business forms in Lithuania were chosen: a person having a business certificate, a person engaged in agricultural activity (a farmer), a self-employed person engaged in agricultural activity, a person owner of sole-proprietorship and a person owner of the joint-stock company.

In order to compare and evaluate the amount of taxes mathematically, the hypothetical data were taken which allowed to identify the least and the most taxable forms of business in Lithuania. Analysing different business forms and their taxation conditions, the following methods were used: systematic, comparative, logical analysis and synthesis. Legal acts regulating the taxation of each form of organizational business were investigated and summarized.

The most difficult conditions for the owners of sole proprietorships in Lithuania were observed in 2010. They had to pay about 50 percent of their incomes. But the best conditions for small business had those people who worked with business certificates. They paid only 6 percent of their incomes.

Key words: business conditions, business forms, comparison, methodology, investment.

Introduction

Those people who are going to launch their own business face the problem of choosing the form of business organization. The decision should be made according to:

the activity they are going to develop; whether they will be 'self-employed' or will establish their own company and become one of the shareholders; and whether they will be employed by the employment contract in the established company.

Nowadays there are many forms of commercial business activities in Lithuania. Lithuanians and other investors may choose any form of business which is legitimate in the country.

A person who has decided to develop agricultural or alternative activity in rural areas may select one out of several forms of organizational business. He or she can become a self-employed businessman or obtain business certificates and provide services. In addition to this, a person can register a farm and become a farmer according to the procedures and terms set by the legal acts. Furthermore, this person can establish a sole proprietorship or become the only incorporator and shareholder of a joint-stock company. As a farmer, a person can become either a member of cooperative society, or work by the employment contract in the same cooperative society and in any other farming partnership or agricultural company.

The variety of the most frequent forms of activities and the benefit for incorporators and for all the country will be discussed. The results of the research would enable business organizers to make reasonable decisions while registering and executing activity.

Materials and Methods

The object of the research is the regulation of the taxation small business residents of Lithuania.

The aim of the research is to propose the methodological model to compare taxation conditions of various business forms and test it with hypothetical data on the basis of Lithuanian law.

The methods of the research

Analyzing different forms of business organization and their taxation conditions, the following methods were used: systematic, comparative, logical analysis and synthesis. The background of the research was formulated in the theory of Jensen, Mercer and Johnson (1996) as well as Boragan, Diebold, Scotti (2009) and for the first time refereed by Marcinkeviciute and Zukovskis (2006). Finally, the research algorithm was created on the basis of system theory summarized by Zukovskis (2007) and Zukovskis (2008).

Legal acts regulating the taxation of each form of organisational business were investigated and summarised. In order to compare and evaluate the amount of taxes mathematically, the hypothetic data were taken, which allowed to identify the least and the most taxable forms of business.

The research aims at comparing the taxation of different self-employed forms of business. The objective of the research was to determine which of 6 business forms is the most profitable for nascent entrepreneurs. The evaluation has been done according to the same algorithm. Hypothetically, it has been identified that all business forms receive the same and equal amount of income. Performing

required calculation, the amount and kind of taxes business people pay if they choose one or another form of business have been evaluated. The fundamental result is the amount of income received for personal needs after taxation. The following proportions have been assessed: the amount of income after taxation and the amount of income received by the Treasury and the State Funds. Comparing received results, the least and the most taxable business forms and the average tax burden have been identified. Furthermore, the suggestions for nascent entrepreneurs have been provided. The research has been done following the legal acts of the year 2009 and 2010.

Results and Discussion

Every Lithuanian can become a **self-employed** person. A self-employed person can start the activity after the registration in accordance with procedures established by law (hereafter referred to as *self-employment by issued certificate*) or business certificate which requires a fixed value of income tax paid in advance, received from such form of self-employment which is 'the self-employment which can be obtained by the business certificate and included into the list of activities' (*Business certificates,* 2010).

Received income from self-employment (*self-employment by issued certificate*) is the tax rate of 15% of Personal Income Tax (PIT, 2010). Income is assessed by the following procedure: income minus allowable deductions (common and necessary expenditure). In spite of the PIT, a resident should pay Compulsory Health Insurance (CHI) contributions payable in the amount of 9% of such income. Annual PIT contribution can not be less than 9% of the amount of twelve minimum monthly wages (hence, MMW; recently MMW is 800 LTL (232 EUR), so CHI is 864 LTL (250 EUR) i.e. 800x0.09x12) unless a resident receives the income from a salary or is insured by the state social insurance. In such case, a contribution payable is of individual earnings. In addition to this, a resident should pay social insurance contributions, i.e. 10% of individual income of individual activity.

Those residents, who acquire **business certificates**, pay a fixed PIT established by municipal councils. Lower PIT rate may be applied only for some groups of people, for example, pensioners or disabled people. Having business certificates, residents each month pay CHI contributions in the amount of 9% of MMW (currently, it is 72 LTL (21 EUR), i.e. 800x0.09). CHI contributions are not counted from all income. These people have to pay social insurance contributions: 50% of basic pension (recently, the contribution aims at 180 LTL (52 EUR), i.e. 360x0.5).

Similar to farming partnerships, the owners of **sole proprietorship**, who get income from taxable profit, are not taxed if they receive less profit than of 4000 LTL (1158 EUR) a year. If it is more than 4000 LTL (1158 EUR), it is taxed in amount of 15% of PIT of all the income. The contribution of CHI is counted out of the same taxable base as PIT, and it should be not less than 9% a year of profit of sole proprietorship (or farming partnership) and not less than 864 LTL (250 EUR) (800x0.09x12).

For farmers and other residents who work in the field of agriculture, the taxation is much more difficult. The taxation of their income depends on the size of the agricultural holding. The size of the area is measured by the arbitrary parameter: European Size Unit (ESU). It is the economical measure of agricultural holding in the European Union, measured according to the landed property declared, the number of livestock and the standard production profit of adequate sort of production.

The taxation of the residents who are engaged in agriculture-related activities is taxable by PIT only when the agricultural holding is larger than 14 ESU. In 2009, the income of the residents was taxed in amount of 5%. In 2010, it must be 10 % of the taxable incomes. CHI contribution is paid by the very owner of the agricultural holding. The contribution increases if the agricultural holding rises. A person whose agricultural holding does not exceed 2 ESU, in 2009 it was required to pay not less than 3% of 12 MMW (i.e. 288 LTL (83 EUR), because 800x12x0.03). If the agricultural holding is larger, i.e from 2 ESU to 14 ESU, in 2009 an owner paid not less than 9% of 12 MMW (i.e. 864 LTL (250 EUR), because 800x12x0.09). If it is more than 14 ESU, the contribution consists of 3% of all taxable incomes. The annual contribution of incomes received by individual agricultural holding is not more than 17856 LTL (5171 EUR) and the maximum contribution of CHI is 536 LTL (155 EUR).

The contributions of State Social Security are to be paid by the residents, whose agricultural holding is larger than 4 ESU. The contribution includes not less than 8% of 12 MMW. If the holding is larger than 14 ESU, these people should pay 8% of taxable income, received from this sort of activity, but not less than 8% of 12 MMW. In 2010, the rates of tax increased to 16% of taxable incomes (see Table 2).

In Lithuania, the **joint-stock company** can be established even by one individual. A person can become the only incorporator and a shareholder and, at the same time, to be the employee of the same company. According to the recent laws of social insurance, such individual must 'employ' himself, i.e. in accordance with procedures established by law of social insurance system, the individual should announce about the start of employment relations and pay for oneself not less than a minimum wage. The rest of the profit can be used at discretion: to invest into the company or take out as dividends. Since 2009, the annual income, related to employment relations after the basic and additional non-taxable sizes, is taxes 15% of personal income and 9% of social insurance. As the years before, an employer should have paid the additional contribution of social insurance of 30.98% of salary. Dividends are taxed 20% of the rate of PIT and 6% of CHI of the taxable profit.

Proposals to create the methodology to compare business conditions in different economies and / or countries are formulated in the model (see Table 1)

Tabel 1

Methodological model to compare business conditions

Denotation	Item			Example (EUR)
P	**Incomes**			10000
(-) minus				
E	**Expenditure**	"Brutto" salary for employee (for example: 2780 EUR)		
		Incom tax (15%)	Taxes	417
		Social insurance contribution (9 %)	Taxes	250
		"Netto" salary for the employee		2113
		Employer's (30.98%) social insurance + contributions for Guarantee fund (0.1%)	Taxes	864
		Total		3644
(=)equals				
P - E	**Profit**	Financial		6356
		For taxation		6356
		Profit tax (15%)	Taxes	318
		For distribution		6038
		Non taxable by income tax (0 %)		
T	**Taxes when profit taking out**	Income tax for inhabitants (personal income tax, 15%)	Taxes	906
		Compulsory health insurance (9%)	Taxes	
		Social insurance contribution (16.0 - 26.3 %)	Taxes	
B=P-E-T	Balance of income after all taxes for businessman			7245
S	Total taxes to treasury and goverments funds		Sum of all taxes	2755
B/P	Part of income for bussinessman in 2010 (%)			72%
S/P	Part of income for state treasury and funds in 2010 (%)			28%

Assuming that received income of the activity was the same, Table 2 shows six different forms of organizational business. In this table, individuals were not taxed by personal (basic and additional) non-taxable sizes due to the complexity of the calculation. However, in this particular case this does not have any crucial impact.

Table 2

Taxes for different organizational business forms in Lithuania per year by 2010 (EUR)*

Indicators	Indicators	Legal organisational forms of business						Average
		BC+C	BC	Farmer	Ltd+C	IB	IE	
Incomes (P) (+)		10000	10000	10000	10000	10000	10000	**X**
Expenditure related to employment relations (E) (-)	Total (if minimal payment per month 231.70 EUR)	0	0	0	2780	0	0	**X**
	Incom tax	0	0	0	172	0	0	**X**
	Social insurance contribution	0	0	0	250	0	0	**X**
	For employee, take-home pay "netto"	0	0	0	2358	0	0	**X**
	Contribution for SI**	0	0	0	864	0	0	

Table 2 continued

Taxes for different organizational business forms in Lithuania per year by 2010 (EUR)*

Indicators	Indicators	Legal organisational forms of business						Average
		BC+C	BC	Farmer	Ltd+C	IB	IE	
Profit	Financial	10000	10000	10000	6356	10000	10000	**X**
	For taxation	10000	10000	10000	6356	10000	10000	**X**
	Profit tax (20 proc.)				318		500	**X**
	For distribution	**10000**	**10000**	**10000**	**6038**	**10000**	**9500**	**X**
	Non taxable by income tax (0%)			3000		3000	1633	**X**
Taxes when profit taking out	Income tax for inhabitants (personal income tax)	417	417	1050	1208	1050	1180	**X**
	Compulsory health insurance	250	250	244		450	855	**X**
	Social insurance contribution		626	651		1425	2499	**X**
Balance of income after all taxes for businessman (B)		9333	8707	8055	7188	7075	4967	**X**
Total taxes to treasury and goverments funds(S)		667	1293	1945	2812	2925	5033	**X**
Part of income for bussinessman in 2010 (V/I) (%)		**93**	**87**	**81**	**72**	**71**	**50**	**73**
Part of income for state treasury and funds in 2010 (S/I) (%)		**7**	**13**	**19**	**28**	**29**	**50**	**27**
Part of income for bussinessman in 2009 (V/I) (%)		**94**	**88**	**86**	**61**	**68**	**65**	**74**
Differents of the part of income for bussinessman in 2010 and 2009 (V/I) (%)		**0**	**-1**	**-5**	**11**	**3**	**-15**	**-1**

Notes:
* – Citated from Žukovskis (2010)
** – Contribution for SI- employer's (30.98%) social insurance + contributions for Guarantee fund (0.1%)
BC+C – a person working by business certificate + employement contract;
BC – a person having business certificate, but no employement contract;
Farmer – a person angaged in agricultural activity;
IB – a self -employed person engaged in agricultural activity;
IE – a person having a sole –proprietorship;
Ltd+C – a person having a joint-stock company and work with employement contract.

Conclusions

1. All business forms represented in the article may be acceptable for people, starting one's own business. Such registration of activity, relations with governmental institutions and taxation procedures are relatively explicit and simple.
2. The variety of organizational forms of business evokes positive as well as negative outcomes. Positive outcome is the following:
   - It allows for rural residents to decide which form of activity is more profitable, simpler and requires fewer expenses.

   Negative outcomes are:
   - Such diversity of forms makes it more difficult to decide. Business people do not know what to choose, what is cost-efficient and what conditions for such activity will be in the future. They do not pursue the activity but are obliged to make explanations about the conditions of the activity.
   - Governmental institutions monitoring the activity face the problem of taxation and contributions.
3. Comparing six different forms of organizational business in Lithuania in 2009, it was pointed out that the conditions of taxation and the size of tax depend on the form of activity. The most cost-efficient form of business is having and working with business certificates. Whereas to be employed by the employment contract in one's own joint-stock company is the most non-profitable case.
4. Taking into consideration the difference of the tax

burden of the year 2009 and 2010, it should be noted that the tax burden for economic operators has increased, although very little. The average value of taxes for all business forms has increased by 1 percent (from 26% to 27%). Accordingly, the number of business people has decreased.

5. In Lithuania in 2010, the most difficult conditions have been for the owners of sole proprietorships. The taxes for the State have increased, meanwhile the owners of sole proprietorships have decreased by 15 percent. However, the conditions for the owners of joint-stock companies have improved. Their income increased by 11 percent.

The results of the research may be beneficial theoretically as well as practically. The results of the research may be interesting for the investors who are planning to develop business in Lithuania and choose a particular form of business. Provided methodology should be improved in the future. It is important to find a reference point in order to compare business and taxation results. In this research, the operational income has been chosen as a reference point. In the future, the comparison between the State average and the taxation of business forms of other foreign countries may become a reference point.

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INTEGRATION EFFECT ON BALTIC STATES' DAIRY SECTOR EXPORT PERFORMANCE

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Abstract

Baltic States' dairy sectors are important to their economies. All Baltic States have had substantial current account deficits that exceeded acceptable thresholds until the year 2009. The States are dairy product exporters. Export capability largely depends on international competitive position of dairy processing companies. Several factors, inter alia, company size determine the position. Largest companies have been formed by horizontal integration. At Baltic scale dairy processing is still fragmented.

The aim of this paper is to evaluate economic effect aspects of integration related to exports in the Baltic States' dairy sector secondary level. As the subject has not been explored earlier at company level, the author researched data of 188 annual reports of 53 Baltic dairy processing companies over the period 2003 to 2009. Descriptive statistics, time series analysis and regression analysis methods were primarily used.

The author establishes that among dairy companies which generate significant exports turnover two-thirds are horizontally integrated and include all largest dairy processing firms in the Baltic States. A few smaller firms have succeeded in exporting due to suitable channel management. Among a large group of companies that generate less than 1% turnover from exports, 77% are non-integrated and all are small. Using regression analysis the author estimates that 1% increase in net turnover in the exporting dairy company group is expected to create 0.93 – 0.94% increase in net turnover from exports. Policies promoting mergers of some companies may thus lead to increased dairy exports, higher milk production and fuller realisation of economic potential of the sector.
Key words: dairy sector, integration, exports.

Introduction

As established in existing research, all Baltic States have been traditionally strong in exporting milk and dairy products; trade balance in this group of goods has been positive since 2004, especially in Lithuania (Jansik, 2009). 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 the next with approximately 2%, but in Estonia this sector is relatively smaller – 1.2 – 1.6% of the GDP. The importance 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 (Ozoliņš, 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).

The sector in Latvia faces significant economic problems which affect its export competitiveness, 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. 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).

According to research carried out by Aristovnik, current account deficits of transition economies in excess of 5% of GDP generally pose external sustainability problems; this author indicates that Baltic States cannot have a higher level of external deficit (Aristovnik, 2006). The author's calculations using Eurostat data exemplify that in the period 2003 to 2008 in all Baltic States current account deficit exceeded GDP by more than 5%, especially in years 2006 and 2007 when the Latvian indicator value peaked at – 22% for 2 consecutive years. Dairy sector contributes positively to current account position of the Baltic States and their external financial sustainability. Evaluation of dairy sector economic effect should take into account its role as an exporting part of the economy.

Population of the Baltic States has been decreasing. Data of Central Statistics Bureau of Latvia indicate that population of Latvia has been decreasing in the period 1992 to 2009. Smaller populations and expected tendencies

of further decrease due to low birth rates and economic migration will contribute to shrinking of the Baltic States local market for milk and dairy products on which majority of Baltic dairy processing companies rely profoundly. Ability of dairy processing companies to export not to the declining Baltic market but to the growing global market instead will be a major factor that will determine dairy sector development in the future. According to FAO forecasts, the consumption of milk and milk products will continue to grow at a pace of 1.4% per annum in the period up to 2030 and by 0.9% per annum in the period of 2030-2050. The largest increment rates (2.6 – 2.8% per annum) in the period up to 2030 are expected in South Asia, East Asia and Sub-Saharan Africa. It is expected that there is a considerable scope for further growth in consumption of milk and dairy products (Food and Agriculture Organisation, 2006).

The author assembled and digitised a unique database of all publically available annual reports of the Baltic States dairy processing companies. Previous research by other authors, e.g. Jansik, is based on general statistics, 2009 or general statistics and data from some largest companies, e.g. (Girgzdiene et al., 1999; Hartmann et al., 1999; Kedaitiene and Hockmann, 2002; Leimane et al.; Jasjko et al., 2007). Several theories exist that may be applied in dairy sector integration economic effect analysis from different viewpoints. They include widely acknowledged transaction cost economics (Williamson, 1985), property rights approach (Grossmann, 1986), competence perspective (Dosi, 1988) and strategic behaviour approach (Kogut, 1988). Company-level preliminary analysis by the author indicated that relationships might exist between company net turnover from exports, geographical segmentation of exports, net turnover and other factors. Among those the author initially singled out the size of a company proxied by net turnover, integration patterns and product specialisation.

In a view of the importance of exports for the economic sustainability of the Baltic States and their dairy sectors in particular, it is useful to research factors that are related to how much companies actually export. 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 economic effect aspects of integration related to exports in the Baltic States' dairy sector secondary level. The following tasks had been set to reach the aim:

1) Review of selected Baltic States dairy processing company annual reports to collect statistical data on exports and textual information related to exports performance;

2) Analysis and evaluation of Baltic States dairy processing company exports turnover with respect to their integration patterns;

3) Identification of factors influencing Baltic States dairy processing company exports and determining closeness of found relationships by means of parametric methods.

Hypothesis of the paper is that integrated dairy processing companies have higher exports turnover than non-integrated Hypothesis of the paper is that integrated dairy processing companies have higher exports turnover than non-integrated ones. Hypothesis of the paper is that integrated dairy processing companies have higher exports turnover than non-integrated

Materials and Methods

The author used data of all dairy processing companies approved by the authorities of the Baltic States as of October 1, 2010. The database was created and processed by means of PASW Statistics 18 package. It included 725 annual reports' data of 71 Latvian, Lithuanian and Estonian dairy processing companies for the period 1995 to 2009 in Latvian and Estonia and 2003 – 2009 in Lithuania. Earlier Lithuanian data were unavailable as annual reports were purchased from enterprise registers or their authorised information services of respective countries and Lithuanian enterprises were not obliged to submit annual reports to the Lithuanian Registrų centras in earlier periods.

Companies which process goats' milk, specialize in milk candy production, whose turnover from dairy processing is less than 30%, newly established companies with no publicly available data yet and those that do not submit annual reports due to their small turnover were excluded from the sample. Annual reports' data of 53 companies that publicised exports statistics out of total 71 companies for time period of 2003 – 2009 were selected. Therefore, the paper is based on data of 188 annual reports of Latvian, Lithuanian and Estonian dairy processing companies' in which sales by geographical (secondary) segments were presented. All annual reports of Estonian and Latvian companies for respective period were examined for presence of exports data. In case of Lithuania due to data availability limitations only data of the 3 largest by net turnover, Žemaitijos pienas, Pieno žvaigždės, Rokiškio sūris and also Vilkyškių pieninė were used. The largest Lithuanian companies are important to include in analysis as they are horizontally integrated and largest in the Baltic States.

Descriptive statistics, time series analysis, non-parametric and parametric statistical analysis methods, abstract-logical and monographic methods were used. Linear and non-linear regression methods with single and multiple independent variables were used to explore and determine factors related to company exports turnover. Solely integration via ownership connections is taken into account on account of reasons of data availability. Other integration arrangements such as contractual are mostly not examined due to confidentiality of information. Currency conversion from Lithuanian litas (LTL) and Estonian kroon (EEK) to Latvian lats (LVL) was carried out using Bank of Latvia official exchange rate as of the end of each year. References to the company size are determined on basis of comparing their year 2009 net turnover.

Results and Discussion

Dairy Processing Companies' Export Analysis

During the period of years 2003-2009 mean share of exports in net turnover was between 0 and 10% for 41% of the Baltic States dairy processing companies, more than 10% and less than 30% for 17% of the companies (Table 1). For 9% of the companies export weight in sales was 30 to 50% while only 13% of companies generated most sales in export markets. Sole reliance on their local market was characteristic for 20% of the analysed dairy processing companies. The three largest (by net turnover in 2009) Lithuanian dairy processing companies, Žemaitijos pienas, Pieno žvaigždės, Rokiškio sūris produced highest mean exports turnover in absolute terms, followed by the 6th largest Lithuanian company Vilkyškių pieninė, Estonian E-piim and Võru Juust. The largest Latvian company by mean exports turnover was Preiļu siers, ranking the 7th among the analysed companies.

Data presented in dairy companies' annual reports made it possible to analyse factors influencing volume of exports. Due to space limitation characteristics only of companies with export turnover exceeding 30% are described. This analysis also includes Latvian company Limbažu piens whose turnover from exports is approximately 50%, while mean data show lower value, as it exports via Rīgas piena kombināts since the year 2006.

Estonian company Delibalt Production is a non-integrated company which has been successful in increasing export volumes of curd cheese to the Baltic market, mostly Latvia. BLM Eesti is a horizontally integrated company which is 49% owned by a large Austrian dairy processing company Berglandmilch and mostly exports to Austria. Võru Juust, a horizontally integrated company, is a part of Valio OY group which is the largest Finnish dairy-farmer-owned processing company. It exports mostly to Finland and considerable percentage of exports is produced for Italian customers as well. Vilkyškių pieninė is a relatively large horizontally integrated company which exports mostly to EU countries while approximately one-fifth of exports are to Russia. Rokiškio sūris is the 2nd largest, horizontally integrated, Baltic dairy processing company which exports mostly to EU countries. E-piim is the 5th largest Estonian dairy processing company, a dairy processing cooperative which produces mostly milk powder and cheese. Preiļu siers is the 3rd largest Latvian dairy processing company, horizontally integrated and exports mostly to Germany.

Žemaitijos pienas is the 3rd largest Baltic dairy processing company horizontally integrated; it exports mostly to the Baltic States, other EU countries and CIS member states. Pieno žvaigždės is the largest Baltic dairy processing company horizontally integrated. Its exports are focused to Russia while approximately 30% of the exports revenue is generated in other countries. Jaunpils pienotava is a cooperative-owned dairy processing company which ranked the 37th by turnover. It sharply increased turnover when it was purchased by Estonian investors in years 2004-2005. Subsequently it was sold to a dairy cooperative. Gosupi is a relatively small Latvian dairy processing company which is integrated neither with other dairy processing companies nor with dairy farmers or their organisations. However, it formed daughter companies in Lithuania and Estonia which explain sharp increase in Gosupi exports to the Baltic States from 16% in the year 2003 to 50% in the year 2005. Nantecom is a non-integrated Estonian curd cheese producer which has been successful in exporting mostly to Latvia and also Lithuania. Limbažu piens achieved status of one of the most export-oriented Latvian dairy processing enterprises after it entered a contract with a Dutch dairy product company engaged in wholesale to custom-produce Italian type cheeses. As evidenced by the company's annual report data, over half of Limbažu piens sales were generated by exports to the Netherlands.

Companies with substantial share of exports outside the Baltic States market were Võru Juust, BLM Eesti, Rokiškio sūris, E-piim, Preiļu siers, Pieno žvaigždės, Jaunpils pienotava and Limbažu piens. These companies were mainly exporting cheese.

Table 1

Baltic Dairy Processing Companies' Export, 2003-2009

Company	Mean export turnover, thou. LVL	Share of export in net turnover	Mean export turnover to the Baltic States, thou. LVL	Share of export to the Baltic States in net turnover	Share of export outside Baltic States in net turnover
Delibalt Production	1,735	88.49%	1,579	81.74%	6.75%
BLM Eesti	1,868	76.61%	186	7.69%	68.92%
Võru Juust	14,127	74.89%	409	1.99%	72.90%
Vilkyškių pieninė	15,862	66.06%	…	…	…
Rokiškio sūris	64,755	59.59%	808	1.14%	58.45%
E-piim	14,778	57.97%	0	0.00%	57.97%
Preiļu siers	11,107	53.02%	0	0.00%	53.02%
Žemaitijos pienas	34,357	43.68%	…	…	…
Pieno žvaigždės	48,263	43.51%	3,341	3.24%	40.27%

Table 1 continued

Baltic Dairy Processing Companies' Export, 2003-2009

Company	Mean export turnover, thou. LVL	Share of export in net turnover	Mean export turnover to the Baltic States, thou. LVL	Share of export to the Baltic States in net turnover	Share of export outside Baltic States in net turnover
Jaunpils pienotava	877	40.06%	50	2.55%	37.50%
Gosupi	887	37.29%	858	36.14%	1.15%
Nantecom	592	33.73%	581	33.04%	0.68%
Limbažu piens	2,907	27.36%	0.2	0.00%	27.36%
Smiltenes piens	1,289	19.69%	216	3.67%	16.01%
Rīgas Piensaimnieks	4,023	18.70%	2,292	9.65%	9.05%
Rīgas piena kombināts	8,137	17.25%	696	1.30%	15.96%
Valmieras piens	4,916	16.66%	996	3.48%	13.18%
Balbiino	1,963	15.17%	1,551	12.05%	3.12%
Eesti Juustu Tootmise	264	14.50%	190	10.42%	4.08%
Tere	5,679	11.07%	3,667	7.53%	3.54%
Saaremaa Piimatööstus	1,865	10.59%	532	3.07%	7.52%
Krāslavas piens	676	9.71%	0	0.00%	9.71%
Maag Piimatööstus	1,515	9.39%	1,080	9.38%	0.01%
Valio Eesti	2,017	7.85%	1,245	4.76%	3.08%
Tukuma piens	957	6.47%	813	5.31%	1.16%
Elpa	113	5.94%	113	5.94%	0.00%
Põltsamaa Meierei Juustutööstus	465	5.10%	0	0.00%	5.10%
Vigala Piimatööstus	19	3.08%	16	3.06%	0.01%
Dessert	34	2.74%	10	1.18%	1.56%
Cesvaines piens	201	2.45%	26	0.43%	2.02%
Saltums-2	59	1.43%	8	1.43%	0.00%
Talsu piensaimnieks	42	0.79%	38	0.72%	0.07%
Lazdonas piensaimnieks	27	0.46%	11	0.46%	0.00%
Trikātas siers	41	0.45%	2	0.14%	0.31%
Straupe	70	0.44%	10	0.44%	0.00%
DK Daugava	8	0.27%	3	0.27%	0.00%
Druvas pārtika	7	0.27%	0	0.00%	0.27%
Merriba	1	0.12%	0.2	0.12%	0.00%
Siera ražotne	0.1	0.11%	0.1	0.11%	0.00%
Siera nams	21	0.10%	0	0.00%	0.10%
Rankas piens	5	0.08%	4	0.08%	0.00%
Saidafarm	0.1	0.00%	0	0.00%	0.00%

Note: Dairy processing companies Braslas, Codori, Dundaga, Edaks, Latgales piens, Luke Farmimeierei, Mālpils piensaimnieks, Nopri Talumeierei, Richterite meierei, Unik and Zemgales piens are not shown in the table as they were not exporters.

Sources: author's calculations from companies' annual report data.

Among companies whose mean export share in net turnover was less than 1%, approximately 77% were non-integrated companies and 14% were cooperatives. This group also included two companies that both produce and process milk. Only one of the non export-oriented companies was horizontally integrated. All of the companies were in the first or second quintile by net turnover. In the group of companies with the highest mean share of exports in net turnover (those with indicator values of above 30% and Limbažu piens) approximately 69% of companies were horizontally integrated, one was vertically integrated. Two companies were non-integrated but highly export-oriented and producing curd cheese for the Baltic market.

Factors Influencing Dairy Product Exports

In order to find out which factors determine Baltic dairy companies' net turnover from export, the author carried out regression analysis using export statistics from the

companies' annual reports. Linear and non-linear regression analysis was applied to the data sub-sets separately for each year from 2003 to 2009. Database included approximately 70 factors that were examined as independent variables by means of regression analysis for their influence on dairy companies' exports. Regression analysis resulted in one factor with the highest value or R square in all annual data subsets. No other independent variables apart from turnover passed statistical tests in relatively smaller year-by-year data sets. Turnover in the analysis is used as a proxy variable for company size. Other regressors caused deterioration of determination coefficient values and statistically insignificant coefficient estimate results. As net turnover and net turnover from exports were not distributed normally, both dependent and independent variables were log-transformed. Analysis did not include companies with zero values of exports as they are not suitable for log-transformation.

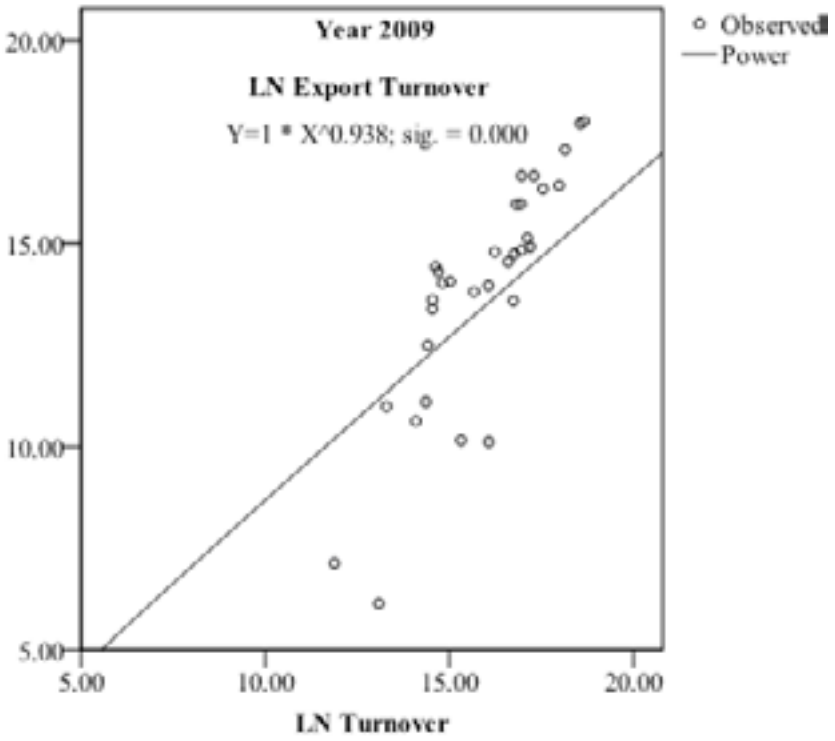

Figure 1. Baltic Dairy Processing Companies' Export Turnover Model.

Power function through origin (log-log model without a constant) was used for the reason that at annual level breakdown obtained constants were statistically insignificant. Although regression through origin must be used and interpreted with caution, both export turnover and turnover data of less than 1 were not included in initial log-transformation. Therefore, the minimum value of original variables was 1 which after log-transformation is 0; therefore, regression through origin in this case was theoretically justified and was the option available due to statistical significance considerations.

The author observed that regression line estimates were varying from year to year slightly (Figure 1). Regression analysis shows that the company size is related to larger export turnover. As both dependent and independent variables are log-transformed, it can be interpreted that regression models represent change in export turnover in case turnover changes by 1% (e.g. Arhipova and Bāliņa, 2006). Thus, analysed data allow concluding that 1% change in turnover in 2009 was associated with 0.938% change in export turnover. The author tested the obtained models with actual turnover data to determine the degree to which predicted values fit actual export turnover data. The model predictions were reasonably close to actual data, although at higher values they tended to underestimate export turnover. Therefore, the model is appropriate for conducting conservative forecasting.

In order to explore the influence of additional factors on dairy processing company turnover, the author also used multi-factor linear regression analysis. To ensure statistically significant constant and coefficient values, data of the period 2003 to 2009 were used as one data set. This may create statistical problems because the data set contains a number of time series. Large number of time series diminishes possible negative effects of this approach: 53 companies' time series were used. As the companies with substantial share of exports outside of the Baltic States market were producing cheese or milk powder, the author introduced a dummy variable for the companies that specialise in these products. Interviews with board members of several large and medium Baltic dairy processing companies converged in the opinion

that in order to become a successful producer of the main export product, cheese, previous experience of a company is important. It was deemed unlikely by the interviewed experts that a company without previous experience would be able to enter cheese export markets. Another factor used was a log-transformed return on equity (ROE) as a proxy for management quality. The third factor was a log-transformed net turnover

$$LN(exp) = -10.089+1.421*LN(turnover) + 1.073* (Cheese\_Powder) + 0.251*LN(ROE) \quad (1)$$

where LN (exp) – log-transformed turnover from exports value; LN(turnover) – log-transformed net turnover value; Cheese_Powder – dummy variable that takes value of 1 if a company specialises in production of medium soft or hard cheeses or milk powder, else 0; LN(ROE) – log-transformed value of return on equity.

The R square value for the model is 0.767; the model, its constant and coefficients were statistically significant at 95% level (Equation 1). The author checked this model using actual independent variable data of several years and established that computed values were close to actual values in 70 – 80% of cases. In cases when predictions were unreliable, other minor or company – specific factors, such as production of an extremely successful cheese brand by a medium-size company were isolated as causes of major deviations. Thus, a conclusion can be drawn that the size of a company and specialisation in major export products are important determinants of a dairy processing company's turnover share from exports.

Conclusions

1. Among dairy processing companies which generate in excess of 30% of their net turnover from exports more than two thirds are horizontally integrated. They own, are owned by other dairy processing companies or have been formed in mergers and acquisitions. This group includes largest dairy processors by net turnover in the Baltic States. Several companies are medium-sized but realise competitive export advantage due to the reason that they are a part of an international horizontally integrated company group.
2. Several dairy processing companies have been successful in achieving high share of exports in net turnover even though they are not large companies due to successful management of marketing channels. One Latvian company has achieved high exports growth by vertical upward integration into wholesale of export target markets. Two Estonian curd cheese producers have achieved high shares of exports but just within the Baltic States market.
3. Cheese is the main export product of companies that have share of exports in net turnover in excess of 30% and export more than 30% outside of the Baltic States market. With some exceptions these companies are large or belong to an integration arrangement with large aggregate turnover.
4. Among companies which are not export-oriented, generating less than 1% of net turnover from sales in foreign markets, 77% were non-integrated companies and 14% were cooperatives. All of these companies were in the lowest 1st or 2nd quintile by net turnover. As most of the export-oriented companies are integrated and large whereas most of non export-oriented companies are non-integrated and small, the paper hypothesis is proven.
5. The size of a company approximated by its net turnover is an important factor closely connected with its export turnover. Analysing the dairy processing company group which are exporting, it was estimated by regression analysis that a 1% increase in net turnover resulted in a 0.93 – 0.94% increase in net turnover from exports. Testing various models allowed the author to conclude that this estimate is conservative as most models not passing statistical tests suggested even higher export increase. Specialisation in production of major export products, cheese and milk powder is a significant determinant of dairy processing companies' net turnover from exports.
6. Most of the largest dairy processing companies tend to generate a significant share of their turnover from exports while many medium sized companies still mainly attempt to compete in the declining Baltic States market. The author suggests that in case some of the largest or upper medium size companies merge (or are persuaded to merge by means of targeted public policy), it would be possible to increase the overall exports of the dairy sector and realise the economic potential of the dairy sector to a fuller extent.

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LATVIAN SERVICES SECTOR DEVELOPMENT MODEL: INTERNET SOLUTION

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Abstract

The paper "Latvian Services Sector Development Model: Internet Solution" addresses an issue of the quality of business environment in the Latvian services sector. In the paper, there are analyzed governmentally supported information systems, data bases and e-services aiming at simplification of B2G communication process, identified their advantages and drawbacks, as well as determined potential for their further development. As a result, a model for optimization of governmental on-line tools, fostering an access to business-related information and fulfillment of administrative procedures in the services sector, has been developed. The paper provides a diversified four-layer solution, which may be progressively realized, depending on the available financial resources.
Key words: point of single contact, e-solution, information system, data base, optimization.

Introduction

The services sector is the most considerable sector of the Latvian economy, and its successful functioning is an important precondition for welfare of the country. Nevertheless, companies admit, that the main problems they face when providing services are connected with the quality of regulatory environment. The single regulation for all the services sector in Latvia or the European Union (EU) does not exist, as services have a very specific and diverse nature. The term 'service' embraces a huge variety of commercial and non-commercial activities. Parallel to traditional services sectors, new peculiar services providers appear on regular basis. Operational forms of businesses can substantially differ according to a services sector.

In order to foster the services provision in the EU internal market, there has been adopted a directive 123/2006/EC on services in the internal market (the Services directive). One of the initiatives the Services directive envisages is a creation of Points of Single contacts (PSC). PSC should ensure an access through a single gate to exhaustive information on requirements for service provision applicable in a country. In PSC any service provider should be able to easily complete all procedures and formalities necessary for access to and exercise of his or her activities by electronic means. Despite the fact that the scope of the Services Directive is quite wide (it covers such business activities as tourism, leisure services, business consultancy, construction, gardening, services provided by engineers, accountants, etc.), it explicitly excludes a number of services from its scope (e.g. financial services, electronic communications services, transport services, healthcare services, temporary work agencies' services, private security services, audiovisual services, gambling, social services), as well as services provided by notaries and bailiffs. (European Communities, 2006; European Communities, 2007). According to the requirements of the Services Directive, the single state and municipalities' portal www.latvija.lv serves as a PSC in Latvia. Currently, the Latvian PSC portal fulfils the minimum requirements of the Directive. Nevertheless, it is up to initiative of the EU member states to apply the principle of PSC to a broader range of commercial activities, not only covered by the Services Directive.

The aim of the paper is to provide a development model of the Latvian services sector, which raises an efficiency of the existing business supporting instruments, combining them into a powerful internet solution for starting services activity.

Materials and Methods

For the data analysis official data of the twelve line ministries of the Republic of Latvia (the Ministry of Economics, the Ministry of Finance, the Ministry of the Interior, the Ministry of Defence, the Ministry of Education and Science, the Ministry of Culture, the Ministry of Welfare, the Ministry of the Environment and Regional Development, the Ministry of Transport, the Ministry of Justice, the Ministry of Health and the Ministry of Agriculture), the Company Register, and other governmentally supported bodies was used. Latvian and the EU level legal acts related to the commercial activity in the services sector were studied, as well as the draft concepts for electronic solutions planned in particular services sectors analysed. Good practice of the other EU member states regarding the organization of B2G communication was scrutinized as well.

To work out the paper, the author has applied analytical and graphical methods such as a comparative method, factor determination method, specifications method, qualitative analysis and others to process and investigate the available information, as well as applied economic mathematical and statistical methods, quantitative and qualitative methods for statistical data analysis.

Based on the materials published by the State register of information systems of Latvia, state and municipality portal www.latvija.lv, twelve line ministries and the Cabinet of Ministers of the Republic of Latvia, the available information necessary for a services provision, as well as administrative procedures, which may be fulfilled electronically was

thoroughly investigated. The accessibility and transparency of the mentioned information were evaluated. As a result of the thorough investigation, a diversified solution with four possible stages of its implementation, requiring different level of financial investments, which may be implemented up to a capacity of the operational state budget was worked out.

The information on existence of similar researches and papers on e-solutions for administrative procedures in public sector in Latvia is not currently available.

Results and Discussions

The Latvian PSC portal provides information on 102 administrative procedures referable to the services activities being in the scope of the Services directive (The State and municipality portal of Latvia, 2011). However, there is still a room for making improvements in the portal. There exist various supporting tools for businesses provided by the line ministries, chambers and agencies, but companies are often not informed about them. Moreover, the single reliable web gate to up-to-date business-related information does not exist in Latvia. Some of the mentioned supporting tools even overlap. The portal www.latvija.lv may serve as PSC not only for purposes of the Services directive, but to ensure access to e-solutions for administrative requirements in other services sectors as well.

The author of the article has performed a research on e-solutions (information systems, data bases, registries, etc.) created or planned to be created inclosefuture by competent authorities in Latvia to simplify administrative procedures and facilitate B2G communication process in a particular sphere of services provision. Table 1 reflects the outcome of the investigation.

Table 1

Information systems and data basis in services sector

Competent authority	Number of services		E-solution does not exist (A+B)	E-solution exists, but is not available from PSC (A+B)	It is planned to connect e-solution with PSC (A+B)	E-solution is available from PSC (A+B)	E-solution does not exist (A+B)
	The Services directive (A)	Exemption from the Services Directive (B)					
1	2	3	4	5	6	7	4
Ministry of Defence	2	6	8 (2+6)	0	0	0	8 (2+6)
Ministry of Economics	12	11	17 (6+11)	4 (3+1)	1 (1+0)	1 (1+0)	17 (6+11)
Ministry of Finance	7	21	14 (3+11)	14 (4+10)	0	0	14 (3+11)
Ministry of Interior	4	8	5 (0+5)	7 (4+3)	0	0	5 (0+5)
Ministry of Education and Science	3	2	0	0	5 (3+2)	0	0
Ministry of Culture	1	2	3 (1+2)	0	0	0	3 (1+2)
Ministry of Welfare	3	3	2 (1+1)	1 (0+1)	4 (2+2)	0	2 (1+1)
Ministry of Transport	10	7	8 (6+2)	5 (4+1)	4 (0+4)	0	8 (6+2)
Ministry of Justice	8	1	1 (0+1)	2 (2+0)	7 (7+0)	1 (1+0)	1 (0+1)
Ministry of Environment and Regional Development	9	6	12 (6+6)	3 (3+0)	3 (3+0)	0	12 (6+6)
Ministry of Healthcare	2	13	3 (2+1)	2 (0+2)	12 (0+12)	0	3 (2+1)
Ministry of Agriculture	16	6	1 (1+0)	12 (11+1)	18(12+6)	1 (1+0)	1 (1+0)
Total	77	86	74	50	54	3	74

In table 1 the data is systemised according to the ministries responsible for a certain services sphere. The second and the third column demonstrate the number of services spheres covered by the Services directive (A) or exempted from the scope of the Directive (B). Consequently, the columns 4-7 reflect the availability of e-solutions for fulfilling administrative procedures in the mentioned services sectors. The fourth column shows the number of the services sectors, where e-solutions still do not exist, the fifth – the number of spheres, where e-solutions are created, but they are currently not available from the Latvian PSC portal, the sixth column shows the spheres, where it is planned to improve an existing e-solution or create a completely new e-solution, connecting it with the PSC portal. Finally, the seventh column demonstrates those services, where access to e-solutions is already ensured from the Latvian PSC (the Ministry of Economics, 2009; The Ministry of Regional Development and Municipalities, 2010, etc.).

Table 1 demonstrates that the Ministry of Defence is the competent institution for 2 services being in the scope of the Services directive and 6 services, which are out of the scope. E-solutions for the services activities being in the competence of the ministry of Defence (the Ministry of Economics, 2009[a]; The Ministry of Regional Development and Municipalities, 2010, etc.) are not created and planned in the closest future.

The Ministry of Economics is the competent institution for 12 services being in the scope of the Services directive and 11 other services spheres. An electronic supporting tool is not provided to 17 of the services (6 services of the Services directive and 11 the other services); there exist e-solutions for 4 services (including 3 services referred to the Directive), but they are not available from www.latvia.lv. It is planned to create an e-solution to one service being in the scope of the Services directive. However, currently the PSC portal ensures access to an e-solution for a single service, which is in the scope of the Services Directive (the Ministry of Economics, 2009[a]; The Ministry of Regional Development and Municipalities, 2010, etc.). In the same vein, in Table 1the other line ministries of Latvia are characterised as well.

According to the survey, at the moment, 42% of all the services spheres having administrative requirements stated in the Latvian legal acts are not supported by electronic solution (the Ministry of Economics, 2009; The State register of information systems of Latvia, 2011, etc.). The Ministry of Education and Science, followed by the Ministry of Agriculture has the best track record.

The services spheres where e-solutions exist could not be accessed through the PSC portal and make 18% of all the regulated services spheres in Latvia (the Ministry of Economics, 2009; The State register of information systems of Latvia, 2011, etc.). The weakest position regarding to the accessibility of the existing e-solutions with a help of the PSC portal has the ministry of Finance and the Ministry of Interior. For those services spheres no modifications in the closest future are planned. The Ministry of Economics, the Ministry of Transport and the Ministry of Environment and Regional Development plan to further develop the existing solutions of the services spheres of their responsibility; however, the number of the planned improvements is considerably lower than the number of the existing e-solutions, which are not connected with the PSC. At the same time, the Ministry of Education and Science, the Ministry of Welfare, the Ministry of Justice, the Ministry of Healthcare and the Ministry of Agriculture are to ensure e-solutions to all (or almost all) services of their competence after the planned modernization. Currently, the services spheres waiting for an upgrade of their e-solutions make 36% of all the regulated services spheres in Latvia (the Ministry of Economics, 2009a; The State register of information systems of Latvia, 2011, etc.).

As a result of the performed investigation on the existing situation concerning the electronic supporting instruments for B2G communication, the author has concluded, that in order to foster the development of the Latvian services sector, it is necessary to realize successfully the following tasks:

1. To elaborate new e-solutions to the services spheres, where the administrative e-support is currently not available;
2. To ensure an access to all the existing e-solutions from the PSC portal;
3. To ensure that the e-solutions, which are to be created in the closest future, are connected to the PSC;
4. To provide in the PSC portal the information on services spheres, where a specific regulation does not exist.

1. Elaboration of new e-solutions from scratch.

One of the best encouragements for business is the creation of e-solutions for the administrative procedures in all the legally regulated services spheres. According to the survey performed by the author, the costs of elaboration of one e-solution for an administrative B2G procedure are approximately 331 thousand EUR. For the creation of e-solutions in the governmental sector, financial support of 85% from the European Regional Development Fund ((The Ministry of Economics, 2009b; the Ministry of Finance, 2007) may also be attracted. The necessary financing from the Latvian national budget in that case is 15% or 50 thousand EUR for each e-solution. As it is shown in Table 1, currently, the number of the service spheres without any e-solution is 74. Consequently, the costs for ensuring the services sectors with e-support are as follows:

Total costs = 331 * 74 = 24,494 thousand EUR

Financing from the state budget = 50 * 74 = 3,700 thousand EUR

Unfortunately, in the conditions of the economic slowdown the allocation of such a considerable sum (3,700 thousand EUR) to the purposes of entrepreneurial facilitation in Latvia may be problematic. Therewith, other - lower cost solutions should also be considered. At the same time, to the services spheres, where an e-solution does not exist, an Estonian experience, when the PSC portal provides just a road map with instructions where a certain administrative procedure may be fulfilled and where to search for a more detailed information might be applied (The state portal of Estonia, 2011).

2. Accessibility of existing e-solutions through the PSC portal

To raise the effectiveness of the existing e-solutions created to simplify administrative procedures in services sectors, it is necessary to make those e-solutions easily accessible through the single state portal (PSC). As it is demonstrated in Table 1, in Latvia there are currently available 50 information systems and electronic data bases, which are not connected to the PSC. There exist two alternative approaches for making the mentioned e-solutions available from the PSC.

The first approach, which is a simpler solution, considers placing a link to a corresponding Internet resource (information system or e-data base) in the PSC, where a description of an administrative procedure is

currently provided. With a help of the link a user of the PSC is to be brought to the web page of a responsible governmental institution, where an e-solution could be activated. The approach does not require huge financial investments and may be even realized within the internal budget of the Ministry of Environment and Regional Development. However, the drawback of the approach is that the web pages of institutions are not harmonized and the corresponding information may be difficult to understand by an entrepreneur, who searches for the information. The user of the portal will be not able to fulfil all the administrative procedures in a single place.

The second approach considers ensuring an access to administrative e-solutions directly from the PSC portal without any moving to external Internet resources. In this case, the existing infrastructure of the PSC could be used. The PSC portal provides the authentication possibility with a help of e-signature and the electronic authentication tools of the Latvian commercial banks (Internet banking). After the authentication, a user directly accesses the personalized web page of a corresponding e-procedure, fulfils the procedure and gets the necessary reply in the PSC.

According to the investigation, the rough costs for adjusting of the PSC portal to the second approach solution could take about 36 thousand EUR for each e-solution (The Ministry of Economics, 2009b).

Financial support of 85% from the European Regional Development Fund (the Ministry of Finance, 2007) may also be attracted. Consequently, the necessary financing from the Latvian budget for the above described initiative is 15% or 5.4 thousand EUR for each e-solution. The total financing for all the 50 e-solutions, which are currently not available from the PSC portal is:

Total costs = 50 services * 36 = 1,800 thousand EUR

Financing from the state budget = 50 services * 5.4 = 270 thousand EUR

In regard with the economic downturn of Latvia, it is necessary to evaluate the possibility to integrate the existing e-solutions into the PSC portal when working out the operating state budget. There is also a possibility to gradually realize the described above approaches. The first implementation stage may consist of placing the links to the responsible institutions' external web resources on the PSC. However, the second stage, which could be implemented later, should ensure the direct accessibility to the e-solutions through the single PSC portal.

3. The accessibility of new e-solutions from the PSC portal

It is highly important to ensure the availability of the newly created administrative e-solutions from the PSC portal. In 2010 Latvian government adopted 65 priority projects, which aim to launch or develop e-governance solutions and information systems in different spheres of economy (The Ministry of Regional Development and Municipalities, 2010). As a result of an analysis of the priority projects, 17 projects to facilitate the development of the services sector, particularly if the created e-solutions are connected to the PSC portal (e.g., the Construction Information System, the Client-oriented Information System of the Ministry of Agriculture and the Subordinated Institutions, the State Environment Agency Information System, etc.) were indicated.

As the decision on creation of e-solutions has been already approved, the key task of the PSC is just to ensure an access to the e-solutions requiring comparatively low costs. There will be no need to particularly adjust the e-solutions to the infrastructure of the PSC, as it could be duly done during the e-solution creation process.

The costs of adjusting an e-solution to the PSC infrastructure are 28.2 thousand EUR on average (The Ministry of Economics, 2009b). As in the previous cases, it is possible to attract the 85% financing from the European Regional Development Fund (the Ministry of Finances, 2007). Consequently, the total costs for integration of the newly created administrative e-solutions into the PSC are 338.4 thousand EUR, including the state budget financing 50.8 thousand EUR:

Total costs = 12 services * 28.2 = 338.4 thousand EUR

Financing from the state budget = 12 services * 4.23 = 50.8 thousand EUR

Despite the fact, that the European Fund requires co-financing from the state budget, even in the situation of budget deficit, the integration of the e-solutions into PSC shall be considered as priority, as there is a considerable potential for a positive feedback in the state economy.

4. Availability of information on services spheres, where a specific regulation does not exist.

Currently, the PSC portal provides information only on services, which have a particular regulation in Latvian legal acts. However, in order to provide services having no particular legal requirements (hairdresser, business consultancy, etc.), it is necessary to meet general business requirements – to register in the Company Register, in the State Revenue Service, etc. Wherewith, the PSC search function shall be expanded – in case a PSC user searches for the legal requirements in a services sphere without any specific requirements, he or she gets information just on horizontal business requirements. An access from the PSC to the respective information systems, data bases and other e-solutions should also be ensured. Based on the study of the Ministry of Justice on the most important businesses horizontal public services (the Ministry of Justice, 2010), the author concluded, that the PSC shall provide access to at least following administrative e-services:

- Information system of the Company Register;
- Single Municipality Information System;
- Public Procurement Electronic System;
- Information System of State Labour Inspection;
- Information System on Registration of Unemployed and Vacancies;
- Information System on Taxes;
- Financial Statistics Information System;
- Information System of Central Statistical Bureau.

All the horizontal e-solutions, excluding already existing Information System on Taxes, Financial Statistics Information System and Information System of Central

Statistical Bureau are to be created in the closest future.

The stated above task may be solved by the two approaches. The low-cost approach considers placing links for the external internet resources of the mentioned e-solutions to the PSC, and it may be realized within the budget of the responsible institution.

The second approach requires financial investments. As it was already mentioned, the costs for adjusting existing e-solutions to the infrastructure of the PSC are 42.3 thousand EUR per e-solution. The costs for adjusting a newly created e-service to the PSC are 28.2 thousand EUR. The necessary costs for the realization of the project are:

Total costs = 5 services * 28.2 + 3 services * 42.3 = 140.8 + 126.8 = 267.6 thousand EUR
The financing from the state budget = 5 services * 4.2 + 3 services * 6.3 = 21 + 19.0 = 40.1 thousand EUR

The total costs for the implementation of the second approach are 267.6 EUR, including 40.1 EUR financing from the state budget. Consolidating all the information on the described above tasks and the possible solutions for their implementations, the Latvian Services sector development model was created (see Fig.1).

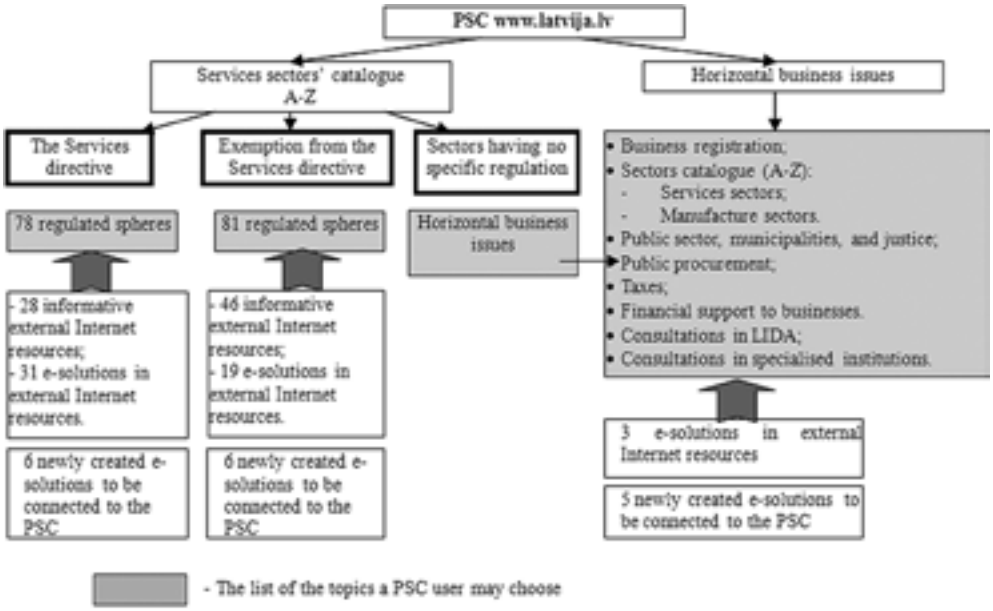

Figure 1. Latvian services sector development model.

The model proposes to modernize the PSC portal, elevating the efficiency of the B2G communication. Fig.1 demonstrates that according to the model, in the portal www.latvija.lv the PSC user can choose either to search for data referring to the services spheres (A-Z) or go on with the horizontal business-related issues. The grey background in figure 1 specifies the topics a PSC user may choose to receive the desirable information. The highlighted titles are connected with the existing e-solutions and other informative resources, which are provided by external internet channels, or integrated into the PSC infrastructure (depending on the available financial resources).

The data bases mentioned in Fig.1, information systems and other e-solutions aim to facilitate the entrepreneurial activity in Latvia. However, the integration of the e-solutions and informative resources into the single portal (PSC) will gain the synergy effect, considerably pushing the effectiveness of each particular e-resource up.

Table 2 provides the cost overview for the referred above tasks of the Latvian services sector development model. As it is demonstrated in the table 1, the minimum plan (low cost) considers ensuring the availability of e-resources from the PSC only within the internal budget of the Ministry of Environment and Regional Development. At the same time, the ideal solution, which is the high-cost solution, requires investments of 26,822.4 thousand EUR, including national financing from the state budget of 4,049.3 thousand EUR.

Table 2

Implementation costs of the Latvian services sector development model

The tasks of the Services sector development model	Minimum cost solution		Ideal solution (high-cost solution)	
	Total costs, EUR	Financing from state budget, EUR	Total costs, thousand EUR	Financing from state budget, thousand EUR
1. Elaboration of new e-solutions to the servicespheres, where the administrative e-support is currently not available	0	0	24,494	3,700
2. Ensuring an access to existing e-solutions from the PSC portal	0	0	1,800	270
3. Connecting to the PSC portal the new e-solutions, which are to be created in the closest future	0	0	338.4	50.8
4. Ensuring in the PSC portal information on service spheres, where a specific regulation does not exist	0	0	267.6 (140.8 + 126.8)	40.1 (21 + 19)
Total:	0	0	26,822.4	4,049.3

Taking into account the fact that in the closest future referring to the budget deficit the allocation of such a considerable sum (4,049.3 thousand EUR) for improvement of business environment could be hardly accepted by the government, the author also proposes a compromise solution. The compromise solution is highlighted with a grey background in table 2.

The compromise solution proposes to assign financial resources for integration of the newly created e-solutions into the PSC. The availability of all the other e-resources should be ensured by placing to the PSC the corresponding links to external internet resources. The implementation of all four tasks of the services sector development model is to be postponed and considered when working out the operating state budget.

The total costs of the compromise solution = 338.4 + 140.8 EUR = 478.8 thousand EUR
The compromise solution's financing from the state budget = 50.8 + 21= 71.8 thousand EUR

The calculations show, that the necessary for the implementation of the compromise solution financing from the national state budget is 71.8 thousand EUR.

Moreover, promoting a single web portal is a more cost effective initiative in comparison with popularization of several thematic portals. For example, it is planned that the number of users of the Company Register's Informative System will be approximately 800 per day (it is equal with the number of daily information requests in the Company Register) (the Ministry of Justice, 2010). So, the clients of the Company Register, as well as other informative systems and data bases will automatically become clients of the PSC portal. Consequently, ensuring the centralized access to all the informative e-resources and e-solutions in Latvia, as well as launching an appropriate promotion campaign, there will be considerably improved accessibility of information and, therewith, the business environment in the services sector of Latvia. At the same time, if the centralized access to all the existing governmental e-resources is not ensured, there is a risk, that the recognition of various thematic web portals will be rather low. As a result, the number of the clients of the mentioned portals will be also lower, than the number of interested persons.

Conclusions

In her research the author concluded that there is a high necessity for a centralized gate to in-depth business-related information, which ensures step-by-step instruction on all the existing administrative requirements necessary for a services activity, as well as provides a possibility to fulfil the existing formalities electronically. Currently, there are several public information systems in Latvia, which are not interconnected and have low popularity in society available. The Latvian state portal www.latvija.lv has a great possibility for becoming the best facilitator for business activity in Latvia. Based on analysis of the situation with e-governance, the author elaborated the solution on integration of existing and potential informative systems and data bases into the PSC. One of the advantages of the solution is the flexible nature – an appropriate modification of the solution may be accepted up to available financial resources.

The low-cost compromise solution proposed by the author, suggests assigning the financial resources for integration of the newly created e-solutions into the PSC. The centralized availability of all the other e-resources should be ensured by placing to the PSC the corresponding links to external internet resources. The necessary investments for the realization of the compromise solution are 478.8 thousand EUR (or 71.8 thousand EUR from the state budget).

The implementation of all the four tasks of the proposed by the author services sector development model (elaborating new e-solutions to the services spheres, where

the administrative e-support is currently not available; ensuring an access to all the existing e-solutions from the PSC portal; ensuring that the e-solutions, which are to be created in the closest future, are connected to the PSC; providing in the PSC portal the information on services spheres, where a specific regulation does not exist) requires total investments of 26,822.4 thousand EUR (or 4,049.3 thousand EUR from the state budget). Due to the financial complications in Latvia, the author considers that the full implementation of the services sector development model is to be postponed and considered when working out the operating state budget.

The implementation of the presented services sector development model will considerably improve the business environment in the services sector, fostering the development of the state economy.

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THE INFLUENCE OF DIFFERENT SOIL USE PRACTICE ON MINERAL NITROGEN CYCLE IN AGROECOSYSTEM

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Abstract

The investigations were carried out in the Lithuanian Agricultural University Water Research Institute land plots in the Endocalcari Endohypogleyic Cambisols (CMg-n-w-can). The basis of the investigation is 3 variants field experiment. Each variant consists of 3 in 0.54 ha drainage.

The traditional arable farming is applied in variant I. In the variant II the land is not being cultivated, but in spring the perennial ryegrass ('Lolium perenne L') is being seeded into the spring barley and kept till spring. In the variant III the land is not being cultivated after the harvest and left for the rest till spring.

The variant II is distinguished by the minimal mineral nitrogen content. Applied to cultivated and uncultivated land, the min N reserves are increased 51 - 83 and 33 - 40 and 11 - 101 and (38 - 134%) (to 9.5 - 14.3 mg kg^{-1} and 152 - 68 and 154 - 61 kg ha^{-1}).

The average investigation of N concentration in the drainage water shows, that the minimum concentration of this element was in the second variant. Applied to the traditional farming and uncultivated land, the N concentration is increased by (30 - 42% to 34 and 37 mg l^{-1}). By average data the min N, leaching by drainage water in the variant II was minimal and about 27 kg ha^{-1}. Applied to the arable farming and uncultivated land, the min N leching is increased (30 - 55%) (to 35 - 42 kg ha^{-1}).

Key words: soil, soil use practict, mineral nitrogen, concentration, leaching.

Introduction

In order to renew nourishments taken from the land, fertilizers are used. Thus, is their scouring from the land and water pollution danger appear. It is determined, that the mineralization of nitrogen in the swimming pool is more important process by examining N scouring than the direct losses of fertilizers (Dunn et al., 1999; Repšienė and Skuodienė, 2010). In Germany, the spread pollution by nitrogen is one of the main problems. It is forecasted, that this problem will not be handled till 2010 (Gomann et al., 2004).

Due to our climate conditions that create strong leaching process in various genetic origin soils, there is polluted gravitational water, which reaches the groundwater aquifers. The intensity of leaching greatly depends on the granulometric structure of soil. The smaller particles are in a soil, the higher its sorbtional possibilities and less danger of leaching. Many scientists indicate that the maximum danger of nutrient leaching is in the facile soils where the larger particles dominate (Cormack et al., 2003; Soon and Clayton, 2003; Chloupek et al., 2004; Crews and Peoples, 2004), however, it happens only in spring or first half of summer. In the second half of summer, especially for a small amount of rainfall, the soil is being dried, it begins to chap and the vertical openings are being formed; therefore, the danger of leaching and the surface water pollution by the dissolved nutrients are increased.

In the countries where much attention is being paid to reduction of the environmental pollution, there is an effort to keep the soil's surface overgrown by the plants as long as possible, because they accumulate the nutrients. In Sweden, Germany and other West European countries more plants, with a longer vegetation period are being grown, or various catch crops are being grown after removing the main crops. Right in Sweden by using perennial ryegrass the scouring of mineral nitrogen is decreased by (40 - 50%). However, less cropping perennial ryegrass cause the min N leaching by drainage equality to auditory variant (without grass) (Aronsson and Torstensson, 1998; Torstensson, 1998).

In Lithuania, there are not many investigations evaluating different usage influence of the land for nitrogen leaching carried out. It is determined that the min N amount in soil and its leaching are decreased in the late cultivated land than in the early cultivated land. Also, the late keeping crops help to reduce min N amount that is left in the frozen soil. It is stated that for min N amount reduction the undercrops have more importance than the late plowing (Kutra et al., 2004). It is determined in Joniskėlis, that white mustard's growing in agrosystems after corns or red clover growing in intermediate crops provides a possibility to make a better use of vegetative period. Accumulating the nutrients and keeping them in a soil, these plants protect the underground water from pollutionmore efficiently than ryegrass (Arlauskiene and Maikštėnienė, 2005).

However, it is indicated, that the main plants yield can be slightly reduced by keeping the undercrop perennial ryegrass. The reduction of the yield can cause the spring ryegrass insertion into soil (Aronsson and Torstensson, 1998).

It is determined, that by applying various tillage systems the min N amount in soil is being changed. By applying usual and minimal tillage, the less amount of $N\text{-}NO_3$ is in soil than it is in the land which was not being cultivated (Halvorson et al., 2001; Papini et al., 2002). Also, it is determined that by growing the perennial Lucerne for a

longer period, the nitrogen leaching was decreased, but the nitrogen saved in the plants and eliminated from the land was increased (Kelner et al., 1997; Entz et al., 2001). Nitrates leaching reduction also assures the maize growing (Owens et al., 1995).

However, there are opinions that undercrop growth in small amounts reduces the nitrogen leaching (Kankanen et al., 2003). It is stated, that the years meteorological conditions more affect the nitrogen leaching than various experiences of the usage of land (Stalnacke and Bechmann, 2002).

The goal of the investigation is to examine the influence of different tillage (digging up, sowing the perennial ryegrass and not cultivating the land) for the nitrogen compounds migration in agroecosystem.

Materials and Methods

The investigations were carried out in 2005-2007 in the Middle Lithuanian Lowland, LZUU Water management institution land, Juodkiskis village. The basis of the investigation – 9 drainage systems. Each variant includes 3 by 0.54 ha drainage systems. In order that one drainage system would have no impact to others, the polyethylene screens in drainage depth between them are mounted (Fig. 1).

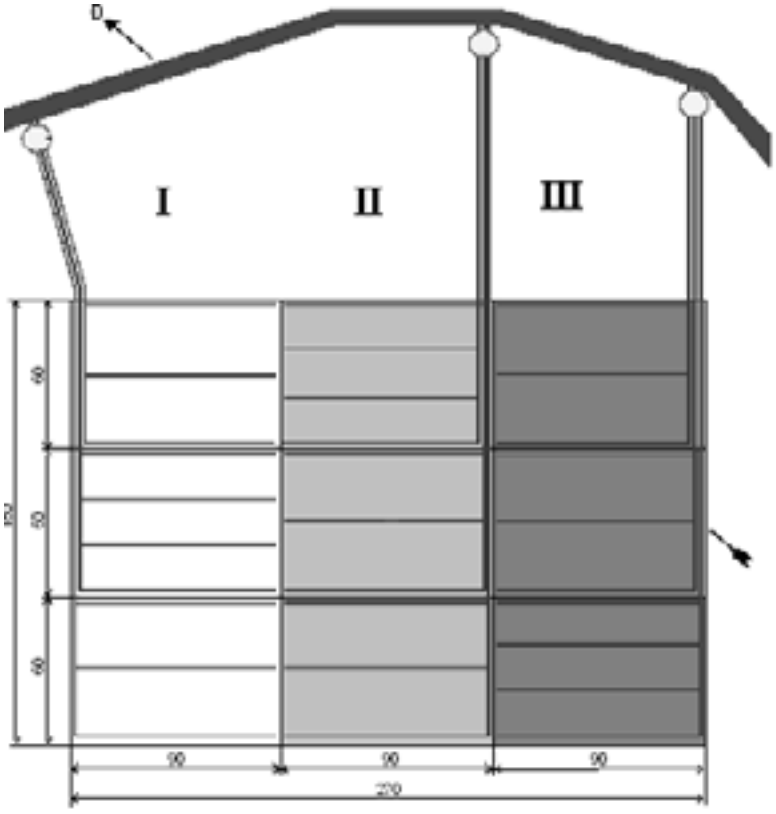

Figure 1. Proving ground scheme: Variants I-III; O – drainage water collection wells.

In 2005, the sugar beets were grown in the proving ground, but in 2006 and 2007 – spring barley. Fertilization was applied to the whole variants; in 2005 – N32P52K23, in 2006-N68 and in 2007 – N68.

In the first variant the traditional arable farming was applied. In 2005 after the harvest of sugar beets, the soil was deeply dug up. In 2006 and 2007, it was also dug up. In variant II in 2005 after the harvest of sugar beets, the soil was not dug up, but in 2006 and 2007 together with spring barley there was undersown perennial ryegrass, and it was kept there till spring. In variant III in 2005 after the harvest of sugar beets, the soil was not cultivated. It was kept non arable i for two years - 2006 and 2007. After cutting barley, the soil was not cultivated again.

Thesoil Endocalcari Endohypogleyic Cambisols *(CMg-n-w-can)*. According to the granulometric composition the test area soil is sandy loam on sand, in some places (variant III) – sandy loam on the light loam. Test area soils have many skeleton (approximately 4.7%). There is less skeleton in the upper horizons 1.5%. The large sand fraction (2 - 0.05 mm), which approximately makes 75.3%; dust 0.05 - 0.002 mm makes 17.9%. Silk fraction <0.002 mm approximately is 6.7%.

It proves that ground soil is separated by its alkaline reaction due to pHkcl>7. Besides that, there are small and medium humus (in the arable layer the average of humus is 1.2 - 2.2%), low nitrogen content (in 0 - 40 cm layer there are 46.6 kg ha^{-1} of mineral nitrogen content), average phosphorus, because of P_2O_5 in the soil is found for about 156 - 117 mg kg^{-1}, and the average potassium, because in

the arable layer K_2O is found for about 130 - 95 mg kg^{-1}.

Samples forthe agrochemical soil characteristics determination were taken with a piercer twice a year (before sowing and after the harvest), every 20 cm in accordance with genetic horizons. In each variant 3 joined samples from 10 mining holes were taken.

Drainage water flow was measured by minuend mean on every third day. Drainage water samples, in the presence of flow, were taken on every tenth day. The nitrogen concentration in the water is determined colorimetrically, NH^{4+} - by gas diffusive method, total nitrogen – occurring organic matters mineralization with potassium persulphate, NO^{3-} - by cadmium reduction method. The soil's analysis is performed by the following methods: pHkcl – potenthiometric, mobile P_2O_5 and K_2O – AL, humus – Tiurin, total N –Kjeldahl (Фомин и Фомин, 2000). Cereal and grass crops accounting area field – 30 m^2, row crops – 45 m^2. Plant yield determined by 6 - 8 replication. General energy harvest is accounted on the basis of literature (Jankauskas et al., 2000). In green production the nitrogen amount is determined by Kjeldahl method.

The data is processed by mathematical statistic methods. Disperse and correlation – regression analysis methods were applied. The errors for each variant are calculated separately (Dyke, 1994).

In the article the following symbols and abbreviations are used: r – pair correlation coefficient; η – correlation proportion; $x_{ekstr.}$ – function extremes; R_{05} – reliable (95%) difference limit, *reliable by 95%, ** - 99% for probability; V% - variation's coefficient.

Results and Discussion

The studies of mineral nitrogen content in soil have determined a great influence of sowing plants and tillage on the said rate (Table 1).

Table 1

Average mineral nitrogen content in soil, (mg kg^{-1}) in 2005 - 2007

Depth cm	Variant 1	Variant II	Variant III
2005 year			
0-20	21.6	15.95	18.4
20-40	13.25	11.50	13.8
40-60	16.9	13.2	16.25
Average	***17.1***	***13.6***	***16.1***
2006 year			
0-20	12.7	4.8	7.3
20-40	10.4	5.7	7.2
40-60	10.2	5.8	6.9
Average	***11.2***	***5.4***	***7.1***
2007 year			
0-20	9.0	2.9	5.6
20-40	9.1	3.2	7.6
40-60	6.0	2.6	6.6
Average	***8.0***	***2.9***	***6.6***
Average			
0-20	***14.3***	***7.8***	***10.4***
20-40	***11.0***	***6.8***	***9.5***
40-60	***10.9***	***7.2***	***9.9***

The findings have shown that the highest mineral nitrogen content was shown by arable farming variant. On average, over three years in conditions of arable farming mineral nitrogen content was 14.3 mg kg^{-1}. Slightly less concentration of mineral nitrogen was in variant III - not plowgh up the soil in the autumn and not working the land - 9.5 - 10.4 mg kg^{-1}. The lowest concentration of mineral nitrogen has been found in variant II, where seed plants (Perennial ryegrass) were hold until spring. On average, under those conditions, min N concentration in soil was 6.8 - 7.8 mg kg^{-1}, or 34 to 45 percent less than with conventional arable farming.

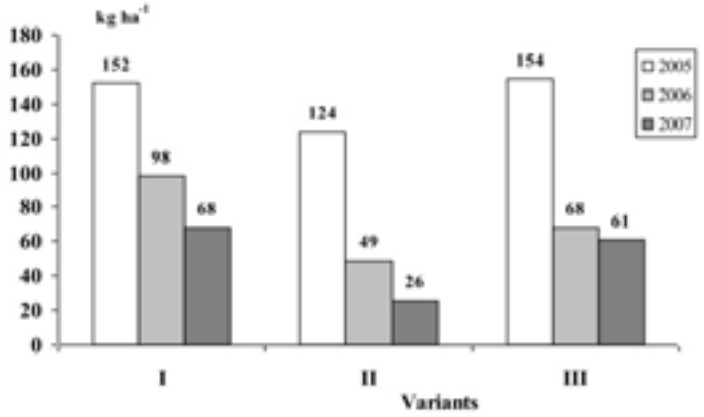

Figure 2. Average stock of soil mineral nitrogen (0 - 60 cm) in the test field during the investigation period (2005 - 2007 years).

Depending on the year, the lowest stock of min N (Fig. 2) (124 - 26 kg ha^{-1}) has been observed in variant II, where seed plants were under cultivation. Slightly higher stock of mineral nitrogen was in variant III, where the soil was not worked in the autumn, and the maximum - (152 - 68 kg ha^{-1}) in the area of conventional arable farming. In variant II, the content of this element was 24 - 14 percent less, compared to variant I.

Reconnaissance studies of sugar beet crop have showed a slight variation in their yields. The average sugar beet yield was 13.9 t ha^{-1}; scope of variation - only 3.9, mean-square error is 0.41, and the coefficient of variation - 8.9.

Examinations of spring barley crop capacity have shown that their highest yield was invariant I, with arable farming (on average - 110 GJ ha^{-1}). In variant II, where the soil was kept sown all year round, yield reduces by approximately by 24%, and comes up to 84 GJ ha^{-1} (Table 2).

Table 2

2006-2007 the average spring barley yield GJ ha^{-1}

Variants	Year		Average
	2006	2007	
I	66	153	110
II	46	123	84
III	48	98	73

The lowest yield has been in variant III, where land wasn't ploughed and hold until spring. Compared to variant I, the yield was reduced by 24%, and came up to 73 GJ ha^{-1}.

In 2006, in the second variant, where crops of perennial ryegrass were stored over winter, the yield was 77 GJ ha^{-1}, and in 2007, by analogy - 14 GJ ha^{-1}.

In some years the amount of nitrogen taken from the field with plants was inconsistent (Table 3).

Table 3

The average take of nitrogen with the yield of plants and perennial ryegrass, kg ha^{-1}

Variants	Year		Average
	2006	2007	
I	64	157	110
II	183	123	153
III	47	92	70

In 2006, the largest amount was taken from the second variant, where under crop perennial ryegrass was grown, the least one - from variant III where after taking plants, the land was not cultivated. In 2007, the highest intake of nitrogen was shown in variant I having abundant yield (arable farming) (157 kg ha^{-1}). In variants II and III, there

were 22 and 61 percent respectively, less than in variant I. The average data of nitrogen take show that, in variant II however, together with plants, the largest amount of nitrogen has been taken (153 kg ha^{-1}). And in variants I and III, the amount of nitrogen reduces by 28 and 54 percent respectively (up to 110 and 70 kg ha^{-1}).

The average examinations of nitrogen concentration in drainage water have shown (Table 4) that the lowest concentration was in variant II with keeping the soil sown by perennial ryegrass throughout the year. Thereby, in comparison to conventional arable farming (variant I), where the land was not cultivated (variant III), concentration of min N reduces: in 2006 the reduction was (9 - 16%) in 2007 - even 40 - 46% (up to 32 and 20 mg l^{-1} respectively). According to the averages, in variant II, compared to I and III, min N concentration in drainage water reduces by 24 - 30% (up to 26 mg^{-1}).

Table 4

The average annual concentration of mineral nitrogen ($N\text{-}NH_4^+ + N\text{-}NO_3^-$) mg l^{-1} in drainage water

Variants	Year		Average
	2006	2007	
I	35±3.6	33±1.3	34±2.7
II	32±2.1	20±1.8	26±2.0
III	38±5.2	37±3.2	37±4.3
R_{05}	***11.5***	***6.4***	***8.9***

Correlation-regression analysis has shown (Fig. 3) that concentration of mineral nitrogen in drainage water (y) is closely related to nitrogen take with the output of plants (x_1) and accumulated amount of min N in soil (x_2), when the taking of nitrogen with yield production from the field increases, min N concentration varies according to linearly reverse dependence (r=0.41). Meanwhile, when nitrogen reserves in soil increases, min N concentration in drainage water changes in direct-linear dependence.

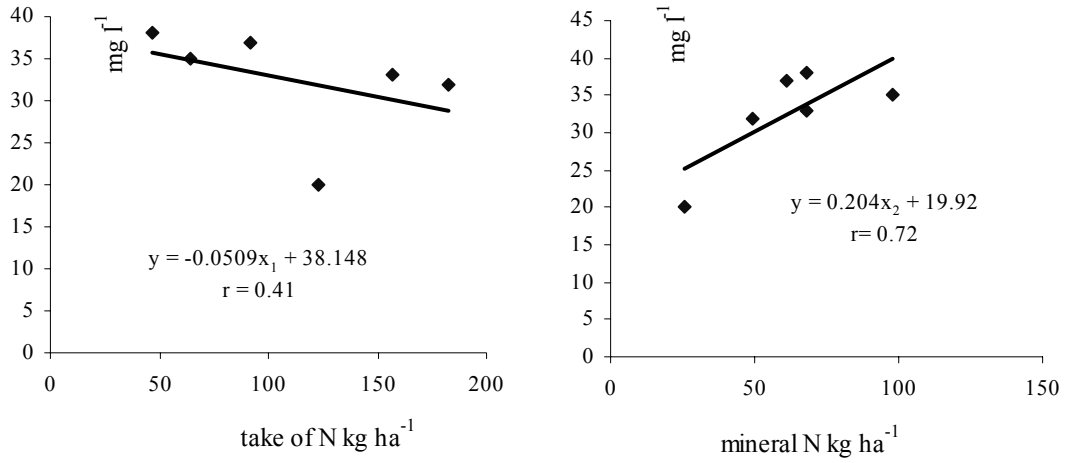

Figure 3. The average concentration of mineral nitrogen in drainage water (y) mg l^{-1} in relation to nitrogen intake with the output of plants (x l) kg ha^{-1} and mineral nitrogen stock in soil (x 2) 0-60 cm kg ha^{-1}.

The average annual data of nitrogen leaching by drainage have indicated that in 2006 the amount of nitrogen was similar and ranged from 21 to 24 kg ha^{-1}. In 2007, further keeping the undercrop of perennial ryegrass, min N leaching in variant II decreased significantly and amounted to 34 kg ha^{-1}. According to the averages, min N leaching also was the lowest in variant II with growing perennial ryegrass, 27 kg ha^{-1}. Using arable farming and not cultivating the land, agricultural min N leaching rose to 42 and 35 kg ha^{-1} respectively (Table 5).

Table 5

The average annual leaching of mineral nitrogen ($N\text{-}NH_4^+ + N\text{-}NO_3^-$) by drainage water kg ha^{-1}

Variants	Year		Average
	2006	2007	
I	21±2.2	48±1.9	35±2.1
II	21±1.4	34±3.0	27±2.3
III	24±3.3	61±5.2	42±4.4
R_{05}	***6.9***	***10.2***	***8.8***

The polynomial correlation-regression analysis has showed that min N leaching by drainage is associated with annual drainage runoff and mineral nitrogen content in soil (Fig. 4). With increasing drainage runoff and mineral nitrogen content in soil, min N leaching by drainage increases. It should be noted that mineral nitrogen leaching is more closely related to drainage runoff (r=0.9), and to a lesser extent - with mineral nitrogen reserves in soil (r=0.63).

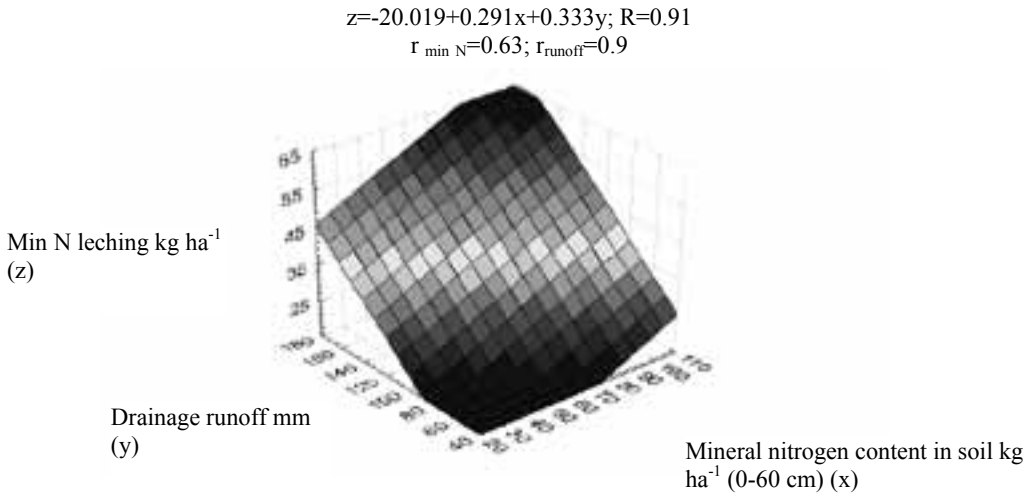

Figure 4. Connection of min N leaching by drainage (z) with annual drainage runoff (y) mm, and the amount of min N in soil (x) kg ha^{-1}.

Conclusions

The investigations were carried out in the Lithuania Agricultural University, Water Research Insititute, institute land plots in the Endocalcari Endohypogleyic Cambisols (CMg-n-w-can).), loam soil, and the following conclusions were made:

1. According to the averages, the lowest content of mineral nitrogen in soil has been revealed in the variant II - with growing perennial ryegrass (6.8 - 7.8 mg kg^{-1}). By using arable farming and not cultivating the land, min N concentration in soil increases 51 - 83 and 33 - 40% accordingly, and it comes up to 10.9 - 14.3 and 9.5 - 10.4 mg kg^{-1}. This is associated with the coefficient of field occupancy with plants.
2. According to the averages, the lowest accumulated nitrogen stock (thickness of 30 - 60 cm) has been in variant II - with growing perennial ryegrass. Depending on the year, their values changed from 124 to 26 kg ha^{-1}, which is 18 - 62% less compared to variants I and III. The maximum stock of min N (152 - 68 kg ha^{-1}) has been shown in conventional arable farming. Mineral nitrogen content in soil is reduced by soil, in which the plants are growing.
4. The highest yield of spring barley has been in variant I - with conventional arable farming, on average - 110 GJ ha^{-1}. By growing perennial ryegrass and not cultivating land, the yield of spring barely, according to the averages, has been reduced by 24 and 34% accordingly.
5. In some years, nitrogen take from field was inconsistent. In 2006, the largest amount of nitrogen was taken from variant II (growing ryegrass) (183 kg ha^{-1}). In 2007, a larger amount of nitrogen was taken from variant I - with arable farming (157 kg ha^{-1}). According to the averages, the highest take of N from the field has been in variant II (153 kg ha^{-1}), in variants I and III it decreased to 28 - 64% (up to 110 and 70 kg ha^{-1}).
6. The average examinations of mineral nitrogen concentration in drainage water have shown that, in all cases, the lowest concentration of this element

was in variant II (growing ryegrass), (according to the averages, 26 mg l^{-1}). Using conventional arable farming and not cultivating the land, concentration of mineral nitrogen increases by 30 - 42% (up to 34 - 37 mg l^{-1}). The study data have showed that concentration of min N in drainage water is closely related to nitrogen taking from the field, when this increases, the concentration decreases, and to min N concentration in soil, when it grows, concentration is also growing.

7. The average annual data of nitrogen leaching by drainage have indicated that in 2006 leaching was similar and ranged from 21 to 24 kg ha^{-1}. In 2007, further growing perennial ryegrass in variant II, min N compared to variants I and III, fell significantly (29 - 44%) and was 34 kg ha^{-1}. According to the averages, min N leaching in variant II was the lowest - 27 kg ha^{-1}. By using arable farming and not cultivating the land, min N leaching increases by 30-55% (up to 35-42 kg ha^{-1}).

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POTASSIUM BALANCE IN CROP ROTATION FIELDS WHERE SLURRY WAS APPLIED

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Abstract

In this article, the results of research on WRI of LUA Juodkiškiai experiment field (1999 – 2003) are discussed. Fertilization and other factors influence over potassium fluctuation, its balance and leaching into drainage water during crop rotation are analysed. In order to evaluate the potassium balance and its quantity passed together with rainfall, seeds, fertilizers and take with the yield (secondary and primary production) was established in plant residues and drainage water.

When fertilizing with liquid manure, potassium balance was negative while growing perennial grasses as much potassium was needed to mature their yield. The investigations established that potassium concentration in drainage water and its leaching was increased by precipitation during the research period, and it was reduced by the amount of this element taking out with yield. Soil geochemical environment had influence on the increase of potassium supply in soil.

It was established that long-term fertilization with liquid manure had raised the potassium supply in soil. However, from an ecological point of view potassium leaching did not cause any problems. In all treatments the potassium concentration in drainage water did not exceed permissible concentration.

Key words: leaching, potassium balance.

Introduction

Modernization of the large animal husbandry enterprises results in big amounts of accumulated liquid manure. Meanwhile, fertilization of fields requires the nitrogen based limitation of nutrients. For this reason, crop rotation fields receive different amounts of potassium, depending on the composition of liquid manure.

In most Lithuanian farms soils are low in potassium, so to increase the potassium content the balance intensity should be about 120 - 150% (Mašauskas et al., 2000).

The influence of mineral and organic fertilizers on the soil microflora is in a very close relation with form, rates and proportions of the fertilizers, as well as crops, physical and chemical qualities of soil and time of fertilizer application. Many scientists indicate positive impact of low amounts of nitrogen, phosphorus and potassium fertilizers and their combinations, especially when they are used systematically or in combination with organic fertilizers (Greimas, 2003; Daugėlienė and Baltramaitytė, 2005; Sapek et al., 2006; Zakarauskaitė et al., 2005).

In organic agriculture fertilization with manure results in negative NPK balance (Pekarskas, 2008; Pekarskas et al., 2008). In specialised plant production farms, application of mineral fertilizers causes deterioration of soil structure; therefore, elimination of soil organic matter mineralization losses is difficult. In potassium salts are highly soluble and they can be leached out from soil to groundwater.

Research has established low level of potassium leaching from the soils fertilized with both manure and mineral fertilizers. In hilly soils of East Lithuania experiments have been conducted to investigate the influence of various manure rates (150, 300 and 450 kg ha^{-1} N in manure) in combination with mineral fertilizers or only manure or mineral fertilizers on plant productivity and soil fertility. The results show that methods of fertilization and the indicated manure rates have no influence on the potassium losses – the amount of leached potassium is 0.3 kg ha^{-1}. No increasing potassium content is observed in any of the fertilization variants (Bundinienė, 1998).

The long-term stationary experiments have been conducted in Vokė branch of the Lithuanian Institute of Agriculture. The obtained results show the dendence of the mobile potassium content in sandy luvisol on the balance of this element during certain period. The average amount of 1900 - 2200 kg ha^{-1} of K_2O gets into the soil together with fertilizers during one rotation but cultivated crops (potato, maize) and mixtures for green mass require huge amounts of potassium to mature harvest. Therefore, in the first rotation fertilization with manure or manure and mineral fertilizers alternately does not increase potassium concentration in lysimeter water or leaching losses after precipitation. Soil fertilization in the second rotation results in the potassium concentration in the infiltration water (6.2 - 8.3 mg l^{-1}) similar to that in the first rotation (8.6 - 9.0 mg l^{-1}), but comparison with non-fertilized soil the concentration increases 1.8 - 3.9 mg l^{-1}, as in the second rotation the non-fertilized soil has significantly decreased potassium content and, consequently, the amount of the leached potassium. In the second rotation the potassium losses make 10.8 - 154 kg ha^{-1}. The amount of potassium leached out from the fertilized soil is by 3.3 - 4.6 kg ha^{-1} larger than that leached out from the non-fertilized soil (Tripolskaja, 2005).

The experiments conducted in cambisol of the Middle Lithuania have established that in the case of crop fertilization with mineral fertilizers low concentrations of potassium are leached out: in the fields of cultivated crops – 0.6, of grasses – 1.3, of cereals – 1.0 mg l^{-1}. Leaching of this element is also low – 0.7, 1.3 and 1.0 kg ha^{-1}, respectively.

The highest losses of potassium drain leaching are suffered in non-fertilized grass crop rotation. In the case of cereals and cultivated crop rotations the leaching of potassium decreases by 23 and 46%, respectively. This is related to biological characteristics and productivity of the crops (Gužys and Petrokienė, 2003).

Analysis of the influence of long-term antropogenic load on the albeluvisol qualities in Vėžaičiai branch of the Lithuania Institute of Agriculture has established that application rates of the mineral fertilizers exceeding the plant needs increase the potassium content in the soil as well as potassium leaching. The average annual potassium leaching from albeluvisol is 6.2 kg ha^{-1} (Končius et al., 2008).

This work aims to determine the ecological impact of liquid manure on natural environment as increased content of water soluble and exchange potassium can be easily leached out into ambience.

The objective of the work is to determine the influence of fertilization and other factors on the potassium soil balance and leaching out to the drainage water in field crop rotation, when liquid manure fertilization is applied.

Materials and Methods

In 1999-2003, the investigations were carried out in Juodkiškis study object of Water Research Institute of Lithuania University of Agriculture.

The experimental scheme comprises treatments I, II, III and IV in three replications (Fig. 1).

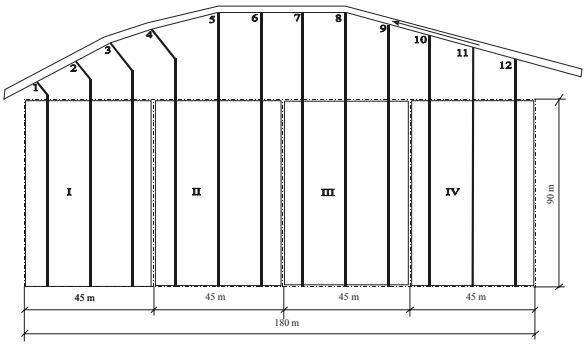

Figure1. Sceme of study object.

Treatment I – slurry applied in spring, treatment II – slurry applied in autumn; treatment III – mineral fertilizers applied, treatment IV – non -fertilized, 1-12 - number of drainage outlet.

The area of the study object (1.62 ha) is drained with drainage, drain spacing is 15 m, draining depth is 1.2 m. Three replications of each treatment are arranged on separate drains. In-between two adjacent drains there are polythene screens arranged in order to separate one drain from the other and avoid nutrient leaching from one drainage system into the other. Each separate drainage system covers the area of 0.135 ha.

The following crops were grown in the test field:

1. Spring wheat (slurry in spring $N_{62}P_{29}K_{103}$ and mineral fertilizers $N_{62}P_{29}K_{103}$);
2. Red clover, 1st year (slurry in spring $N_{41}P_{16}K_{29}$ and mineral fertilizers $N_{43}P_{16}K_{29}$);
3. Red clover, 2nd year (slurry in spring $N_{88}P_{43}K_{97}$, slurry in autumn $N_{60}P_{20}K_{63}$ and mineral fertilizers $N_{87}P_{43}K_{97)}$;
4. Sugar beet (slurry $N_{190}P_{76}K_{271}$, slurry in autumn $N_{206}P_{73}K_{206}$ and mineral fertilizers $N_{200}P_{100}K_{150}$);
5. Spring rape (slurry $N_{75}P_{32}K_{98}$, slurry in autumn $N_{59}P_{80}K_{20}$ and mineral fertilizers $N_{75}P_{32}K_{97}$).

Soil of the study object is Endocalcari-Endohypogleyic Cambisols (CM-n-w-can) (Buivydaitė et al., 2001). According to grain-size composition, the soil is attributed to sandy loam soils. In treatments I and III sandy loam soils are prevailing, in treatment II sandy loam with cohesive sandy subsoil, in treatment IV sandy loam on loam is dominant.

The soil is of alkaline reaction (pH>7), low and medium in humus content (on the average 1.47 - 2.94% of humus in the arable layer), contains low nitrogen concentrations (38.5 kg ha^{-1} N_{min} at a 0 - 40 cm deep layer). The soil is not rich in phosphorus and potassium concentrations as its arable layer contains only 76.9 kg ha^{-1} and 72.6 kg ha^{-1} of plant available P_2O_5 and K_2O respectively.

For the agrochemical analysis the samples are taken from 0 – 60 cm depth at 10 cm intervals in spring before sowing and in autumn after harvesting. All repetitions of every variant are joined into a combined sample.

Samples for the determination of drainage water chemical composition were taken once a month. Analysis of water samples were made at Chemical Analysis Laboratory of Research Institute on the basis of the methodology described in literature (Unifikuoti…, 1994).

Drainage runoff was measured every five days. During the periods of spring and autumn floods the runoff measurements were taken every day in a volumetric way. Discharges were calculated on the basis of linear interpolation, drainage runoff heights were estimated according to everyday discharges.

The investigated period is between the spreading of liquid manure in autumns of the succeeding year.

The investigated period is characterized by various meteorological conditions. Annual precipitation varied from 451.4 mm in 2003 (lower than the multiannual average 23.5%) to 615.2 mm in 1999 (higher than the multiannual average 4.3%); the highest average air temperature was 8.2 °C in 2000 and in 2002, which by 32.3% exceeded the multiannual one. Most of the precipitation was received during the vegetation period and constituted 63.6 - 72.8% of the annual precipitation.

According to the precipitation rate, the driest year was 2002 (461.8 mm) and 2003 (451.4 mm) – the amount of precipitation did not reach the multiannual norm by 21.7 and 23.5%, respectively (Table 1).

Table 1

Meteorological conditions of the study periods

Indices	1999		2000		2001		2002		2003	
	I-XII	IV-X	I-XII	IV-X	I-XII	IV-X	I-XII	IV-X	I-XII	IV-X
Precipitation, mm	615.2	391.4	583.9	394.8	580.5	394.9	461.8	297.7	451.4	328.5
% from perennial rate	104.3	98.1	99.0	98.9	98.4	99.0	78.3	74.6	76.5	82.3
Average air temperature, °C	7.8	13.9	8.2	13.1	7.3	13.5	8.2	14.5	7.1	12.9
% from perennial rate	125.8	113.0	132.3	106.5	117.7	109.8	132.3	117.9	114.5	104.9

Software "Excel 2000" and "Statistika" are used for the statistical data analysis. The data processing is performed by dispersion and correlation-regression analysis methods.

Results and Discussion

The amount taken with harvest composes the biggest output in the potassium balance. Red clover of the second-year has been established to accumulate the largest amount of potassium in their yield (161.0 - 216.8 kg ha^{-1}) (Table 2).

Table 2

Potassium amounts that are removed with harvest, kg ha^{-1}

Treatment	Spring wheat with undercrop	Red clover I year of use	Red clover II year of use	Sugar beet	Spring rape
I	42	100	217	96	88
II	42	99	167	122	63
III	44	89	216	128	78
IV	43	97	161	81	68

Although sugar beets contain the lowest amount of potassium, rich yield is the reason for big losses of this element – 81 - 128 kg ha^{-1}. Spring rape and red clover of the first year take 74 and 96 kg ha^{-1}, respectively. The lowest potassium content has been determined in the spring wheat yield (average 43 kg ha^{-1}).

Other part of potassium losses is attributed to leaching out of the soil to the drainage water.

In different seasons fertilization with liquid manure and mineral fertilizers have similar impact on the crop yield, as no essential differences among the treatments have been established (Table 3).

Sugar beets give the highest yield (the main production amounts from 4.8 to 7.4, and the secondary production – from 1.4 to 2.7 t ha^{-1}). Other plants of the rotation, red clover of the second year, produce a slightly lower yield – from 4.4 to 5.9 and from 2.5 to 3.2 t ha^{-1}. Due to the droughty investigated period, red clover of the first year produces the lowest yield: the first grass – from 1.7 to 2.1, aftermath – from 2.2 to 2.9 t ha^{-1}.

Due to unfavourable meteorological conditions in 1999, the spring wheat yield was low, and the undercrop of red clover started growing only in late autumn, when moisture content increased in the soil. In 2000, the red clover yield was also low; therefore, the impact of fertilization on the yield was not distinct. In 2001, the yield of the second-year red clover in all three variants was larger than that in the non-fertilized treatment (respectively 30, 25 and 20%).

Table 3

Crop yield t ha^{-1} (absolutely dry matter)

Treatment	Spring wheat with undercrop		Red clover I year of use		Red clover II year of use		Sugar beet		Spring rape	
	Grain	Straw	Haymaking I	Haymaking II	Haymaking I	Haymaking II	Roots	Leafs	Seeds	Stems
I	2.0	2.9	1.9	2.9	5.9	3.2	7.2	1.8	2.6	4.5
II	2.4	3.6	2.1	2.6	5.4	3.2	5.2	2.7	2.1	4.1
III	2.5	2.9	1.7	2.2	5.4	3.0	7.4	2.6	2.2	3.7
IV	2.6	3.3	2.0	2.6	4.4	2.5	4.8	1.4	2.0	3.4
R_{05}	0.5	1.0	0.2	0.2	0.7	0.5	1.6	0.4	0.7	1.3

Note. R_{05} – 95% probability level.

In 2002, fertilization increased the sugar-beet yield by 45, 27 and 61%, respectively if compared with that in non-fertilized variant. In 2003, the spring rape yield in fertilized variants was higher than that in non-fertilized ones (respectively by 31, 15 and 9%).

Strong correlative relation has been established between the spread fertilizers and the yield; correlation coefficient r=0.71, n=20. The following requirement is satisfied $t_{theor.95\ \%}=2.1<t_{fact.}=6.04$.

$$y=0.0183x+5.4041; \quad (1)$$

here y – yield t ha^{-1} absolutely dry matter;
x – fertilization kg ha^{-1}.

The investigations show that precipitation brought the following amounts of potassium into the experimental field: in 1999 – 2.2, in 2000 – 4.6, in 2001 – 3.4, in 2002 – 10.4 and in 2003 – 6.1 kg ha^{-1}.

The biggest amount of potassium taken into the soil together with the seeds was recorded in 1999: spring wheat and red clover undercrop – 2.8 kg ha^{-1}. In 2000 and 2001 the first-year and the second-year clover was grown in the experimental field, so no potassium came with the seeds. In 2002 and 2003 sugar-beets and spring rape enriched the soil with 2.7 and 0.09 kg ha^{-1} of potassium respectively.

Plant parts, i.e. roots and leaves contribute to potassium stores in the soil; however, every year plant residues contain different amounts of potassium.

Chemical analysis of plant residues has determined the biggest amount of potassium to be accumulated in sugar beet leaves – average 3.62, red clover of the first year – 1.7, spring rape and red clover of the second year – 1.52; at the end of experiments moisture deficit caused decreased potassium accumulation in spring rape – 1.34%.

Spring rape was the forecrop in the first year of the experiments. After harvesting the stems were chopped and plowed in. The amount of spring rape residue was determined and, calculations, based on the analysis data, established that the soil received 156 kg ha^{-1} of potassium. In 1999, after plowing in the spring wheat and leaves, the soil received on average 48 kg ha^{-1} of potassium. The above-ground part of red clover that regrew in autumn of 2000 died in winter; therefore, the soil received on average 36 kg ha^{-1} of potassium. In 2001, after plowing in the red clover residues, the potassium content in the soil increased by 60, and in 2002, after sugar beet harvesting and spreading its leaves on the experimental plot – by 77 kg ha^{-1}. In 2003, after plowing in the spring rape residue, the potassium content in the soil increased by 55 kg ha^{-1} on average.

As experimental variants were enriched with almost similar potassium rates, no essential differences were established among potassium concentrations in drainage water (Table 4).

Table 4

Potassium concentrations mg l^{-1} in drainage water, 1999 – 2003

Year	Concentration, mg l^{-1}				R_{05}	Fisher criterion
	Treatment I	Treatment II	Treatment III	Treatment IV		
1999	0.47	0.52	0.42	0.40	0.16	$F_{fact.}=1.11$; $F_{teor.95\%}=4.1$
2000	0.94	1.04	0.61	0.71	0.97	$F_{fact.}=0.47$; $F_{teor.95\%}=3.5$
2001	0.56	0.48	0.42	0.36	0.33	$F_{fact.}=0.61$; $F_{teor.95\%}=3.5$
2002	0.88	0.78	0.67	0.92	0.29	$F_{fact.}=2.4$; $F_{teor.95\%}=3.5$
2003	0.00	0.00	0.00	0.00	-	-

Note. R_{05} – 95% probability level.

A number of factors influence potassium concentration in drainage water – the amount of potassium that has been brought to the experimental plot together with seeds and precipitation, the amount of precipitation, fertilization, plant residues that were left in autumn for mineralization, the amount of potassium removed with harvest and potassium stores in the soil. The experimental data has established strong interrelation of these factors (r=0.95, n=20, $F_{theor.95\%}=2.1<F_{fact.}=14.5$). The results of multiple correlation show that the amount of precipitation during the test period (r=0.88), the amount of potassium brought with precipitation (r=0.44) and the one removed with harvest (r=-0.43) have the strongest influence on the potassium concentration in drainage water. Influence of other tested factors is not significant.

$$z=-1.61522+0.00426x_1-0.13698x_2-0.13698x_3+0.00007x_4 +0.04988x_5-0.001545x_6-0.00005x_7. \quad (2)$$

here: z – potassium concentration in drainage water, mg l^{-1};
x_1 – amount of precipitation during the test period, mm;
x_2 – amount of potassium, brought with seeds, kg ha^{-1};
x_3 – fertilization rate, kg ha^{-1};
x_4 – amount of potassium, brought with precipitation, kg ha^{-1};
x_5 – amount of potassium, brought with plant residues, kg ha^{-1};
x_6 – amount of potassium, removed with harvest, kg ha^{-1};
x_7 – amount of potassium in soil, kg ha^{-1}.

The potassium balance is calculated as difference between the potassium brought with precipitation, seeds, fertilizers and plant residues, and the potassium removed with harvest (the secondary and the main production) and leached out with the drainage water. The soil potassium content is also evaluated (Table 5).

Table 5

The potassium balance, kg ha^{-1}

Year	Treat-ment	Input	Output	Diffe-rence	Uptake, %	Removal from the soil, %	Stores in soil in spring	Stores in soil in autumn	Balance
Spring wheat with undercrop									
1999	I	264	42.25	221.8	16	Not required	720	798	299.7
	II	161	42.22	118.8	26	Not required	720	660	59.0
	III	264	44.16	219.8	17	Not required	450	666	435.6
	IV	161	44.3	116.7	28	Not required	474	600	243.0
Red clover I year of use									
2000	I	82.6	143.9	-61.3	174	74	654	450	-223.8
	II	50.6	135.5	-84.9	268	168	576	480	-146.5
	III	80.6	127.0	-46.4	158	58	540	600	13.6
	IV	54.6	130.1	-75.5	238	138	720	480	-283.7
Red clover II year of use									
2001	I	142.4	283.7	-141.3	199	99	720	726	-135.3
	II	102.4	210.5	-108.1	206	106	678	504	-239.2
	III	137.4	294.3	-156.9	214	114	684	462	-301.5
	IV	35.4	214.6	-179.2	606	506	450	432	-197.2
Sugar beet									
2002	I	350.1	96.9	253.2	28	Not required	558	594	289.2
	II	262.1	128.8	133.3	49	Not required	513	486	106.3
	III	240.1	122.7	117.4	51	Not required	468	456	105.4
	IV	66.1	81.9	-15.8	124	24	354	504	134.5
Spring rape									
2003	I	168.1	88	80.2	52	Not required	714	828	194.2
	II	121.2	63	58.2	52	Not required	690	924	292.2
	III	202.2	78	124.4	39	Not required	660	804	268.4
	IV	57.2	68	-10.8	119	19	483	690	196.2

According to the data, presented in the table, red clover consumed the biggest amount of potassium. To compensate the losses, red clover of the first year consumed from 158 to 238, of the second year – from 199 to 606% of the potassium, which had to be taken from the soil stores. Other cultivated plants did not require potassium supply from the soil with the exception of the control variant, which had not been fertilized, so sugar beets required additional 24, spring rape – 19% of potassium.

Leaching of potassium was under the strongest influence of the precipitation during the test period (r=0.82), the amount of potassium brought with precipitation (r=0.46) and the one removed with harvest (r=-0.25), while other factors played no significant role. Very low relations were established between the potassium balance, fertilization, plant residues, the soil potassium content and the leaching of potassium (respectively r=-0.009, r=0.02, r=0.08, r=-0.01).

$$z=-2.71939-0.00014x_1-0.46985x_2+0.00027x_3+0.10075x_4+0.00201x_5-0.00419x_6-0.00015x_7+0.00720x_8, \quad (3)$$

here: z – potassium balance, kg ha^{-1};
x_1 – amount of potassium, brought with seeds, kg ha^{-1};
x_2 – fertilization rate, kg ha^{-1};
x_3 – amount of potassium, brought with precipitation, kg ha^{-1};
x_4 – amount of potassium, brought with plant residues, kg ha^{-1};
x_5 – amount of potassium, removed with harvest, kg ha^{-1};
x_6 – amount of potassium leached out by drainage water;
x_7 – stores of potassium in soil, kg ha^{-1};
x_8 – amount of precipitation during the test period, mm.

During the test period the potassium concentrations fluctuated from 0.45 to 0.82 mg l^{-1}, leaching – from 0.2 to 1.4 kg ha^{-1} (in the fields of spring wheat with undercrop and perennial grasses, respectively).

Fertilization of the crop rotation plants has a positive influence: the soil potassium content increases (Table 6).

Table 6

The amounts of mobile potassium in the soil at the beginning and at the end of the experiment mg kg^{-1}

Sampling date	Treatment I	Treatment II	Treatment III	Treatment IV
1999 04 06	58	120	75	79
2003 09 11	138	154	134	115

The most significant increase of the soil potassium content was observed in variant I (238%), which during five years of investigations received the biggest amount of potassium (1007 kg ha^{-1}). Treatment III received 924 kg ha^{-1} of potassium; therefore, at the end of the investigations the amount of potassium exceeded that one at the beginning of the period by 179%. Treatment II received 697 kg ha^{-1} of potassium; however, it had the smallest stores of this element, which increased by 128% from the beginning of the experiments. Treatment IV received the smallest amount of potassium; however, favorable geochemical soil environment (loam layer) conditioned the increase of potassium content by 146%. According to scientific literature, the potassium balance is determined not only by the applied rotation, its productivity and fertilization system but also by soil geochemical environment (Aksomaitienė et al., 2004).

Regression analysis has established the potassium accumulation in the soil to be under the influence of several factors such as potassium removal with the main production, potassium reserve in the soil with the secondary production, potassium input with seeds, precipitation, fertilizers, plant residues and soil potassium content in spring (r=0.78. n=20. $F_{theor.95\%}=3.2<F_{fact.}=8.5$).

$$z=26.20577-0.14460x_1+0.06780x_2+0.86703x_3. \quad (4)$$

here: z – potassium accumulation in the soil after the experiment, mg kg^{-1};
x_1 – amount of potassium, removed with harvest, kg ha^{-1};
x_2– total potassium input to the experimental field during the test period, kg ha^{-1};
x_3 – soil potassium content in spring of each year, mg kg^{-1}.

It has been established that the lower yield (r=-0.54) and the higher potassium input with seeds, precipitation, fertilizers and plant residues (r=0.33), the higher soil potassium content. Supplement of spring soil potassium content by fertilization determined a reliable increase of this element (r=0.73).

Conclusions

1. The most potassium is removed with harvest, determined by fertilization (r=0.71).
2. The potassium concentration in drainage water is increased by the amount of precipitation during the test period (r=0.88) and by the amount of this element, received with precipitation (r=0.44); decreased – by the amount of potassium, removed with harvest (r=-0.43).
3. Leaching of potassium is under the strongest influence of the precipitation during the test period (r=0.82), the amount of potassium brought with precipitation (r=0.46) and the one removed with harvest (r=-0.25), while other factors play no significant role. Very low relations are established between the potassium balance, fertilization, plant residues, the soil potassium content and the leaching of potassium (respectively r=-0.009, r=0.02, r=0.08, r=-0.01).
4. A long-term fertilization increases the soil potassium content from 128 to 238%; however, leaching of potassium causes no environmental problems: in all variants the potassium concentrations in drainage water are lower than the HPC.

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RESEARCH METHODOLOGY OF SEDIMENT AERATION ZONE OF THE RIVER BANK BUFFER AREA

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Abstract

The negative impact of agricultural pollution with biogenic materials on surface water bodies is a relevant problem. This problem is addressed by limiting or prohibiting certain activities in so called buffer areas. The biogenic materials are carried by surface or groundwater runoff. Water infiltration is influenced by the lithological composition of sediments. Its structure is determined by analyzing geological and geomorphological maps and by drilling boreholes in the selected area. With the help of boreholes the level of groundwater and chemical composition of the infiltrate can be assessed. An installed system of lysimeters and piezometers in the borehole allows to monitor the change of water quality and groundwater level in vertical level of sediments over time. The set of lysimeter boreholes allows to capture and map the spacial change of these parameters. This article presents the systematic and practical methodology of drilling the lysimetric boreholes of original construction and using long-term monitoring equipment for water quality.
Key words: lithology, river basin, infiltration, lysimetric borehole.

Introduction

Water sample analysis shows the momentary state of the hydrogeological and chemical conditions at the research point. When carying it out properly there is a possibility to better understand the origin of the pollution, its extent and degree, as well as to predict the consequences. It should be noted that hydrogeological and hydrogeochemical conditions of the underground hydrosphere vary a lot in space and time, and that the groundwater is a dynamic system. Therefore, a sampling frequency and a distribution of monitoring locations in the researched area should be well analyzed and based on as much accurate and fuller assessment of geological and hydrogeological conditions as possible. This is very important because it helps to distinguish the real hydrochemical frequency from the apparent which results from sampling, storage and analysis errors. Each outside measurement or water sample which is taken for laboratory analysis also has to characterize a specific observation point. It is often only the importance of quality control and its assurance to chemical analysis emphasized. Nothing can replace good quality samples and outside meassurements taken during the research (Pozeminio..., 1999). The aim of the monitoring is always to set the true values of the processes that take place in hydrogeosphere under natural conditions. By installing a monitoring point these conditions unavoidably are being more or less deformed: the natural structure of the sediments, a separating layer for the hydraulically watery horizons are being broken, the underground watery horizon is being directly connected with the atmosphere, etc. In addition, certain conditions arise between the sediments and the monitoring point installed in them at the contact area with the wall. Because of these listed circumstances a certain error appears between the actual hydrogeological conditions of the layer and its values meassured at the point of observation. The size of this error depends on many factors – installing technology of a monitoring point, constructional features, geological and hydrogeological conditions, extent and type of underground contamination, etc.

Practically every device, in which it is possible to carry out one or another underground water status parameter meassurement, is suitable for underground water monitoring. Commonly used ones: soil lysimeter, hydrophysical surf, and lysimetric borehole. The process of a monitoring point installation always consists of two stages. In the first stage, a geological section is prospected at a certain point, in the second stage – a monitoring location is installed. During the first stage, an accurate geological section is determined – drilling and taking the kerns (sediment sample) or geophysical research conducted in the borehole (diagraph), allowing accurately and reliably identify geological section of the borehole.

Buffer areas are widely used as an effective way to protect rivers and streams from the negative impact of agricultural pollution. As it is submitted in the references, the results of the retention of nitrogen in river bank buffer area are very different (Brian et al., 2004), but overall up to 74.2 ± 4.0% nitrogen compounds can be retained in the water flowing through the river bank ecosystem. Nitrogen retention in the river bank buffer areas is happening in incoming surface water flow as well as in subsoil underground water flow. Comparing the surface and subsoil retention efficiency it was found that the average rate of retention of nitrogen compounds in ground water is 89.6 ± 1.8%, and only 33.3 ± 7.7% in surface water. In addition, the nitrogen retention efficiency in subsoil water flow contrary to the surface water flow does not depend on the width of buffer area. Most transformations of nitrogen compounds take place in subsoil water layer. Moreover, the nitrogen removal efficiency in river bank buffer areas planted with trees can change due to the features which do not depend on the width of buffer areas, i. e. nitrogen

load in the basin, soil hydraulic conductivity and the depth of a conducting layer (Pinay and Decamps, 1988; Pinay et al., 1993; Sabater et al., 2003). The balance of nitrogen and phosphorus has been studied in 4 different-age forested river bank buffer areas (two areas overgrown with gray alders were studied in Estonia, the other two – the deciduous forests – in the United States). A strong rectilinear correlation was derived between logarithmically transformed nitrogen and phosphorus load and retention in river bank buffer (where r=0.99 and r=0.997). Despite the different loads (72.9 – 110.4 kg N ha^{-1} $year^{-1}$, and 2.5 – 3.0 kg P ha^{-1} $year^{-1}$), leaching into streams was relatively small (9 – 13.2 and 0.38 – 0.62 kg ha^{-1} $year^{-1}$). Less biogenic materials were retained by older forests in the United States because younger forests were able to absorb more nitrogen and phosphorus (Mander et al., 1997).

From the data of the research that was carried out in Finland and Germany it can be seen that when fertilizing with relatively low rates of nitrogen fertilizer, the nitrate concentrations in water do not exceed the allowable limit (50 mg l^{-1}) (Saarijärvi et al., 2004; Skowron et al., 2005). Rational use of relatively low rates of mineral nitrogen influences less the leaching of NO_3^- rather than the incorrect usage of manure or other organic fertilizer (Borin et al., 2003).

More significant leaching of phosphorus is possible when fertilizing with higher rates of mineral fertilizers or manure, especially in light soils or those rich in organic matter, also when more precipitation falls than evaporates (Sims et al., 1998). Larger quantities of phosphorus are lost due to surface leakage (Turner et al., 1999). Intense leaching processes take place in Lithuania due to increased quantity of precipitation (700 – 830 mm). European Union Water Directive (Directive…, 2000) aims to restore the status of all water bodies to "good ecological status" by 2015. The Directive regulating the concentrations of nitrate ions (NO_3^-) (Directive…, 1991) provides the allowable amount for drainage water of 50 mg l^{-1} NO_3^-.

Not only the climate determines the feeding type of Lithuanian rivers and the entering way of biogenic materials into rivers. Climate influences annual watery rate and phase periods of the runoff regime. Other factors such as river basin geomorphological features, quantity of forests, lakes and swamps or land-use content structure in the basin area, and especially – the lithologic composition of the sediments, also has an influence (Litvinaitis, 2010; Litvinaitis et al., 2010; Litvinaitis, 2009). A. Dumbrauskas (2000) declared that the surface runoff formation process also largely depends on the rainfall structure. The distribution of the intensity of the rainfall however largely depends on the changing meteorological conditions.

In conclusion, it should be noted that most of the data showing a significant nutrient retention is based on the research carried out in broad (>30m) buffer areas. However, economically speaking, it is irrational to leave buffer areas of such width unused, and so the research should be focused on the buffer areas of the same size that land users could actually leave for the protection of water sources, i. e. 1 – 10 m. It is problematic however to draw definite conclusions in the shortage of such research. Research is confronted with the aeration zone and reach at least modifying the environmental monitoring of cost-type problem. The aim of this research is to develop the low-cost assessment framework for the change of quantity and quality in aeration zone and the groundwater upper layer which would be based on the usage of outside investigation equipment.

Materials and Methods

Quantitative assessment of groundwater in river basins is based on the evaluation of several environmental components (the structure of precipitation, evaporation, runoff, surface split, sediments and land use). Empiric formulas that describe the quantitative values of these components (Juodkazis, 1992) are used for assessment. In order to assess the infiltration speed, formulas for long-term precipitation are used:

$$V_i = k + kh\ s^{-1}, \quad (1)$$

for one rainfall precipitation:

$$V_i = s \times t \times k, \quad (2)$$

where V_i – water infiltration speed; k – filtration coefficient of the deposits; s – precipitation column height; h – suction force of the capillary meniscus; t –time to produce the column height s.

When the surface of sediments is very quickly saturated with water and the size $kh\ s^{-1} \rightarrow 0$ becomes close to 0. It is therefore appropriate to use a simplier formula:

$$V_i = k, \quad (3)$$

Gravitational water resource was assessed using the formula:

$$V_{gr} = \mu \times V. \quad (4)$$

where V_{gr} – gravitational water resources; μ – waterback coefficient; V – surface water volume (precipitation layer).

An important factor is regional and local river basin features, the settlement of which is often problematic. The amount of precipitation in river basins is estimated in several aspects: its quantity, duration, intensity and frequency. Data of the nearest meteorological stations is used for the research and is either interpolated or extrapolated. It is quite difficult to assess the quantity of effective precipitation, leading to the actual river basin water resources. For this it is necessarry to know the precipitation retention and interception volumes. In addition, the evaluation of evaporation and infiltration in river basins require individual outside research.

An important indicator determining underground water resources is surface sediments infiltration features. Large-scale (1:10000) lithological and soil maps are suitable for the sediment assessment. Precipitation infiltration conditions are determined by the horizontal and vertical river basin surface diffusion. One of the most important surface diffusion indicators that influences precipitation infiltration is a surface slope. Even a slight surface inclination leads to a rapid direct precipitation water run off the slope or its lower infiltration (Cesnulevicius, 1998).

The main background elements for the anthropogenic pollution are nitrogen and phosphorus compounds.

Nitrogen compounds are one of the most widespread in nature as well as the main element for plant nutrition; however, its surplus is detrimental to the environment. Evironmentally most dangerous form of nitrogen is nitrates (NO_3^-) which unlike the amonium (NH_4^+) are not absorbed by soil and are less collected by plants, thus migrate in the biosphere. About 90-98% of nitrogen leached from soil is in the form of nitrates. In addition, some of the nitrates become harmful nitrites (NO_2^-). In Lithuanian conditions, NO_3^- contrentration in soil water depends on soil features, fertilization and precipitation. Having soil humus and fertilizing with nitrogen fertilizers increased, NO_3^- concentration in lysimetric waters also rose. It also increased at a low water infiltration (Adomaitis et al., 2004; Miseviciene, 2007).

Phosphorus migrates slightly in soil and sediments. Most significant resources are of the agile phosphorus that exists in the arable layer of the soil, concentrating the main root mass of plants. There are a lot of recearchers studies (Tripolskaja, 2002; Saarijärvi et al., 2004; Cermak et al., 2005; Ulén et al., 2005) that phosphorus compounds slowly migrate in soil, therefore the leaching of phosphorus is negligible and only up to 1 – 1.5 kg ha^{-1} are leached.

The transformations of nitrogen and phosphorus compounds are affected by the oxygen quantity and acidity that exist in the environment. All these parameters can be assessed in the borehole, so the lysimetric type of borehole has been chosen for the empiric groundwater level and quality researches. This choice was influenced by following reasons:

1) during the installation process, the deformation of the natural status of sediments and underground water is minimal;
2) unified monitoring conditions are created regardless of the unconfined groundwater depth;
3) maximum depth is reached using simple technical tools and low physical effort.

Results and Discussion

A manual, original A.Litvinaitis' screw-type drilling complex was designed for the research. There are drill bits of the diameter 80 and 160 mm and drill extensions included in it. On behalf of them it is possible to scoop a borehole of up to 7 m depth. By using additional extensions in sand and sandy loam sediments, deeper leayers are possible to reach. A manual 4 AG gasoline engine was used to turn the drill bits, and a 320-kg-load capacity three-legged crane was used to uplift the drills.

The research area was mapped by making a well-balanced boreholes network. Boreholes were drilled 3, 5, and 10 m. perpendicularly to the shore. The first borehole was placed in the river bank, followed by two intermediate ones, and the last one was drilled behind the water buffer area (Figure 1).

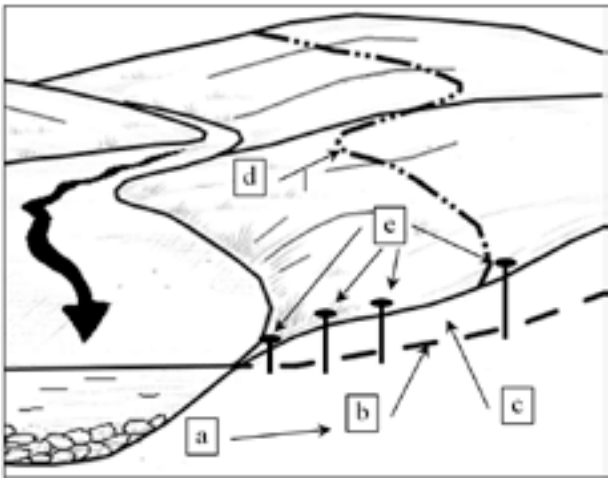

Figure 1. The Scheme of boreholes places: a – groundwater zone, b – groundwater table, c – aeration zone, d – boundary of river protection zone, e – places of lysimetric boreholes.

Samples for the water quality assessment were taken from the upper soil layer (background value evaluation), in the subsoil every 1 m deep down in the aeration zone up to depression zone. Hydrochemical parameters of the biogenic materials (ammonium, nitrates, nitrites, and phosphates), pH and oxygen quantity were investigated in water samples. Water samples for the instantaneous determination, using the portable photometer Hanna HI83206, were taken from the sediments from the uplift drill blade excluding water with the groundpress. The purpose of the groundpress designed by A.Litvinaitis – to distinguish moisture from the sediments. Subsequently, the water quality was assessed by using the chemical analysis. The moisture was removed from sediments with the help of a 30 t hydraulic press, creating a 58.5 MPa pressure in the working cylinder. In this way, gravitational and capillary water was isolated from the sediments (Figure 2).

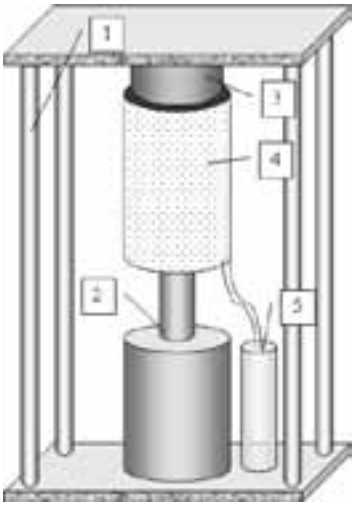

Figure 2. The scheme of the 58.5 MPa groundpress: 1 – frame, 2 – hydraulic press 30 t, 3 – piston, 4 – cylinder for sediment, 5 – water tank with a pipe.

Lysimetric boreholes were installed in order to collect laboratory water samples. Estuary of the monitoring borehole was arranged in the way that an accidental pollution could not get into the borehole (Figure 3).

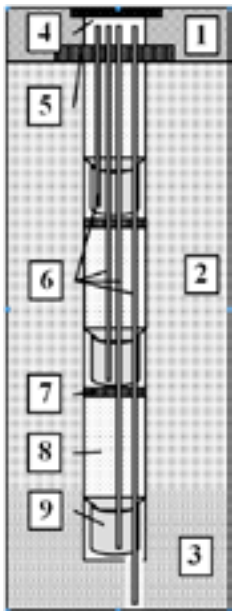

Figure 3. The principal scheme of the lysimeter bore: 1 - soil layer, 2 - zone of aeration, 3 - groundwater layer, 4 - tubes and piezometers cavity with a lid, 5 - waterproof cover, 6 - tubes and piezometers, 7 - waterproof cover, 8 – budge sediment, 9 - reservoir to trap and filter.

The estuary of the borehole is embedded with a special mechanical-resistant cover. On the cover there is an inscription identifying the borehole number and owner's contact information. Influenced by gravitational forces, water is flowing pressure downward direction. It comes into the filtration leachate tanks installed every 1 m to the groundwater surface borehole. Below the tank there is a water resistant layer installed. It prevents water seep downward. Above the tank there is a 20 mm thickness gravel infusion filter. Infusion groups are sized by the granulometric texture according to the established interlaminar coefficient (Pozeminio..., 1999), using the ratio of 7/15:

$$E = \frac{D_{80\,filler}}{D_{80sedment}}. \quad (5)$$

The part of the borehole that is above the trap and filter is poured with the uplifted sediment during the drilling. Tanks are connected with the ground surface by 4 mm PVC pipes that serve two functions: taking the filtrate, and reducing the pressure in the tank. Before taking the filtrate for research, the tanks of lysimetric well are emptied and the newly filled filtrate samples are used for laboratory research.

In 2010, during summer-autumn seasons, the device was adapted in Lithuanian rivers bank buffer areas of sandy, loamy and clay lithology.

Conclusions

The importance of the outside research assessing the anthropogenic impact on river water quality is highlighted in the literature. Researchers of the underground water quality face a problem of reaching the groundwater. The basic point of the problem is the financial part when leasing the expensive equipment. In that case modeling is in use by adapting the models to nearest lysimetric platforms which are investigated in the river basin or when similar lithologic sediments are investigated. This results in additional errors especially in those river areas which are formed in the river sediments. Acknowledging that nothing can replace good quality samples and outside measurements that are taken during the research, the importance of a specific area has to be stated. The manual screw-type drilling complex and methodology described in the article can be also used for low-budget studies. The construction of a borehole allows to carry out long-term monitorings. Instant background investigations by removing moisture from the ground with the help of pressure can be carried with the groundpress which, as shown by the research, can remove both gravitational and capillary water.

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ADDITIONAL REMOVAL OF PHOSPHORUS USING COAGULANT BY PURIFICATION OF WASTEWATER IN SAND FILTERS

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Abstract

The aim of the study was to examine the effect of coagulant PAX – 18 (polyaluminum chloride) on additional phosphorus removal in reed sand filters. Batch experiments for precipitation reaction with wastewater from septic tank and after treatment in the reed sand filter were carried out. The doses of coagulant under 200 mg L^{-1} and time of coagulation under 72 h were applied.

Coagulant PAX – 18 efficiently removes phosphorus from the wastewater. The efficacy of removal depends on the dose of coagulant and the time of coagulation. Optimal hydraulic retention time is about 40 hours.

With regard to the consumption of coagulant to remove 1 mg of P, it is most efficient to apply coagulant before wastewater treatment in the filter. During the coagulation time of 40 hours, 1 milligram of aluminium oxide precipitated 0.23 mg of P in the wastewater from the filter and 0.39 mg in the wastewater from the septic tank. In this case the removal of P was 1.65 times more effective.

Coagulant decreases the wastewater pollution according to BOD_5 and the concentration of suspended solids. Therefore, it is advisable to use the coagulant before wastewater treatment in the filter, as it reduces the organic load of filters and the possibility of filter clogging due to lower concentration of suspended solids.

Key words: phosphorus removal, constructed wetlands, coagulation, polyaluminium chloride.

Introduction

Reed sand filters so called constructed wetlands are a certain type of wastewater treatment facilities ensuring optimal conditions for natural self-purification processes of wastewater to occur. 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 et al., 1997; Haberl et al., 1995; Vymazal, 2002).

Phosphorus within constructed wetlands is removed from wastewater via physical, chemical and biological processes occurring between the wetland substratum, vegetation and wastewater stream (Kim et al., 2000). Biological oxidation of phosphorus within CW converts most phosphorus species to an orthophosphate (soluble) form (Cooper et al., 1996; Kadlec et al., 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 et al., 1993; DeBusk et al., 1999). According to R.H. Kadlec (1985), every type of 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 et al., 1999).

We calculated the efficiency of phosphorus removal in the filters of different construction. Without using additional means of phosphorus removal, on average, less than 50 per cent of phosphorus waste can be removed. In addition, the efficiency of phosphorus removal is constantly decreasing because of saturation of sand with phosphorus compounds. Research on sand filters carried out in Lithuania indicates that average total P removal efficiency in subsurface flow horizontal filters reaches 55.3%, subsurface flow vertical filters – 30.4, free water flow filters – 12.5% (Gasiunas et al., 2008).

Such chemical coagulants as alum, lime ferric chloride, and polyaluminium chloride may be used in the wastewater treatment processes. (Teleman et al., 2004; Banu et al., 2008). Aluminium and iron salts have advantages over calcium salts since they are not sensitive to pH, are easy to handle as well as produce much less sludge (Van der Houwen et al., 2001). One of them is PAX – 18, a coagulant commonly used in water and wastewater treatment.

The aim of this study was to examine the effect of PAX – 18 on additional phosphorus removal in reed sand filters.

Materials and Methods

For the additional phosphorus precipitation we used the coagulant PAX – 18 (polyaluminium chloride). The observation was carried out before and after treatment in the filter. The samples of wastewater were taken from functional wastewater treatment facilities. Batch experiments for precipitation reaction were carried out in 6 litre flasks. To evaluate removal performances of phosphorus, a desired volume of coagulant was added into the wastewater. In the certain periods of time (after 2; 24; 48; 72 h) the samples were being taken for the evaluation of parameters under research.

Table 1

Variants of the experiment

	I – wastewater from septic tank		II – wastewater from sand filter	
	mg L^{-1}	Al_2O_3, mg L^{-1}	mg L^{-1}	Al_2O_3, mg L^{-1}
PAX – 18 concentration in wastewater	0	0	0	0
	50	8.5	50	8.5
	100	17.0	100	17.0
	150	25.5	150	25.5
	200	34.0	200	34.0

Coagulant: PAX – 18 (polyaluminium chloride, Al - 9.0 ± 0.2%; Al_2O_3 - 17.1 ± 0.4%)

Not only phosphorus but also N total, BOD_5 and suspended solids were analysed in the water samples. Regression analysis was applied for mathematical analysis of data.

Results and Discussion

Reed – sand filters are usually used in wastewater treatment facilities of low capacity (up to 2000 population equivalent). If the territory is not sensitive, there is no demand for using additional means of phosphorus removal. However, there is a requirement in Lithuania that in the wastewater under discharge into environment the concentration of total P should not exceed 4.0 mg L^{-1}. Wastewater indices before coagulation are presented in Table 2.

Table 2

Wastewater indices before coagulation

	From septic tank	From filter
BOD_5 mg O_2 L^{-1}	189.0-393.0	10.9-101.0
N total, mg L^{-1}	70.2-100.0	68.1-74.6
P total, mg L^{-1}	9.2-18.0	2.8-10.1
Suspended solids, mg L^{-1}	52.0-188.0	20.0-84.0

The table shows that before starting the experiment, the initial wastewater parameters fluctuated in a wide range. Maximum concentration of total P in effluent wastewater after treatment in filter reached 10.0 mg l^{-1}, which exceeded the limit of 4.0 mg l^{-1}.

The regression analysis of data was applied to estimate P total concentration with respect to the dose of the coagulant and hydraulic retention time in the wastewater from septic tank (Figure 1) and after treatment in the filter (Figure 2). The dose of coagulant was calculated as the amount of Al_2O_3 (mg) for 1 mg of phosphorus in the wastewater before coagulation.

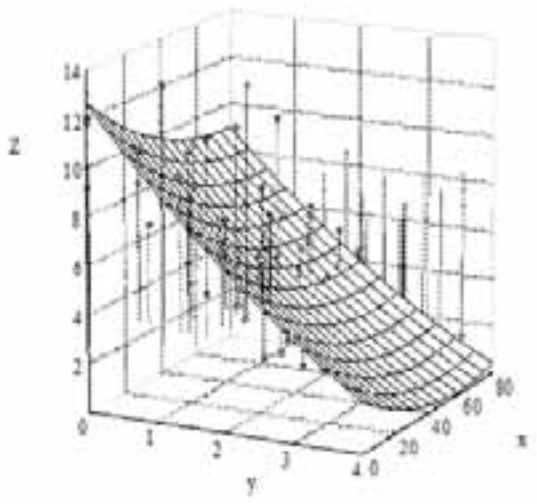

Figure 1. P total concentration with respect to the dose of the coagulant and hydraulic retention time (wastewater from septic tank).

$z = 12.64 - 0.093\ x - 3.35\ y + 0.0006\ xx + 0.006\ xy + 0.18\ yy;$ (1)

R=0.85; p<0.0000
Where:
x - hydraulic retention (coagulation) time, h
y - dose of the coagulant, mg Al_2O_3 1mg P^{-1}
z - residual P total concentration after coagulation, mg L^{-1}

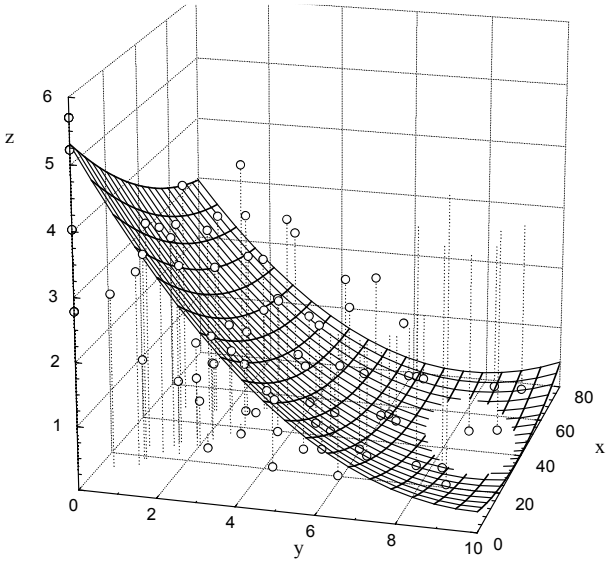

Figure 2. P total concentration with respect to the dose of the coagulant and hydraulic retention time (wastewater after treatment in a filter).

$z = 5.31 - 0.047\ x - 1.005\ y + 0.0002\ xx + 0.0031\ xy + 0.051\ yy;$ (2)

R=0.73, p<0.0000
Where: x - hydraulic retention (coagulation) time, h
y - dose of the coagulant, mg Al_2O_3 1mg P^{-1}
z - residual P total concentration after coagulation, mg L^{-1}

The graphs indicate that the concentration of P after treatment with coagulant depends on the dose of coagulant and hydraulic retention time. For both wastewater under research the graph is similar. It can be deduced from the graphs that optimal hydraulic retention time is about 40 hours.

The residual total P concentration in the wastewater was

calculated using 40 hours coagulation time and different doses. The calculation was made using the previous (in Figure 1 and 2) equations. The results of calculations are presented in Figure 3. The graph shows that with the same dose of coagulant the concentration of phosphorus in the wastewater from septic tank decreases faster than in wastewater after treatment in filters.

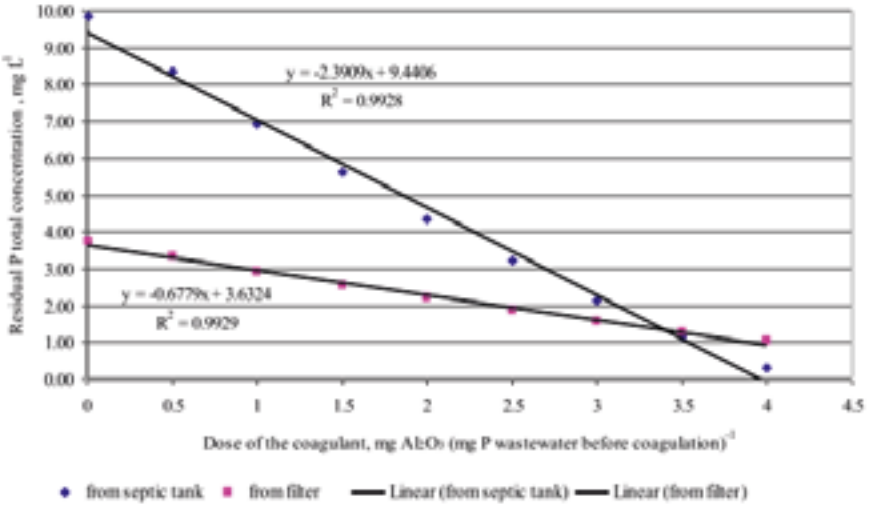

Figure 3. P total concentration in wastewater after coagulation time of 40 h with respect to the dose of the coagulant.

We evaluated the average amount of phosphorus removed per one mg of coagulant calculated as aluminium oxide. During the coagulation time of 40 hours, 1 milligram of aluminium oxide precipitated 0.23 mg of P in the wastewater from the filter and 0.39 mg in the wastewater from the septic tank. In this case the removal of P was 1.65 times more effective.

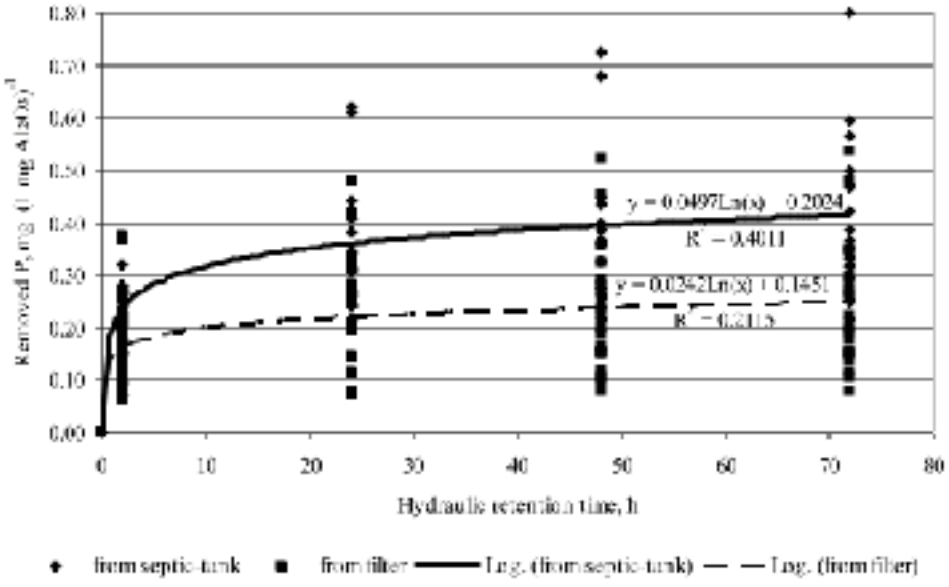

Figure 4. Average amount of phosphorus removed per one mg of coagulant calculated as aluminium oxide with respect to the hydraulic retention time.

Phosphorus is removed from the wastewater by precipitation. With the use of coagulant the concentration of suspended solids significantly reduces. Applied coagulant is more efficient in the wastewater from the septic tank, as the concentration of suspended solids there is higher. The concentrations of suspended solids after coagulation in the septic tank are presented in Figure 5.

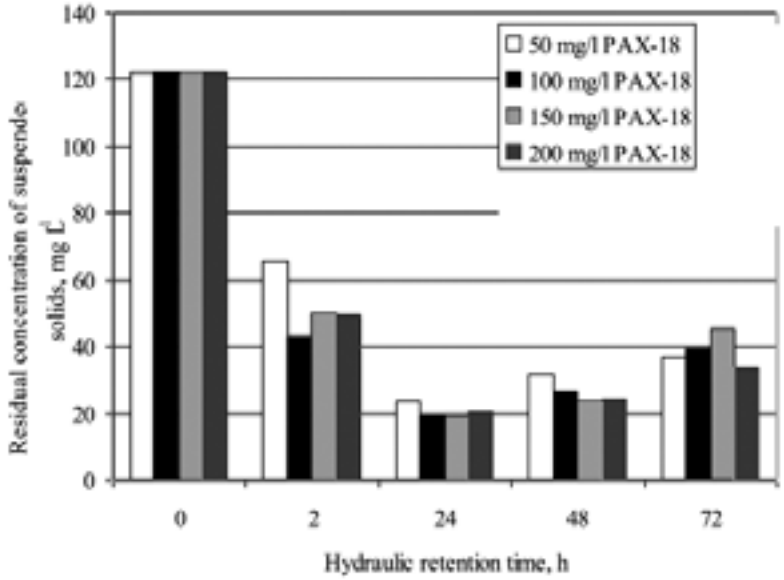

Figure 5. Residual concentration of suspended solids in wastewater from the septic tank after coagulation.

The research showed that after the use of coagulant in the case of untreated wastewater from septic tank, the concentration of suspended solids decreased about 6 times.

We calculated the effect of coagulant on BOD_5 concentration in the wastewater after 40 hours, because it was deduced as the optimal time of coagulation. The results of calculation are presented in Figure 6. The graph shows that the coagulant had little effect on the wastewater already treated in the filter. However, with the increasing coagulant dose in the wastewater from the septic tank the concentration of BOD_5 was considerably decreasing.

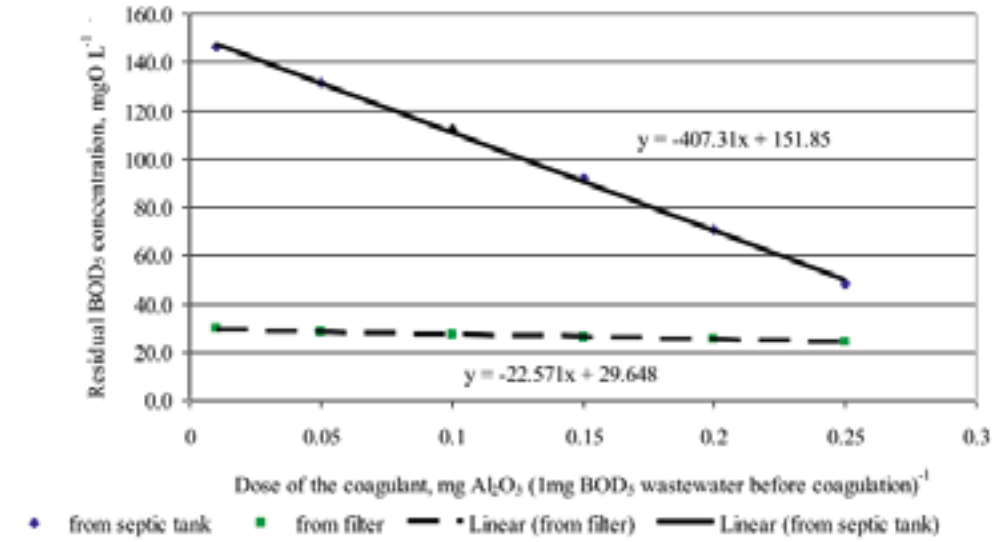

Figure 6. BOD_5 removal with respect to the dose of coagulant and time of the coagulation of 40 h.

Conclusions

Coagulant PAX – 18 (polyaluminium chloride) efficiently removes phosphorus from the wastewater. The efficacy of removal depends on the dose of coagulant and the time of coagulation. Optimal hydraulic retention time is 40 hours.

With regard to the consumption of coagulant to remove 1 mg of P, it is most efficient to apply coagulant before wastewater treatment in the filter. During the coagulation time of 40 hours, 1 milligram of aluminium oxide precipitated 0.23 mg of P in the wastewater from the filter and 0.39 mg in the wastewater from the septic tank. In this case the removal of P was 1.65 times more effective.

Coagulant decreases the wastewater pollution according to BOD_5 and the concentration of suspended solids. Therefore, it is advisable to use the coagulant before wastewater treatment in the filter, as it reduces the organic load of filters and the possibility of filter clogging due to lower concentration of suspended solids.

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REMOVAL OF THE ORGANIC POLLUTION FROM THE DAIRY WASTEWATER OF THE MILK COLLECTION STATION IN THE DIFFERENTLY CONSTRUCTED SAND FILTERS

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Abstract

In 2003 an experimental model of the dairy waste water cleaning facility was equipped for cleaning the wastewater of the milk collection station. We examined the possibilities to destruct the organic pollutants present in the dairy wastewater in the sand filters of vertical and horizontal filtration. The pollution level of the dairy wastewater is from 2 to 4 times higher than that of the domestic wastewater. The dairy wastewater was cleaned following the procedure: cleaning in the aeration-flocculation system-cesspool-two stage sand-reed filter.

The pollution of the wastewater leaving the cleaning facility never exceeded the allowable norms. The average BOD_5 was 4 mg O_2 L^{-1} and the maximal value was 9.6 mg O_2 L^{-1}. The investigation revealed that the horizontal sand-reed filter with the filtration path of 7 meters ensured cleaning of the dairy wastewater up to the allowable norms. The organic pollutants were cleaned with the efficiency of 97.2% after filtration through such a sand layer.

In order to find out the possibilities of vertical filtration filters use for cleaning the dairy wastewater leaving the milk collection stations, we performed a modelled investigation. The wastewater cleaning efficiency in respect to BOD_5 reaches 99.3% in these filters. The calculation according to the regression equation received showed that filtration through 0.6 m sand layer ensured successful cleaning of the wastewater up to the allowable norms. In such a vertical filtration filter the average BOD_5 cleaning level was 20 mg O_2 L^{-1}.
Key words: organic pollutants, sand filters, wastewater cleaning, filtration path.

Introduction

The pollution level of the wastewater leaving the milk collection stations directly depends on the loss of milk and the quantities of the water used. These factors are dependent on the level of technologies and the work-place culture. As the experience shows, most milk losses happen when the tank cars and refrigerator tanks are emptied carelessly and reach 0.26 kg BOD per ton. The highest pollution level of the dairy wastewater with the organic pollutants (BDS_5 parameter) is measured when the tank cars are cleaned. The pollution level reaches 1565 - 2130 mg O_2 L^{-1} because up to 10 l of milk are left in the tank cars. The lowest level of pollution is measured when the premises and the refrigerator tanks are cleaned, and it reaches 617-826 mg O_2 L^{-1}. The milk entering the public sewerage can drastically increase the pollution of the domestic wastewater. In small villages where the domestic wastewater is cleaned in the biological wastewater cleaning facilities, the sudden increase in pollution (the so-called shock of pollution load) starts interfering with the established wastewater biooxidation processes. Therefore, the pH level starts decreasing (the wastewater grows acidic) and this in turn reduces the efficiency of the facilities for long. Afterwards a lot of efforts are needed to stabilize the performance of the wastewater cleaning facilities (Strusevičius, 1996). Therefore, it is advisable to clean the dairy wastewater leaving the milk collection stations and containing high levels of organic pollutants separately from the domestic wastewater. The sand-reed filter is one of the options.

The more the wastewater is polluted, the more difficult is its biological cleaning. The pre-treatment in the septic systems is not enough. Due to this reason, the wastewater cleaning technology needs the primary cleaning stage. During this stage the pollution of the wastewater as regards BOD_5 is reduced to 400 - 600 mg O_2 L^{-1} and the further biological treatment is continued in an aerotank (Henze et al., 1995; Šeškevičius, 1977). Nowadays, the hydration and carbonization method is becoming more and more popular and widely used for the primary cleaning of the highly polluted wastewater (BOD_5 reaches 1200 - 6000 mg O_2 L^{-1}) leaving the meat processing companies (Strusevičienė and Strusevičius, 2001; Strusevičius et al., 2002). When this method is applied, the BOD_5 parameter showing the pollution of the wastewater with the organic pollutants decreases by 50%. In the territory of UAB "Agaras" the sand-reed filters are equipped and the biological wastewater cleaning process is going on without any use of the electric power (Gasiūnas and Strusevičius, 2003; Strusevičienė and Strusevičius, 2004).

With the help of the primary cleaning stage even the highly organically polluted dairy wastewater of the milk collection stations can be cleaned up to the allowable norms. However, there are cases when the air blast or the chemical material dosing equipment breaks and the primary cleaning stage goes down. Therefore, it is necessary to learn the possibilities for the wastewater cleaning facilities to function without the primary cleaning stage.

Recently, the sand-reed filters of vertical filtration (VF) are becoming very popular. They take much smaller areas than the horizontal filtration (HF) filters. When calculating their efficiency for one surface area unit, the BOD_5, COD and suspended solids are removed better in these filters than in the horizontal filtration filters. When the BOD_5 load

on the filters is the same and equal to 4 g m^{-2} d^{-1} the organic pollutants are removed with the efficiency of 97.0% in the vertical filtration filters and only with 77.5% efficiency in the horizontal filtration filters. In order to reach the normative BOD_5 cleaning level which is equal to 25 mg O_2 L^{-1}, the load exerted on the vertical filters has to equal 19.0 g m^{-2} d^{-1}. In the horizontal filters 6 g m^{-2} d^{-1} load is enough (Gasiūnas and Strusevičius, 2006).

The aim of our investigation is to find out the possibilities to remove the organic pollutants from the dairy wastewater in differently constructed sand filters.

Materials and Methods

We performed the research on the dairy wastewater in the milk collection station's wastewater cleaning facility located in Padargupiai village, Ariogala Eldership territory, Raseiniai district in the years 2003-2008. The estimated amount of the wastewater was 5 m^3 $d^{-1,}$ but as the production volumes increased, it rose to 12.5 m^3 d^{-1}. The dairy wastewater was flowing through two sewage collectors into the well-type pumping station. With the help of the pumping station the dairy wastewater ran through the pressure line into the aeration-flocculation system (which useful volume was 8 m^3). In the reaction chamber of this system the wastewater was treated with the chemical material and air mixtures, and after that it left for the setting chamber (which useful volume was 8 m^3). After leaving the cesspool, the dairy wastewater was entering 2 consecutively connected sand-reed filters. Coarse sand was used to equip the filters. The particles smaller than 0.2 mm made no more than 10% of the sand, its porosity was 30% and the filtration coefficient equalled 16 m d^{-1}. Both these filters had the same size and took 200 m^2 each. The total length of the filtration path (made of the sand media) was 10 m. After the treatment in the filters the dairy wastewater that satisfied the norms was poured into the reclamation trench.

We performed the research on cleaning of the dairy wastewater in the modelled filters of vertical filtration in 2007. The dairy wastewater leaving the same milk collection station which had undergone the pre-treatment was used for our research. The area taken by the vertical filter model was 0.2 m^2. Taking into account the experience of other authors (Gasiūnas and Strusevičius, 2004), the length of the wastewater filtration path was made equal to 0.8 m. Also, the second vertical filter model with the same diameter and a different length of the filtration path was equipped. The length of the filtration path of this filter was 0.4 m. Both filters received the same dairy wastewater. On the background of the data received, the dependence equations were created. The dependencies of the possibilities to remove the main pollutants from the dairy wastewater on the length of the dairy wastewater filtration path were taken into account.

The coarse sand was used to equip the vertical filter model. The filtration coefficient of the sand was 39.5 m d^{-1} and the ratio of the sand particles was d_{60}/d_{10} – 5/6.

The research lasted for 3 months. The production environment was imitated and the dairy wastewater was poured into the models twice per day daily. The samples were taken twice per month.

The analyses of the wastewater were conducted in the certified chemical analysis laboratory of the Water Management Institute of the Lithuania University of Agriculture. The unified methods were applied (The unified methods of the wastewater …, 1994).

Results and Discussion

The main index used to evaluate the efficiency of the cleaning facility is BOD_5. It integrates all the quickly decomposing organic pollutants best. To coagulate the pollutants, the quicklime (CaO) was supplied into the reaction chamber. Its quantity was 1 kilo per 1 m^3 of the dairy wastewater. 90% of the wastewater was collected in the milk collection station in the period of 5 hours; therefore, it was very important to use such a chemical material which could clean the wastewater in as short time as possible. That is why the coagulation material "ZETAG 8660" was becoming more and more popular and almost displaced the quicklime in such cases. For 1 m^3 of the dairy wastewater 4 g of the coagulation material were used. This coagulation material had the following exploitation advantages as compared to the quicklime: its dosing was very simple (it is dissolved in the water and dripped into the wastewater from a dish with a spout) and the amount of sediments setting in the cesspool was much lower. When this coagulation material was used, the wastewater was cleaned with the efficiency of 70% under the laboratory conditions. A very similar efficiency was observed when the quicklime was used. In the primary cleaning stage of the real production environment such results were not achieved. The organic pollutants were removed from the wastewater with the low 30% efficiency. Many factors influenced this phenomenon. Among them were: the regime of temperature, inaccurate dosing of the chemical material, lower than necessary capacity of the reaction and setting chambers for the increased amount of the dairy wastewater. The average of the BOD_5 parameter showing the average pollution of the dairy wastewater was 821 mg O_2 L^{-1} (the minimal value was 369 mg O_2 L^{-1} and the maximal value was 1388 mg O_2 L^{-1}) before cleaning and it was 521 mg O_2 L^{-1} (the minimal value was 103 mg O_2 L^{-1} but the maximal one was 926 mg O_2 L^{-1}) after cleaning with the chemical material. As the dairy wastewater of the milk collection station which had undergone the primary cleaning still was twice as much polluted as the domestic wastewater and the sand-reed filter was used to clean the dairy wastewater in our republic for the first time, we had no experience. Therefore, we increased the filtration path from its usual length of 5 m up to 10 m. The dairy wastewater was cleaned up to 4 mg O_2 L^{-1} on average after filtration through 10 m long sand layer and the maximal pollution level of the dairy wastewater leaving the filter barely reached 10 mg O_2 L^{-1}. It is clear that 10 m filtration

path was too long. The length had to be reduced to such a number which would approximate the pollution level to the norms. This would guarantee lower construction costs. The dairy wastewater samples were taken in two points only: after passing 5 m and 10 m filtration path. The research revealed that filtration through 5 m sand layer was not enough to clean the dairy wastewater up to the allowable norms. 88.5% of the organic pollutants were removed but the pollution level of the dairy wastewater in many cases did not meet the ecological requirements (the average of the BOD_5 pollution index was 60 mg O_2 L^{-1}), the dairy wastewater had a blackish colour and cleared only after a while.

In order to assess the pollution level of the wastewater at any point of the filtration path, we calculated the dependencies of the possibilities to remove the organic pollutants from the dairy wastewater on the length of the filtration path (Figure 1).

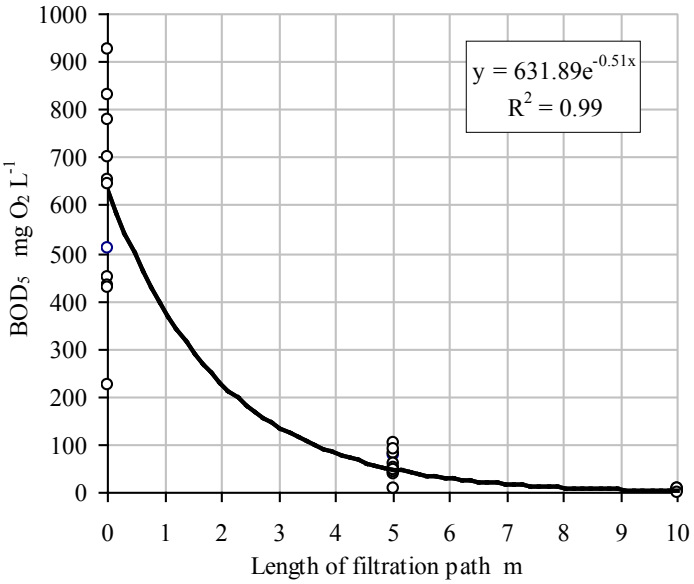

Figure 1. Dependence of the possibilities to remove the organic pollutants from the dairy wastewater on the length of the filtration path.

With the help of the dependence equation received, we estimated the amounts of the organic pollutants present in the dairy wastewater after its filtration through the different layers of the sand. The calculation results are given in table 1.

Table 1

Dependence of the possibilities to clean the dairy wastewater in the sand filter of horizontal filtration on the length of the filtration path.

Index, mg O_2 L^{-1}	Length of the filtration path, m										
	0	1	2	3	4	5	6	7	8	9	10
BOD_5	632	381	229	138	83	60	30	18	11	7	4

We can see from the data presented in table 1 that 10 m length filtration path was too long to clean the dairy wastewater up to the allowable norms. In order to reach the normative cleaning level, the filtration path of 7 m is enough. In such a sand-reed filter the average wastewater pollution as regards BOD_5 reaches 18 mg O_2 L^{-1} and the cleaning efficiency is 97.2%.

Big land plots are needed to equip the sand-reed filters of horizontal filtration for cleaning the dairy wastewater in the milk collection stations. As we have already mentioned, the milk collection stations are located in the rural areas and the land costs are not that high there. The popularity of the filters is backed on their positive qualities: simple exploitation and the abundance of the local material used for their construction. These filters meet the requirements of Hygiene and Ecology and their use has a future.

The milk collection stations are located in the rural areas, and as the long lasting experience shows, the cleaning equipment in these stations is used inadequately. The milk collection station that we examined was not an exception. For a long period of time the primary cleaning of the dairy wastewater was not performed: the chemical material, i.e. the quicklime or coagulation material "ZETAG 8660" were not used even if it was foreseen in the project and the aeration-flocculation system was not functioning. That is why it was possible to learn the possibilities of cleaning

the highly polluted dairy wastewater in the sand-reed filter without its primary cleaning. For our research we used the data of the environment monitoring. Only the overall efficiency of the dairy wastewater cleaning was assessed: only the pollution of the incoming and the outgoing dairy wastewater was estimated. In the two stage septic system and the sand-reed filter the organic pollutants were removed from the chemically untreated dairy wastewater with the efficiency of 98.8%. Despite the fact that the average organic pollution level of the incoming dairy wastewater was the same during both our research periods (BOD_5 level was equal to 821 mg O_2 L^{-1}), the pollution of the untreated dairy wastewater after it left the sand-reed filter was 6.2 mg O_2 L^{-1} higher. As figure 2 shows, the pollution of the outgoing dairy wastewater fluctuated in the wide range (it was changing 14.7 times). This phenomenon depended on the initial pollution level of the dairy wastewater: when the pollution level of the incoming dairy wastewater reached 1300 mg O_2 L^{-1}, the pollution level of the outgoing dairy wastewater approached the allowable 30 mg O_2 L^{-1} norm. Therefore, in order to save the environment and not to cause any damage to it the organically polluted chemically untreated dairy wastewater can be cleaned in the two stage septic system and the sand-reed filter only up to the established pollution norm.

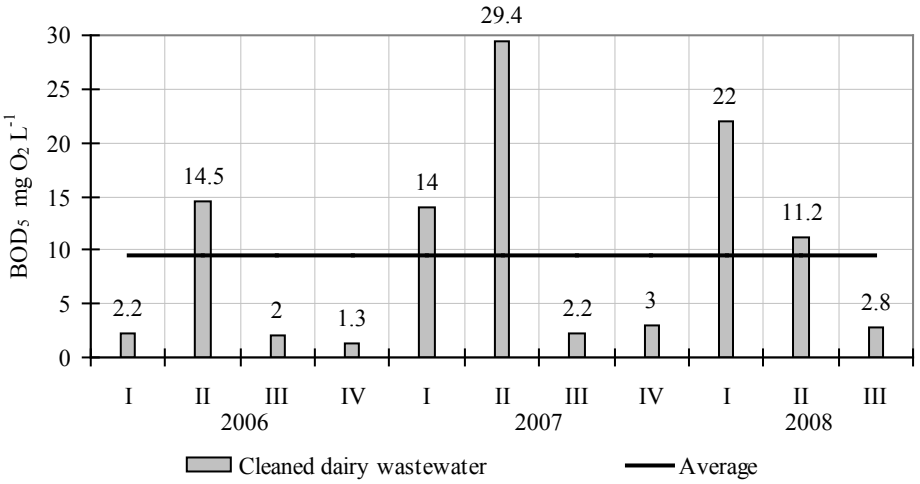

Figure 2. The dynamics of the BOD_5 index showing pollution of the dairy wastewater pre-treated in the septic system and cleaned in the sand-reed filter.

On the background of the results received the functional dependence of the possibility to clean the dairy wastewater on its initial pollution with the easily decomposing organic pollutants was assessed (as regards the BOD_5 index) (Figure 3).

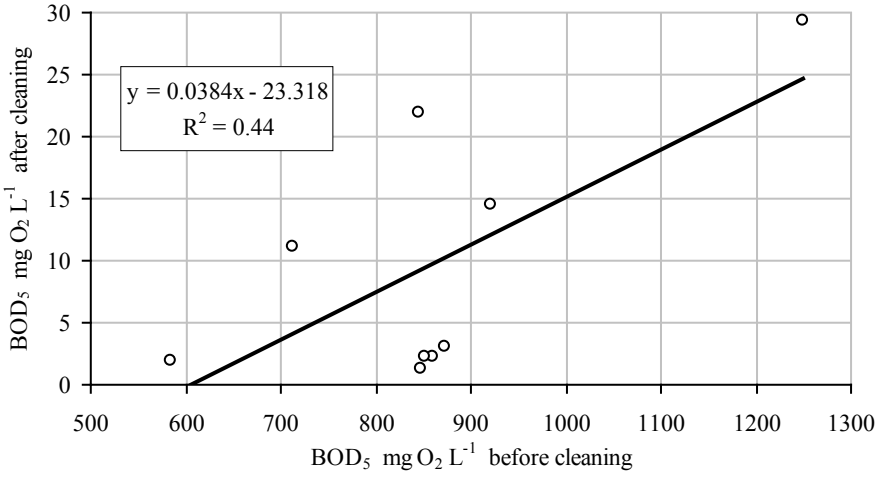

Figure 3. The dependence of the possibility to remove the organic pollutants from the dairy wastewater on its initial pollution level.

According to our regression calculations, in order to ensure an adequate cleaning of the dairy wastewater up to the allowable norms skipping the primary cleaning stage, the amount of the easily decomposing organic pollutants in the dairy wastewater of the milk collection stations cannot exceed 1400 mg O_2 L^{-1}. Despite the fact that the dairy wastewater was cleaned up to the allowable norms in the facility, the layer of the dairy wastewater used to accumulate and concentrate on the surface of the first filter. This phenomenon depended on the fact that the amount of the suspended particles entering the first filter was too high and it slowed down the filtration process. Under the anaerobic conditions the reeds disappeared. Their disappearance worsened the cleaning process in the sand-reed filter because the deep system of the reed roots acted in the whole filtration profile and the root tips which grew and decayed periodically constantly hoed the sand filter and supported its good filtration qualities. Furthermore, the reeds aerated the filter very well and in such a way improved decomposition of the organic pollutants. The second sand-reed filtration stage went on smoothly and without disturbances (the reeds did not disappear, and it was never flooded with the diary waste).

The variously polluted dairy wastewater of the milk collection station which had undergone the primary septic treatment was used in the vertical filter model. Its BOD_5 index showing pollution of the dairy wastewater with the easily decomposing organic pollutants fluctuated from 332 O_2 L^{-1} to 860 O_2 L^{-1} and depended on the quantity of the water used to clean the premises. The average pollution level was 600 O_2 L^{-1}. The organic load was changing from 10 to 26 BOD_5 m^2 d^{-1}. When the dairy wastewater was passing 0.8 m sand layer, 99.3% of the organic pollutants were intercepted on average. Even in the case when the dairy wastewater was 3 times more polluted than the domestic wastewater and reached 860 O_2 L^{-1}, the pollution of the dairy wastewater leaving the filter was equal to 12.4 mg O_2 L^{-1} (Figure 4). As the long-term investigation of the dairy wastewater in the milk collection station located in Padargupiai village revealed, the maximal pollution with the organic pollutants reached 1388 mg O_2 L^{-1} and the average value was 821 mg O_2 L^{-1}. Therefore, the pollution level must be reduced with the help of the coagulation material "ZETAG 8660". When 4 g are poured into 1 m^3 of the dairy wastewater, the organic pollution decreases down to 68% in 6 hours and on average does not exceed the pollution level of the domestic wastewater. In this case, the organic load on the filter decreases 1.5 times.

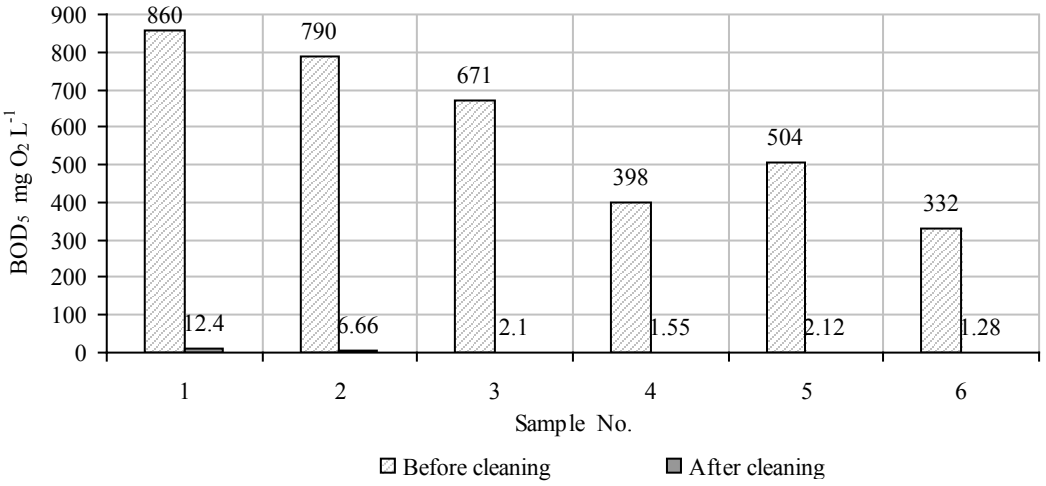

Figure 4. The pollution level as regards the BOD_5 index of the incoming and the outgoing dairy wastewater in the vertical sand filter model.

Due to the economic reasons, it is important to find out the thickness of the sand layer which ensures cleaning of the dairy wastewater up to the allowable norms. In order to calculate the pollution level of the dairy wastewater at any point of the filtration path, we calculated the dependence of the possibilities to remove the easily decomposing organic pollutants from the dairy wastewater on the length of the filtration path (Figure 5).

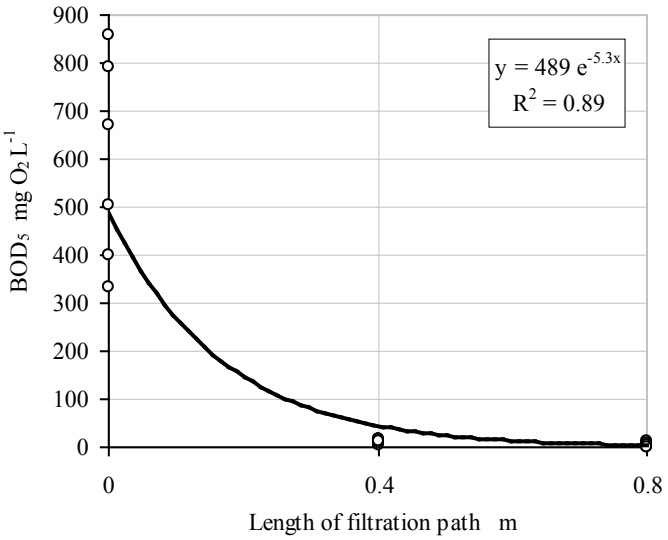

Figure 5. The dependence of the possibilities to remove the organic pollutants from the dairy wastewater on the length of the filtration path.

On the background of the dependence equation we calculated the amounts of the organic pollutants present in the dairy wastewater filtered through the sand layers of different thickness.

Table 2

Dependence of the possibilities to clean the dairy wastewater in the filter of vertical filtration on the length of the filtration path

Index, mg O_2 L^{-1}	The length of the filtration path, m									
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
BOD_5	489	288	171	100	60	35	20	12	7	4

The table shows that 0.6 m sand layer can clean the dairy wastewater up to the allowable norms. In such a filter of vertical filtration the average BOD_5 is 20 mg O_2 L^{-1} and the cleaning efficiency is 95.9%. The preliminary investigation of the model revealed that the vertical sand filter is an optimal choice for cleaning the dairy wastewater of the milk collection stations. Such stations are located in the rural areas and the primary treatment with the coagulation materials is usually skipped even if it is anticipated in the projects. The very efficient removal of the organic pollutants safeguards the surface waters and prevents their pollution.

Conclusions

1. The two-stage sand-reed filters are a good choice for cleaning the dairy wastewater. The average of the BOD_5 index indicating how well the dairy wastewater is cleaned is 4 mg O_2 L^{-1}.
2. The two stage sand-reed filters ensure cleaning of the wastewater up to the allowable norms skipping its primary cleaning stage for a long time: pollution as regards the BOD_5 index reaches 10.2 mg O_2 L^{-1} on average.
3. The sand-reed filter with the filtration path of 7 meters guarantees cleaning of the dairy wastewater up to the allowable norms. Upon passing such a sand layer, 97.2% of the organic pollutants are removed.
4. Preliminary modelled investigation revealed that the vertical filters can be successfully used to clean the dairy water of the milk collection stations. The dairy wastewater cleaning efficiency as regards BOD_5 reached 99.3%.
5. Filtration through 0.6 m sand layer ensures cleaning of the wastewater up to the allowable norms. In such a vertical filtration filter the average BOD_5 index indicating how well the dairy wastewater is cleaned is 20 mg O_2 L^{-1} and the cleaning efficiency equals 95.9%.

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LABORATORY-SCALE INVESTIGATION OF WASTEWATER PURIFICATION IN FILTERS WITH DOLOMITE CHIPPINGS MEDIA

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Abstract

The article explores the possibility of the vertical filter instead of sand used for more coarse media for recharging, which would reduce the risk of freezing and clogging and ensure the cleaning of wastewater up to the limits. For this purpose the dolomite chippings have been chosen for research. It was equipped with two 0.2 m^2 filters area: one of their models was 0.4 m dolomite chippings layer, the other 0.8 m. They have been loaded by the wastewater after the primary cleaning in the septic system. Medium contamination in organic pollutants have been 358 mg O_2 L^{-1}, P_{total} 14.6 mg L^{-1}, N_{total} 108.5 mg L^{-1}, suspended solids 161.1 mg L^{-1}, pH 7.8. Hydraulic load of the filters was 0.03 m^3 m^{-2} d^{-1}. Wastewater flowing through a vertical sand layer by an average of 98.2% of the organic pollutants to be detained. The average of effluent wastewater contamination of the filter was 22 mg O_2 L^{-1}. In the filter with dolomite chippings media can be cleaned wastewater with pollution reaches 500 mg O_2 L^{-1}. The maximum load of organic pollutants is 14 mg O_2 L^{-1}. The filtration path length to ensure wastewater cleaning up tolerance 0.8 m.

In the filter with dolomite chippings media P_{total} is cleaned even 87.0%, N_{total} only 13.0% efficiency.

Key words: dolomite chippings media, wastewater cleaning, cleaning efficiency.

Introduction

When there are no possibilities to connect a private residential house or a homestead to the public sewerage network, a separate sewage system has to be installed and the wastewater has to be cleaned in a separate cleaning unit. Recently the sand filters of vertical filtration became very popular and widely used in such cases in Lithuania. Complex physical, biological and chemical processes take place in these filters and their activity mostly depends on the sand composition, granuliometric composition, hydraulic load and the pollution level. In these filters BOD_7, COD and suspended solids are removed from the wastewater very efficiently. When the BOD_7 load on the filter is equal to 4.6 g m^{-2} d^{-1}, the efficiency of removal of the organic pollutants reaches 97.0%. In order to reach the normative BOD_7 cleaning level which is equal to 29 mg O_2 L^{-1}, we have to maintain 22.0 g m^{-2} d^{-1} load on the vertical filter. The suspended solids are removed from the wastewater in the vertical filter with the efficiency of 87.3%. At present, the coarse sand is used as a filter media but new filter media widely spread in Lithuania, cheap and surpassing the qualities of the sand is searched after. With the wish to avoid clogging of the filters of vertical filtration we performed the search for a filter media coarser than sand and allowing successful cleaning of the wastewater up to the allowable norms. Big quantities of any filter media are needed in the vertical filters therefore a local media which was dolomite chippings was chosen for the research. Dolomite is a sedimentary mineral belonging to the carbonate class and a rock from the carbonate group. It contains 20 - 30% of calcium oxide (CaO), 17 - 22% of magnesium oxide (MgO), 37 - 48% of carbon dioxide (CO_2). The dolomite is found in the layers of the Devonian system in northern Lithuania. It is being excavated in Petrasiunai, Klovainiai (Pakruojis district) and Skaisgirio (Joniskis district) quarries.

The sand-reed filters for wastewater purification are limited bandwidth and built-up areas with the old sewers in rainy periods because of foreign inflow of sewage waters increase in volume from a few to ten times. So such terms and conditions in addition to the sand-reed filters are prepared biological ponds and macrophyte filters, receiving the increased quantity of wastewater in rainy periods. Whereas dolomite chippings filter bandwidth is large, it has to deal with increased water flow. It is clear that the increasing load of wastewater treatment efficiency of hydraulic reduced, but in this case the reduction and wastewater contamination.

Whereas wastewater distribution pipes are near the surface, relevant vertical filters cause the problem of freezing. To avoid this problem, the construction of the distribution pipe was done: they covered the half sectioned 200 mm tube. The pipes were covered with 10 cm layer of gravel. From the compression of the pipes sprayed with sewage, the pipe wall bounces and splashes. Way around a pressure tube occurs in the warm air in the comfortable indoor climatic conditions, whereas the temperature of the wastewater supplied from septic is significantly higher than 0 °C. Furthermore, the filter shall be borne by winter snow (Gasiunas and Strusevicius, 2004). The risk of the freezing in the dolomite chipping filter would reduce yet; because of the large filtration speed, it shall remain for a very short period of time.

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

Materials and Methods

The modelling research was performed in the Water Research Institute under the Lithuanian Agricultural

University in the year of 2008. The scheme of the research is presented in figure 1.

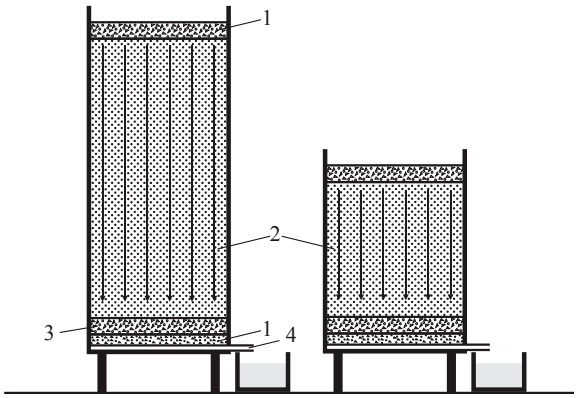

Figure 1. Our model of the vertical filter: 1- chippings; 2- dolomite chippings; 3- the fractional gravel; 4- an outlet pipe.

The filters took 0.2 m^2 area each. The length of the filtration path was made equal to 0.8 m. The second model with the filtration path of 0.4 m was equipped in order to determine the interdependence between the length of the filtration path and the efficiency of the wastewater cleaning. The wastewater of Aristava village (Vilainiai Eldership territory, Kedainiai district) which had undergone the primary cleaning in the septic systems was poured into the filters. The same wastewater was poured into both filters at the same time. The load of the filters was equal to 0.03 m^3 m^{-2}. The research continued for two months. The wastewater was poured into the models every day. Samples were taken once a week. The analyses of the wastewater were conducted in the certified chemical analysis laboratory of the Water Management 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, $N\text{-}NO_2$, $N\text{-}NO_3$, $N\text{-}NH_4$, N_{total}, P_{total}, suspended solids.

Results and Discussion

The dolomite chippings measuring 2-5 mm in diameter were chosen for the research. This media was chosen in order to avoid clogging of the filters and to avoid freezing in winter because due to the good filtration the wastewater was passing through the filter quickly and had no time to freeze. The pollution level of the domestic wastewater before and after the cleaning process is given in table 1.

Table 1

The main indices of the domestic wastewater contamination before and after the treatment in the filter in mg L^{-1} (min-max / average^{-1})

Wastewater	BOD_7	N_{total}	P_{total}	Suspended solids	pH
Before the treatment	213.0-427.0 358.0	90.0-129.0 108.47	11.0-17.0 14.6	82.0-310.0 161.1	7.7-8.0 7.8
After the treatment in the filter of dolomite chippings	17.3-28.0 22.0	57.0-149.0 99.0	0.2-3.5 1.4	7.0-262.0 61.0	8.0-8.3 8.1

The load of the easily decomposing organic pollutants on the filter was ranging from 6.4 to 14.0 g BOD_7 m^{-2} d^{-1}. When the wastewater was filtrated through the vertical layer of the dolomite chippings of 0.8 meters in length, on average 93.8% of all the organic pollutants were removed. The average contamination of the wastewater leaving the filter was 22.0 and fluctuated between 17.3 and 28.0 mg O_2 L^{-1}. The level of contamination of the wastewater coming out of the filter never exceeded the allowable norms.

P_{total} was removed from the domestic wastewater in our model of the filter of dolomite chippings with the efficiency of 87.7% and never exceeded the norms allowed. The N_{total} staid in the wastewater and was not removed. Its average amount in the wastewater before cleaning was 108.4 and it hardly decreased to 99.1 mg L^{-1} after the cleaning process.

The treatment takes place in the normal waste, in particular the importance of their active reaction of sand filters. The optimal medium for biological processes take place – where the wastewater pH 7-8. The average pH of wastewater was 7.8 and ranged from 7.7 to 8.0. The vertical filter model for effluents that filters through the dolomite chippings their leaching has been expanded following a 0.4 m pH was 8.0 (max 8.2), after a 0.8 – 8.1 (max 8.3).

The results of the research revealed functional dependence on the possibility to clean the easily decomposing organic pollutants (BOD_7 index was checked) from the wastewater on the contamination of the wastewater with this material before its cleaning in the filters (figure 2).

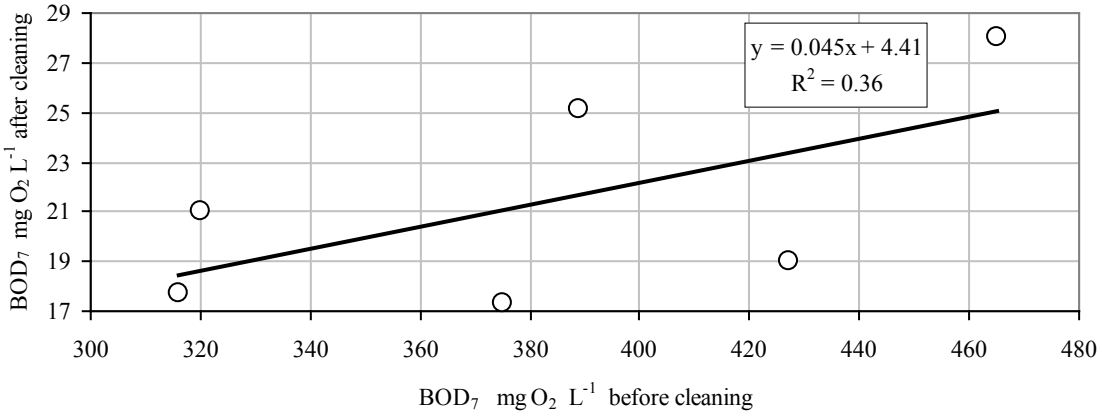

Figure 2. The dependence of the possibility to clean the organic pollutants from the wastewater on the initial contamination level of the wastewater.

When the contamination of the wastewater before cleaning rose from 320 to 460 mg O_2 L^{-1}, the contamination of the wastewater after the treatment in the filter increased from 18.8 up to 25.1. The data of the first sample where BOD_7 was equal to 213.0 mg O_2 L^{-1} were ignored when determining the dependence because biocenosis was present in the filters and it significantly reduced the cleaning efficiency.

By using the regression equation received, we estimated that the wastewater with the contamination level reaching up to 500 mg O_2 L^{-1} can be successfully cleaned in the filters of dolomite chippings. As the contamination level of the domestic wastewater never reaches 450 mg O_2 L^{-1}, it can be cleaned in the filters of dolomite chippings even without its primary treatment in the septic systems. Our calculation results are given in table 2.

Table 2

The dependence of the amount of organic pollutants (BOD_7) in mg O_2 L^{-1} present in the cleaned wastewater on their initial amount in the wastewater before its cleaning in the vertical filter

Index	250	300	350	400	450	500	550
BOD_7	15.7	17.9	20.2	22.4	24.7	26.9	29.2

It was also established the depuration of sewage as a function of the filter load easily decomposing organic pollutants (Figure 3). In addition, this has been used in the 2009 survey data.

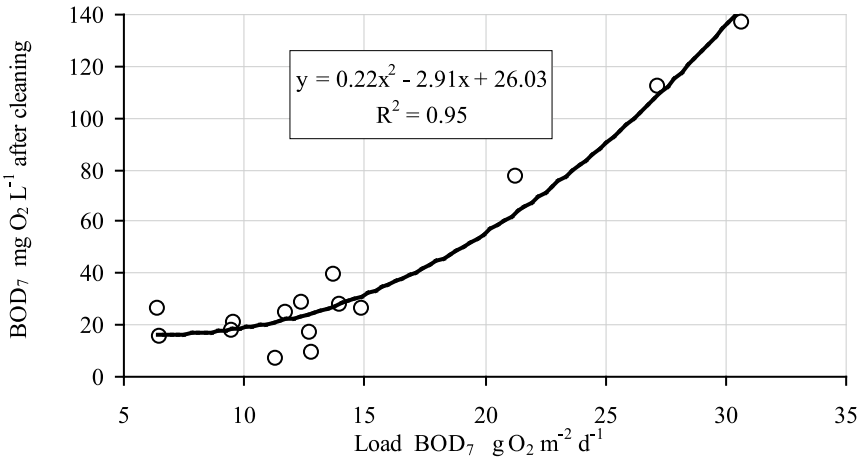

Figure 3. The dependence of the possibility to clean the organic pollutants from the wastewater on the length of the filtration path in the filter of dolomite chippings.

By using the cleaning dependence equations, we estimated permissible load of the spam filter. Calculation of the data in table 3 below.

Table 3

Organic pollutants (BOD_7) in effluent mg O_2 L^{-1}, depending on the load of the spam filter

The filtre load by the BOD_7, g O_2 m^{-2} d^{-1}					
5	10	15	20	25	30
17.0	18.9	31.9	55.8	90.8	136.7

Wastewater to be cleaned when the tolerances dolomite chippings the maximum load easily decomposing organic pollutants 14 mg O_2 m^{-2} d^{-1}. Such a load level of the municipal sewage treatment is in accordance with BOD_7 to 28.8 g O_2 L^{-1}. The maximum instantaneous load is 17 grams of O_2 m^{-2} d^{-1}, which ensures the permissible content of organic pollutants in effluents valytose – 40 mg O_2 L^{-1}.

For the estimation of the contamination level of the wastewater with the organic pollutants and suspended solids at any point of the filtration path, the dependence of the possibilities to clean the wastewater on the length of the filtration path had to be evaluated and calculated (Figures 4 and 5). The results of our calculation are given in table 4.

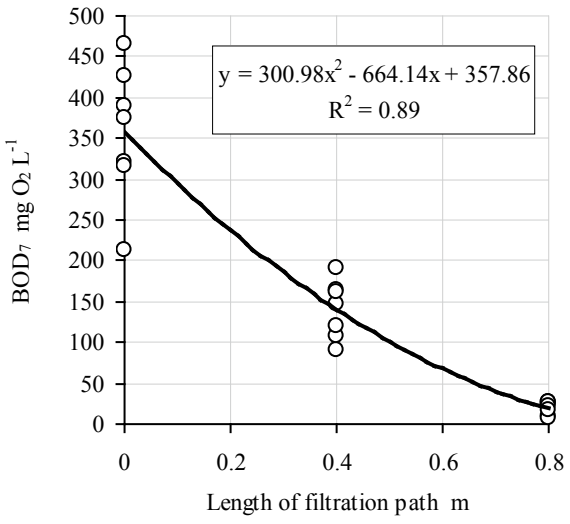

Figure 4. The dependence of the possibility to clean the organic pollutants from the wastewater on the length of the filtration path in the filter of dolomite chippings.

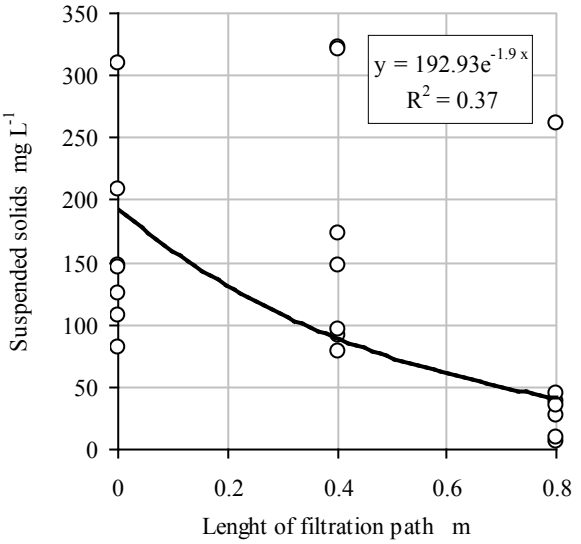

Figure 5. The dependence of the possibility to clean the suspended solids from the wastewater on the length of the filtration path in the filter of dolomite chippings.

Table 4

The dependence of the possibilities to clean the domestic wastewater on the length of the filtration path

Indices mg L^{-1}	The length of the path m								
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
BOD_7	357.9	294.5	237.1	185.8	140.4	101.1	67.8	40.5	19.3
Suspended solids	182.7	170.2	157.7	145.2	132.1	120.1	107.6	95.1	82.7

The research revealed that the minimal length of the filtration path in the filters of dolomite chippings has to be 0.8 meters. The quantity of the suspended solids in the wastewater leaving the filter of 0.8 meters decreased by 54.7%. Some dust is present in the dolomite chippings; therefore, the quantity of the suspended solids in the wastewater coming out of the filter was big and reached 262 mg L^{-1} in the first week. Despite the fact that the vertical filters with this filter media have good perspectives. The wastewater cleaning possibilities they offer are lower than those of the sand or dolomite powder filters, but due to the coarse fractions of the dolomite chippings, the danger of clogging is removed, the hydraulic load can be increased and the area taken by the filter and its cost can be reduced.

It is advisable to wash the dolomite chippings before their use in the vertical filters as the filter media.

Conclusions

1. The easily decomposing organic pollutants are cleaned from the wastewater in the filter of dolomite chippings with the efficiency of 93.8%. Cleaning from BOD_7 averaged 22.0 mg O_2 L^{-1}.
2. The length of the filtration path ensuring effective cleaning of the wastewater up to the allowable norms is 0.8 m.
3. Maximum dolomite chippings filter load easily decomposing organic pollutants, which is available on the standard of domestic waste water to clean up, is 14 g m^{-2} d^{-1}.
4. P_{total} is removed from the wastewater in the filter of dolomite chippings with the efficiency of 87.7%; therefore, it is possible to suppose that the phosphorus will be removed from the wastewater up to the allowable norms (which are 4 mg L^{-1}) for a long time.
5. The N_{total} is cleaned in the filter of dolomite chippings with a low efficiency of 8.7%. Therefore, additional measures for its removal have to be taken in the vertical filters.

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INFLUENCE OF THE VERTICAL FILTER MEDIA ON PHOSPORUS REMOVAL FROM THE DOMESTIC WASTEWATER

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Abstract

Modelling of the domestic wastewater treatment and removal of the P_{total} in the vertical filters with the sand, dolomite powder and dolomite chippings each separately used as a filter media was performed. Six filter models taking 0.2 m^2 each were installed. The length of the filtration path was equal to 0.8 m in three of these models and 0.4 m in the other three models. The hydraulic load on the filters was equal to 0.03 $m^3\ m^{-2}\ d^{-1}$ in 2008, and it was equal to 0.06 $m^3\ m^{-2}\ d^{-1}$ in 2009. The domestic wastewater which had undergone the pre-cleaning in the septic systems was poured into the models. Their average pollution with the P_{total} reached 14.6 mg L^{-1} in the first year and 9.2 mg L^{-1} in the second year.

When the filtration path was equal to 0.8 m and the hydraulic load was equal to 0.03 $m^3\ m^{-2}\ d^{-1}$, the P_{total} was removed from the wastewater with the efficiency of 99.9% in the dolomite powder filter. In the filter models with the sand and dolomite chippings, the P_{total} was removed with the same efficiency of 87.7%. When the hydraulic load doubled, the efficiency of P removal decreased to 59.8% in the sand filter and down to 45.7% in the dolomite chippings filter. When the hydraulic load reached 0.06 $m^3\ m^{-2}\ d^{-1}$, only the dolomite powder filter could ensure the adequate cleaning of the domestic wastewater up to the allowable norms.

Key words: P_{total}, filter media, wastewater cleaning, filtration path.

Introduction

Nowadays the vertical filtration sand-reed filters are replacing the horizontal filtration filters. In the vertical filtration filters BOD, COD and suspended solids are removed from the wastewater very efficiently. When the BOD_7 load on the filters is 4.6 g $m^{-2}\ d^{-1}$, the efficiency of removal of the organic pollutants reaches 97.0%. In order to reach the normative BOD_7 cleaning level which is equal to 29 mg $O_2\ L^{-1}$, the suggested load on the vertical filter is 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). These filters not only guarantee efficient cleaning process which meets all the hygiene requirements but perfectly fit to the environment. However, the P_{total} is removed from the wastewater in the horizontal filtration filters more efficiently. When the P_{total} load on the surface of the filters is the same and equal to 0.3 g $m^{-2}\ d^{-1}$ and the concentration of the P_{total} in the wastewater entering the filters is equal to 10 mg L^{-1}, the cleaning efficiency reaches 55.3% in the horizontal filters and 30.4% in the vertical filters (Gasiūnas and Strusevičius, 2008). Therefore, our aim is to find the filter media which successfully overcomes this shortcoming. We chose the dolomite powder and dolomite chippings for our investigation. The dolomite is found in the North Lithuania where cheap products are produced from it. The composition of the dolomite lets us presuppose that the P_{total} will be removed from the domestic wastewater in the vertical dolomite powder and dolomite chippings filters more efficiently and for longer periods than in the sand filter.

Phosphorus is the main biogenic material which decides the eutrophication of the water bodies. Because no important gas elements are present in the biochemical cycle, Phosphorus tends to precipitate in the natural systems and therefore is rarely met in the ecosystems (Strusevičienė and Strusevičius, 2003).

Some authors (Drizo et al., 1997; Johansson, 1998; Cheung, 2000; Arias et al., 2001; Drizo et al., 2002) performed experiments with materials of different porosity and were trying to find the medium which could ensure long-lasting Phosphorus removal from the wastewater. They used various methods to calculate the useful service time of the filters. Other authors (Lookman et al., 1996 and Monterroso Martinez et al., 1996) tried to understand the relationship between the qualities of the mineral materials and the successful Phosphorus removal.

Due to the physical, biological and chemical processes taking place in the filters one part of Phosphorus is turned into soluble compounds (orthophosphates) but the other part is bound into insoluble aluminum and ferric (iron) phosphates (Cooper, 1999; Kadlec and Knight, 1996; Richardson and Craft, 1993). The power of absorption depends on the quantities of Aluminum, Ferrum, Calcium and Magnesium present in the filter media. Under the aerobic conditions when pH is either neutral or acidic the three-valent Ferrum binds phosphates into the stable complexes. When the conditions change and turn into anaerobic, which means that the filter is dammed, the three-valent Ferrum is reduced into two-valent. This process determines lower absorption and release of phosphates (Faulkner and Richardson, 1989; Gasiūnas and Strusevičius, 2004). We chose the dolomite chippings filter media for our modeling because it does not pose any clogging danger and aerobic conditions are present during the whole cleaning cycle.

The aim of the research is to find out the efficiency of Phosphorus removal from the wastewater in the dolomite powder and dolomite chippings filters and to compare it to that in the sand filter.

Materials and Methods

The modeling was performed in the Water Research Institute of the Lithuanian University of Agriculture in 2008 - 2009. Six vertical filter models were equipped: two of them were filled with the usual media which was sand, other two were filled with the dolomite chippings and the last two were filled with the dolomite powder. The area taken by each of the filters was 0.2 m^2. The same wastewater was poured into the filters. The length of the filtration path was 0.8 m in three of these filters and 0.4 m in the other three filters. This allowed us to make the equations of the P_{total} removal dependence on the length of the filtration path and to find out the minimal quantities of the filter media which could ensure cleaning of the wastewater up to the allowable norms. The domestic wastewater outgoing from Aristava village (Kėdainiai district, Vilainiai Eldership area) which had undergone the primary septic treatment was used for the investigation. In 2008 the hydraulic load on the filters was 0.03 $m^3\ m^{-2}\ d^{-1}$ and it was 0.06 $m^3\ m^{-2}\ d^{-1}$ in 2009. The research lasted for two months. The wastewater was poured into the modeled filters every day, the whole norm at once. The samples were taken once per 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 dolomite chippings belonged to 2-5 mm fraction and had the density of 1.34 t m^{-3}. The analyses of the wastewater were conducted in the certified chemical analysis laboratory of the Water Management Institute of Lithuanian University of Agriculture. The unified methods were applied (The unified methods of the wastewater…, 1994).

Results and Discussion

The wastewater which had undergone the primary treatment in the septic systems was used for the investigation. In 2008 the average pollution level of the domestic wastewater reached 14.6 mg L^{-1} and pollution fluctuated in the range from 11.0 mg L^{-1} to 17.0 mg L^{-1}. In 2009 the average pollution level was equal to 9.2 mg L^{-1} and pollution level fluctuated from 4.0 mg L^{-1} to 13.2 mg L^{-1}. The load of the P_{total} on the modeled filters fluctuated in the wide range: in 2008 it was increasing and decreasing 1.7 times and in 2009 it was increasing and decreasing 4.0 times. It was very important not only to find out the allowable load of the P_{total} on the filters but also to estimate the hydraulic load which ensures cleaning of the wastewater up to the allowable norms. Therefore, in 2008 the hydraulic load was made equal to 0.03 $m^3\ m^2\ d^{-1}$ and in 2009 it was increased up to 0.06 $m^3\ m^2\ d^{-1}$.

For our investigation we chose the following dolomite products: dolomite powder and dolomite chippings. 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). Some authors claim that the quantity of Calcium present in the filter media is more important than the quantities of Aluminum and Ferrum (Arias et al., 2001, Del Bubba et al., 2003).

P_{total} removal dependency on the initial pollution level of the wastewater and the hydraulic load on the filter models are shown in figures 1 and 2.

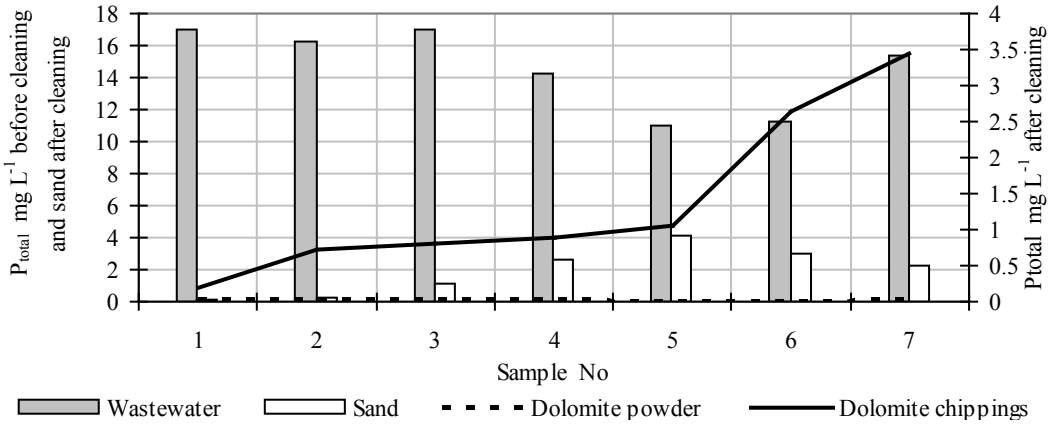

Figure 1. Dependence of the possibilities to clean the wastewater from the P_{total} on the initial pollution of the wastewater when the hydraulic load is 0.03 $m^3\ m^{-2}\ d^{-1}$.

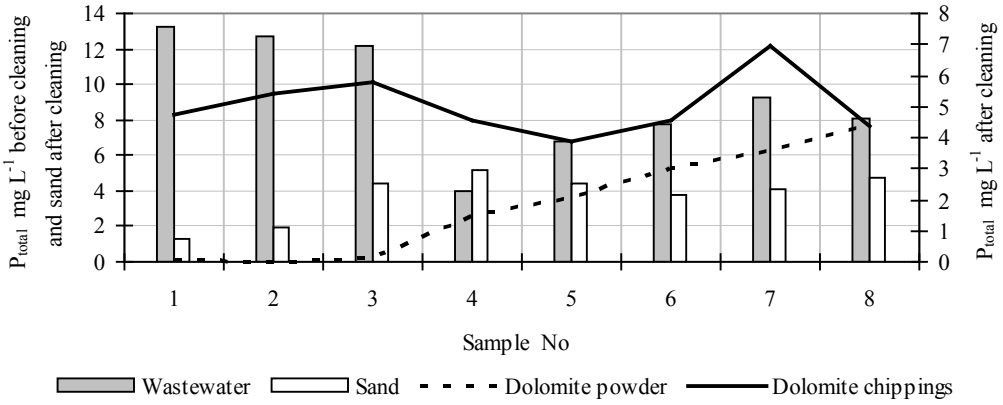

Figure 2. Dependence of the possibilities to clean the wastewater from the P_{total} on the initial pollution of the wastewater when the hydraulic load is 0.06 m^3 m^{-2} d^{-1}.

The investigation revealed that the P_{total} was removed from the sand, and dolomite chippings filter models equally well. The efficiency of the process was equal to 87.7% when the hydraulic load was 0.03 m^3 m^{-2} d^{-1}. In the wastewater which underwent the treatment in the filters the average amount of Phosphorus was 1.9 mg L^{-1} in the sand filter and 1.4 mg L^{-1} in the dolomite chippings filter and the maximal values were 4.0 mg L^{-1} and 3.4 mg L^{-1} respectively. When the hydraulic load was doubled, the cleaning efficiency decreased to 59.8% in the sand filter and to 45.7% in the dolomite chippings filter. The average pollution of the wastewater with the P_{total} after the treatment was 3.7 mg L^{-1} and 5.0 mg L^{-1} respectively. In 2009 the domestic wastewater used for our investigation contained 1.6 times lower levels of the P_{total} than in 2008. Therefore, when the hydraulic load doubled, the load of these elements on the filters increased only 1.3 times. Despite the fact that the cleaning efficiency decreased 2.0 times in the sand filter and 3.6 times in the dolomite chippings filter, none of these filters succeeded in cleaning the wastewater up to the allowable norms. The lower cleaning efficiency in the latter filter was determined by the fact that the wastewater passed the dolomite chippings more quickly than sand and the contact with the chippings was shorter.

Quantities of the P_{total} exceeding 1-2 mg L^{-1} are not desirable because bigger quantities of Phosphorus as well as Nitrogen compounds cause saturation of the water bodies with the biogenic material (Radzevičius et al., 2008). The condition of low quantities was satisfied by the dolomite powder filter. When the hydraulic load was 0.03 m^3 m^{-2} d^{-1} the N_{total} was removed from the wastewater with the efficiency of 99.9%. Its average amount in the cleaned wastewater was 0.02 mg L^{-1} and the maximal quantity barely reached 0.04 mg L^{-1}. When the hydraulic load was doubled, the cleaning efficiency decreased down to 79.4% but its average amount in the cleaned wastewater was 1.9 mg L^{-1} and only in one instance exceeded the norm.

In order to calculate the pollution level of the wastewater at any point of the filtration path, we calculated the dependencies of the possibilities to remove the organic pollutants on the length of the filtration path and the hydraulic load (Figures 3, 4, 5, 6, 7 and 8).

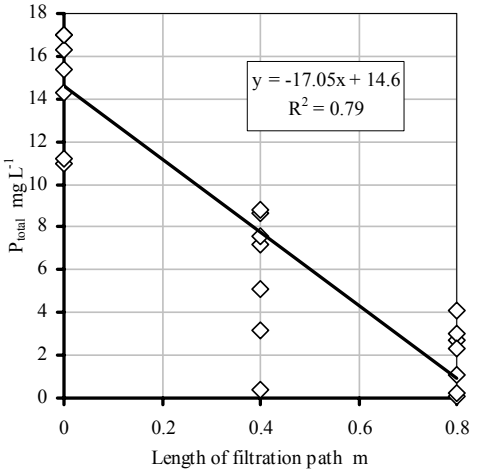

Figure 3. The dependence of the possibilities to remove the P_{total} from the wastewater in the sand filter on the length of the filtration path when the hydraulic load is equal to 0.03 m^3 m^{-2} d^{-1}.

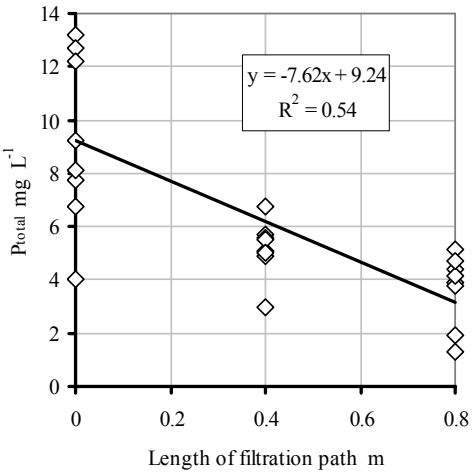

Figure 4. The dependence of the possibilities to remove the P_{total} from the wastewater in the sand filter on the length of the filtration path when the hydraulic load is equal to 0.06 m^3 m^{-2} d^{-1}.

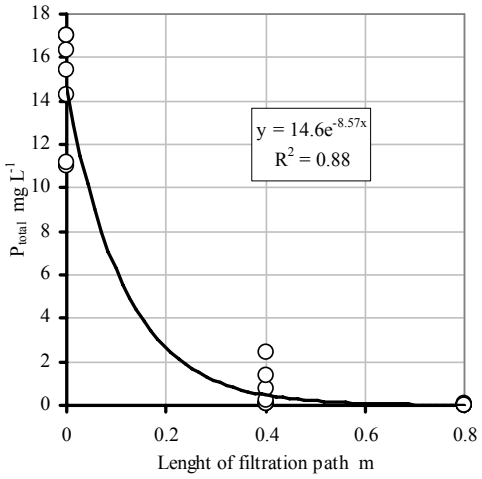

Figure 5. The dependence of the possibilities to remove the P_{total} from the wastewater in the dolomite powder filter on the length of the filtration path when the hydraulic load is equal to 0.03 m^3 m^{-2} d^{-1}.

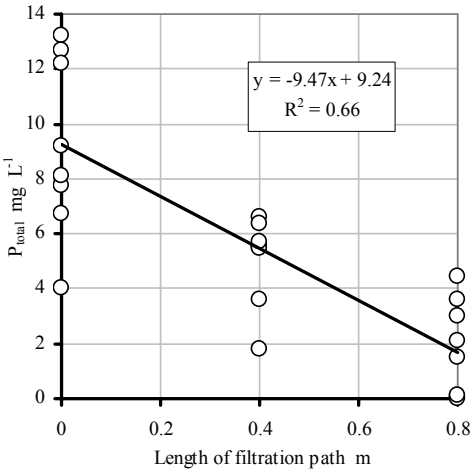

Figure 6. The dependence of the possibilities to remove the P_{total} from the wastewater in the dolomite powder filter on the length of the filtration path when the hydraulic load is equal to 0.06 m^3 m^{-2} d^{-1}.

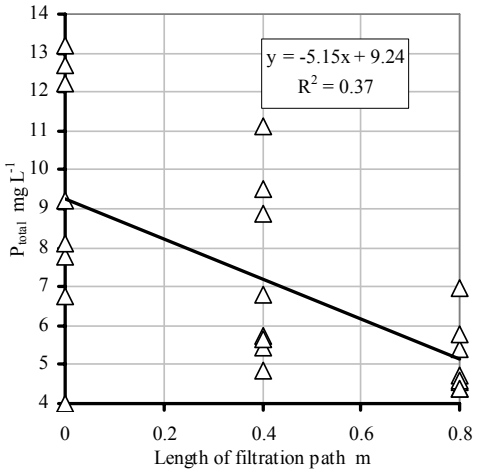

Figure 7. The dependence of the possibilities to remove` the P_{total} from the wastewater in the dolomite chippings filter on the length of the filtration path when the hydraulic load is equal to 0.03 m^3 m^{-2} d^{-1}.

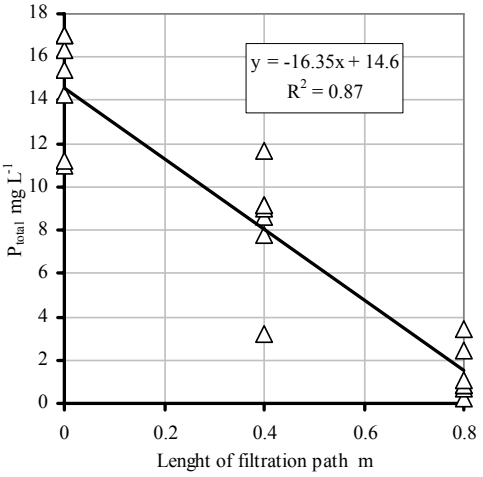

Figure 8. The dependence of the possibilities to remove the P_{total} from the wastewater in the dolomite chippings filter on the length of the filtration path when the hydraulic load is equal to 0.06 m^3 m^{-2} d^{-1}.

Using the equations of the cleaning dependencies, we calculated the amount of the P_{total} in the domestic wastewater which underwent filtration through the different amounts of sand, dolomite powder and dolomite chippings under different hydraulic loads. The calculation results are presented in table 1.

Table 1

Dependence of the domestic wastewater cleaning possibilities on the length of the filtration path and hydraulic load in the filters with different filter media

Hydraulic load $m^3 m^{-2} d^{-1}$	Length of the filtration path m								
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Sand filter									
0.03	14.6	12.9	11.2	9.48	7.8	6.1	4.4	2.7	1.0
0.06	9.2	8.4	7.7	7.0	6.1	5.4	4.7	4.0	3.2
Dolomite powder filter									
0.03	14.6	6.2	2.7	1.1	0.5	0.2	0.09	0.04	0.02
0.06	9.24	8.3	7.4	6.4	5.5	4.5	3.6	2.6	1.7
Dolomite chippings filter									
0.03	14.6	13.0	11.3	9.7	8.1	6.4	4.8	3.2	1.5
0.06	9.2	8.7	8.2	7.7	7.2	6.7	6.2	5.6	5.1

The table shows that when the hydraulic load was equal to 0.03 $m^3 m^{-2} d^{-1}$ the domestic wastewater was cleaned up to the allowable norms by 0.7 m thick sand and dolomite chipping layers. In such a vertical filtration sand filter the average level of cleaning from the P_{total} reached 2.7 mg L^{-1} and the cleaning efficiency was equal to 81.5%. In the dolomite chipping filter the indices were 3.2 mg L^{-1} and 78.1% respectively. When the hydraulic load was equal to 0.03 $m^3 m^{-2} d^{-1}$ the wastewater was successfully cleaned up to the allowable norms by 0.2 m thick layer of dolomite powder. The pollution of the wastewater with the P_{total} was equal to 2.7 mg L^{-1} after filtration through such a dolomite powder layer and cleaning was performed with the efficiency of 81.5%.

When the hydraulic load doubled, 0.8 m filtration path in the dolomite chipping filter was not enough to remove the P_{total} from the wastewater up to the allowable norms. The average pollution of the wastewater after cleaning was equal to 5.0 mg L^{-1} (and the cleaning efficiency was 45.5%) and only in one instance was equal to 3.9 mg L^{-1}, i.e. was lower than the norm allowed.

When the hydraulic load was 0.06 $m^3 m^{-2} d^{-1}$, the average pollution of the wastewater cleaned in the filter with 0.8 m sand layer was equal to 3.7 mg L^{-1}. However, we should not rely on such a hydraulic load in the sand filters because at the time of our investigation the concentration of the P_{total} in the cleaned wastewater 5 times out of 8 exceeded the allowable norm. Such a load might be used temporarily in the case when the water usage increases. When the hydraulic load is growing, the danger of clogging also rises altogether.

When the hydraulic load is equal to 0.06 $m^3 m^{-2} d^{-1}$, the wastewater can be cleaned up to the allowable norms by 0.6 m thick dolomite powder layer. After filtration through such a layer the wastewater was cleaned up to 3.7 mg L^{-1} and the cleaning efficiency was equal to 61.0%.

As many authors are noticing (Ciupa, 1999; Kadlec, 1985), the efficiency of Phosphorus removal is high at the beginning of the filter service but later, when the earth gets saturated with phosphates, it decreases down to the minimal numbers. In the majority of the filters the efficiency of Phosphorus removal does not exceed 50% (Verhoeven et al., 1999). The Phosphorus removal efficiency in the vertical filter receiving the wastewater from the public catering institution "Pastoge" decreased from 60% at the beginning of the year to 20% at the end of the year (Gasiūnas and Strusevičius, 2004). It is clear that the Phosphorus removal efficiency will decrease in the dolomite chippings and dolomite powder filters too. As the time passes, the quantity of the chemical compounds able to absorb Phosphorus decreases. Taking into account the fact that 50% of the dolomite are made of the calcium and magnesium compounds and during 2 months of our investigation the Phosphorus cleaning efficiency did not decrease, it is possible to make a conclusion that these filters will be removing Phosphorus from the wastewater for longer periods of time than sand filters.

The results of the investigation revealed that the dolomite powder and dolomite chipping filters have a future and they can be used for cleaning small quantities of the domestic wastewater. The investigation needs to be continued and the decreasing Phosphorus removal efficiency as compared to the increasing exploitation time has to be analyzed. This year such an investigation is performed in Pasodele village, Panevezys district, Lithuania where a sand-dolomite chipping model filter is equipped.

Conclusions

1. When the hydraulic load was equal to 0.03 $m^3 m^{-2} d^{-1}$ and the length of the filtration path was 0.8 m, the P_{total} was removed from the domestic wastewater with the efficiency of 87.0% in the dolomite chipping and sand filters and with the efficiency of 99.9% in the dolomite powder filter. The maximal pollution after cleaning

was 3.4 mg L^{-1}, 4.0 mg L^{-1} and 0.04 mg L^{-1} respectively.

2. When the hydraulic load was equal to 0.06 m^3 m^{-2} d^{-1} and the length of the filtration path was 0.8 m, only the dolomite powder filter could ensure cleaning of the domestic wastewater up to the allowable norms. The wastewater was cleaned with the efficiency of 80.0% and the average pollution of the cleaned wastewater was 1.9 mg L^{-1}.
3. When the hydraulic load was equal to 0.03 m^3 m^{-2} d^{-1}, the domestic wastewater was cleaned up to the allowable norms after undergoing filtration through 0.2 m thick dolomite powder layer and 0.7 m thick sand and dolomite chipping layers. The cleaning efficiency after filtration in the filter media was 81.5%, 81.5% and 78.1% respectively.
4. When the hydraulic load was equal to 0.06 m^3 m^{-2} d^{-1} 0.6 m, thick dolomite powder layer was enough to clean the domestic wastewater. The sand and dolomite chipping filters could not ensure cleaning of the wastewater up to the allowable norms.

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PRECISE LEVELLING ACROSS THE LIELUPE AND DAUGAVA RIVERS

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Abstract

In Latvia, Class 1 levelling network crosses major rivers. In the places where the river cannot be crossed over the bridge, the levelling across the river should be done directly.

The paper describes the methodology, the applied instruments and the results of levelling performed across the Lielupe and Daugava rivers.

The levelling across the Daugava River at the creek, where the length of the sight reaches 700 m, was performed simultaneously with two Ni002 levellers. To facilitate the reading of the levelling rod, across the river, a special scale type mark was constructed and fitted on a levelling rod. It was concluded that for the levelling across up to 200-m-wide rivers, levelling rods with 3-mm-wide stripes can be successfully used. The scale type mark makes significantly easier and speeds up the measurements. Under unfavourable weather conditions, measurements performed across the Daugava at the creek were less accurate. There was no explanation for the difference in the elevations measured by the two instruments; therefore, further careful studies of both levellers are needed.

Key words: levelling, levelling rod, leveller, levelling mark, benchmark.

Introduction

Between 1929 and 1939, in the process of creating a precise levelling network of Latvia, levelling across the Daugava River and also other water barriers was performed. During the Soviet times, levelling across wide rivers in the territory of Latvia was not performed because a precise levelling network was not fully levelled. Nowadays, because there are no bridges for river crossing or direct levelling across wide rivers, the implementation of Latvian Class I levelling network project has become very significant. Such locations for levelling lines are the Lielupe creek, the Daugava at the Belarusian border near the Kraslava, and the Daugava creek. The objective of the present research study was to create a device for reading of precise levelling rods, which would facilitate and speed up levelling across wide water barriers, as well as increase the accuracy of measurements. Levelling works from 2000 to 2005 were performed by the State Land Service, and from 2006 to 2010 by the Latvian Geospatial Information Agency.

Materials and Methods

Levelling across the Daugava River near the Belarus border was performed on 1 November 2000. Weather conditions were favourable for levelling: Cloudy with little wind, the air and water temperatures were similar. At the site of the river crossing, on both river sides, temporary benchmarks – screw benchmarks – were installed, which were attached to the Class 1 permanent benchmarks with a double run.

For the levelling, optical level with compensator, a Ni002, and bar code levelling rods with 3-mm - wide stripes, were used. As previous research has shown, the bar code levelling rods with 3-mm-wide stripes can be read with a matching technique, just like in levelling with a normal length of sight. Before levelling, the leveller angle of the sight was set at i=-2.5". Leveller standings were chosen so that the temporary benchmarks and leveller were located on the tops of parallelogram (Fig. 1).

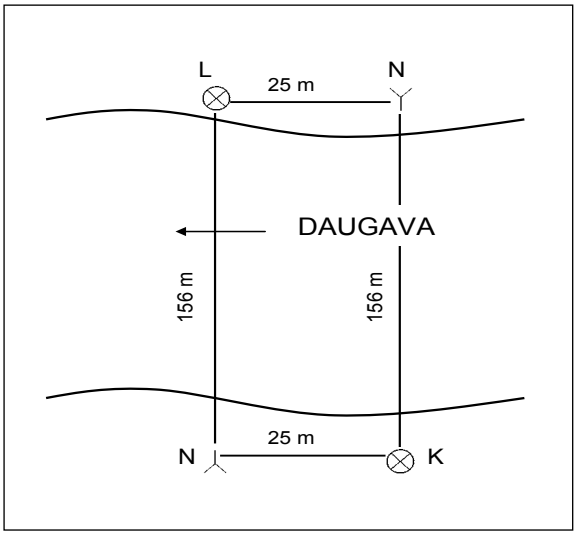

Figure1. The scheme of levelling across the Daugava River near the Belarus border.

Measurements from each coast were performed in four stages. In each stage levelling rods were read similar to those in Class 1 levelling line station to the programme BFFB, FBBF, with the only difference that the far levelling rod (on the opposite coast) was always read 3 times, changing the height of the level.

Measurements on one coast were completed with reading to the levelling rod on the opposite coast. Without changing the focus of binoculars, the leveller was taken to the opposite coast, where the measurements began by

observing the far levelling rod (on the opposite coast).

Levelling across the Lielupe at the creek was performed on 27 November 2009. In the levelling across the Lielupe at the creek, the same level and rods were used, as well as measurements were performed by the same methodology as in the levelling across the Daugava River in the year 2000. The weather was overcast, with a very strong catchy wind in the river direction. Points were established with screw benchmarks. Elevation from each cost was determined in six stages. The levelling scheme is shown in Figure 2.

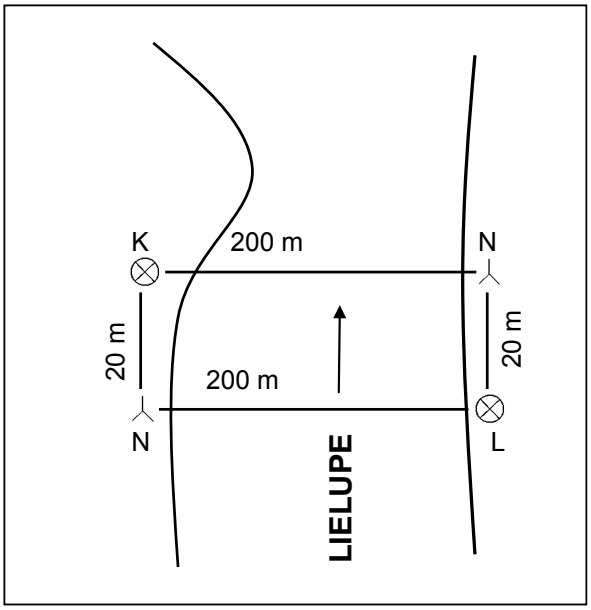

Figure 2.The scheme of levelling across the Lielupe River.

Levelling across the Daugava at the creek was performed on 7 July 2010. Weather conditions were not favourable for levelling: Sunny, almost no wind, a significant air and water temperature difference was observed, in the morning from the left coast the sight was towards the sun. Due to various organizational reasons, it was not possible to choose more appropriate weather conditions.

To simultaneously carry out measurements on both coasts, two levellers, Ni002 and bar code levelling rods with 1.6-mm- wide stripes, were used. For a temporary benchmark on the left coast, 10-cm-long pins with a spherical head were driven into the concrete, on the right coast, and 10-mm-diameter ball bearings were reinforced into concrete slabs.

Since the width of the Daugava at the creek is almost 700 m, the levelling rods could not be read in the usual way. In such cases, for reading the levelling rod across the river, a special mark with one or two wide stripes (Инструкция по нивелированию…, 2003) or a white circle on a black background (Latvijas PSR precīzā nivelēšana, 1941) is usually used, which, following the observer's instructions, is moved and secured on levelling rods so that the binoculars' horizontal stripe coincides with the mark line axis or centre of the circle. The mark position on the levelling rod is determined by a levelling rod scale reading to the marks' index. Since such reading of levelling rods is related to a significant amount of time and is not very big (around 0.5 mm), the authors designed and produced such a mark for the reading of levelling rods, which in the measuring process would not be needed to move on the levelling rod, but the reading of the levelling rod could be obtained by a matching technique using the instrument's micrometer. Instead of the mark with one or two wide stripes, a scale consisting of a 1x2 cm rectangle (similar to rods bars) was constructed on the metal plate. To ensure a 5-mm distance between the stripe axes, stripes were placed in multiple columns obtaining the mark in the scale form. For the mark axis verticality control, a spherical level was fitted (Fig. 3).

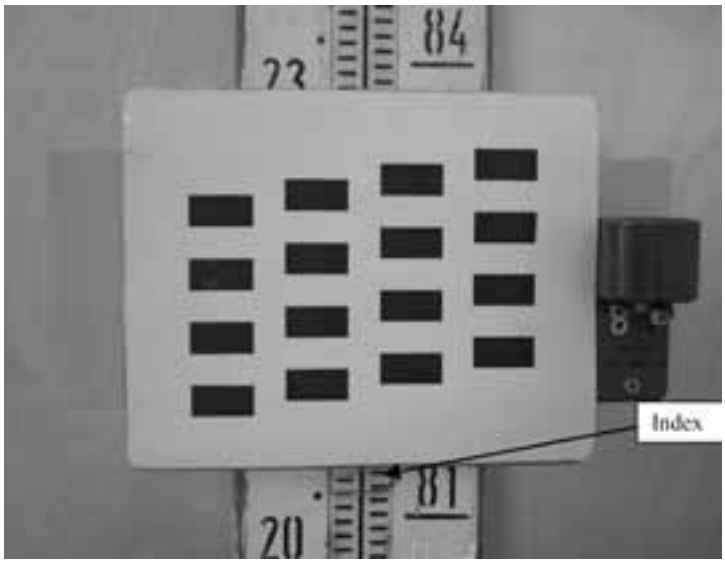

Figure 3. Levelling rod with a mark.

A mark plate was attached to the device which was strengthened on the levelling rod, and for position fixing on the rod the index scale for the levelling rod reading was created. The levelling scheme is shown in Figure 4.

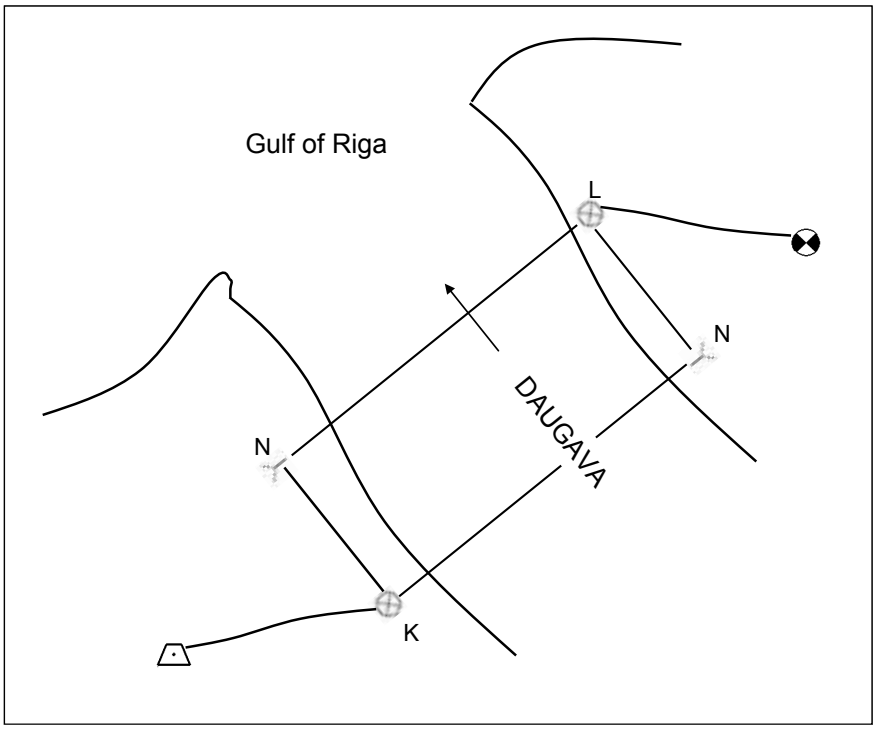

Figure 4.The scheme of levelling across the Daugava at the creek.

Results and Discussion

Before leveling, the leveler angle of sight was set i=-2.5" After completing levelling measurements across the Daugava River near the Belarus border, the angle of the sight was set again at i=-2.7". Therefore, for the measurement period the average angle of the sight could be extended to i=-2.6".

The measured elevations were updated by the angle of the sight and curvature of the Earth's surface. The levelling results are shown in Table 1.

Table 1

Results of levelling across the Daugava River near the Belarus border

Point name	Measured elevation (m)	Correction of		Corrected elevation (m)	Average elevation (m)
		angle of sight (mm)	curvature of the Earth's surface (mm)		
K					
	+0.8482	–1.7	+1.2	+0.8477	
L					+0.8467
	–0.8452	–1.7	+1.2	–0.8457	
K					

As can be seen, the elevation difference in opposite directions is +2.0 mm, which indicates that the measurement was done sufficiently precisely.

The levelling results across the Lielupe are given in Table 2. The correction of the angle of sight was calculated from average slope angle at i=-4.5".

Table 2

Results of levelling across the Lielupe River

Temporary benchmark name	Measured elevation (m)	Correction of		Corrected elevation (m)	Average elevation (m)
		angle of sight (mm)	curvature of the Earth's surface (mm)		
K					
	+0.1919	–3.9	+2.2	+0.1902	
L					+0.1886
	–0.1852	–3.9	+2.2	–0.1869	
K					

As it can be seen, the difference between the elevations in opposite directions is + 3.3 mm. In view of the not very favourable weather conditions, it can be assumed that the elevations are sufficiently precise.

Levelling across the Daugava at the creek was performed in the morning from each coast in 10 stages by the same methodology as in the previous levelling. Before the measurements were started, markings were installed and reinforced on the levelling rods to such height that the sight was about to cross the centre line markings, but the index exactly coincided with the one of the levelling rod strip, thus excluding the levelling rods section's part reading error.

Before the measurements in the afternoon, the positions of the levellers were exchanged. Measurements in the afternoon were also performed in 10 stages. The measured elevations were updated by the angle of sight and curvature of the Earth's surface. The angles of the sight for both levellers were determined before and after the levelling; and for the calculations, the average value was used. The levelling results are given in Table 3.

Table 3

Results of levelling across the river Daugava at the creek

Leveller	Benchmark name	Measured elevation (m)	Correction of		Corrected elevation (m)	Average elevation (m)
			angle of sight (mm)	curvature of the Earth's surface (mm)		
	K					
Ni002 Nr.460552 (HES)		–0.6605	+9.2	+31.2	–0.6201	
	L					–0.6216
		+0.5828	+9.2	+31.2	+0.6232	
	K					
	K					
Ni002 Nr.460817 (LLU)		–0.6295	–14.8	+31.2	–0.6131	
	L					–0.6066
		+0.5837	–14.8	+31.2	+0.6001	
	K					

With one leveller, the elevation difference, measured in opposite directions, is 3.1 mm, whereas with the other 13.0 mm. If such height value differences (because of unfavourable weather conditions) should be allowed, then there is no explanation for average elevation differences, measured by the two instruments. It is possible that external factors have had different effects on the accuracy of each instrument, which should be additionally studied.

Precise levelling across wide water barriers is not a daily routine in the process of creating a national levelling network. For this reason, information about the results is not easily available. Also, in the levelling, described in this paper, a mark for levelling rod reading of a new type was used, which indicates that the measurement results are unique and not comparable with the data obtained by other measurements.

Conclusions

Summarizing the results of levelling across the Lielupe and Daugava Rivers, it can be concluded that:

1. In order to achieve the desired precision in levelling across up to 200-m-wide water flows and water reservoirs, bar-code levelling rods with 3-mm-wide stripes can be successfully used;
2. For levelling across the Daugava, the designed mark for levelling rod reading makes the levelling easier and faster;
3. To achieve higher measurement accuracy, levelling should be performed in most favourable weather conditions, as well as the width of the levelling rod mark stripes should be increased;
4. In the levelling across the river Daugava at the

creek the average elevation difference between the measurements performed by both instruments cannot be explained, and requires additional studies;
5. Levelling across water reservoirs under bad weather conditions is not acceptable.

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THE METHOD OF LANDSCAPE IDENTITY ASSESSMENT

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Abstract

The theme of landscape identity becomes actualized beside with the impact of globalization. Landscape identity is closely linked to the Latvian national identity. The concept of identity is multifaceted and touches on a number of scientific areas that currently in Latvia are actively investigating this phenomenon. Landscape investigators admit the multidisciplinary structure of the concept of identity, including in their researches the investigations of historical, visual and associative aspects. Landscape identity is related to detection, identification and definition of landscape elements, because landscape elements are the key to the perception of identity. The method of landscape identity assessment is based on three stages: the assessment of the historic, visual and cognitive elements in formation of landscape identity. The assessment of historic elements in formation of landscape identity is associated with the investigation of historic materials and description of structural elements according to the stages of development. The assessment of visual structural elements of landscape identity is based on the material collected during the field work by filling in the landscape assessment matrix. The assessment of cognitive structural elements of landscape identity is based on the opinion survey, which makes it possible to find out the concealed associative identity. The information obtained in all stages of landscape identity assessment forms the landscape identity model. The aim of the research is to develop the method of landscape identity assessment. The research was carried out at Latvia University of Agriculture in 2010.

Key words: landscape identity, landscape elements, visual elements, historical elements, cognitive elements.

Introduction

The research of Latvian identity after regaining the national independence in Latvia has become very popular among investigators. It is recognized that no country can exist without its own identity, which covers the traditions, the heritage, the language and the environment, as well as the inner world of each individual and the country as a whole. Under the influence of globalization the problem of identity has become more urgent because self–realization is today's actuality, which helps to be distinguished and not to lose oneself at each individual's level, as well as at national level. Globalization is a global phenomenon. For this reason it is impossible to define it, to determine the expression of its form or content (Hanovs, 2008). There is no doubt that globalization embraces and transforms everything – from each person's inner world and ending with the physical changes we really see when we look at a landscape. Different understanding of the concept of identity is the reason for various approaches to scientific research. As noted by Sergey Kruki (2004), referring to the Polish Rikeru – there are two aspects of identity, which often are mutually mixed. Oneness (*memete*) is a self-similarity in the course of time, self (*ipseite*) is a separation of self from each other (Kruks, 2004). The origin of the word has Latin roots – *identificare, identifico* – to identify, means the object co–relativity with self and in close connection with the ongoing variability of self, proving the independent existence of self and separation of self from other persons (Новейший..., 2003). On the other hand, the other word used in Latin is – *identificus* – meaning identity, absolute matching or coincidence of two objects. Currently, the Latvian identity is mostly investigated from sociological, philosophical, political, linguistic and pedagogical aspects. One should point out the research on pedagogical aspects, performed by Māra Dirba (2003), where in relation to the identity assessment process the author deals with a layered structure, which concerns also Latvian identity – ethnic, national, supranational (Latvian and / or minorities, Latvian, European and global) (Dirba, 2003). We can find similar patterns in modeling landscape identity, where a single element of landscape fits into a definite landscape space, which in its turn fits into the type of the landscape, region and further – into the image of Latvia. In sociology, researches on identity include its symbolic expression, for example, symbols, habits and rituals may help to identify the nation from the outside, as well as identify it innerly (Kurks, 2004). The symbolic meaning of separate landscape elements is certainly a constituent part of landscape identity, which is of most importance when defining the identity of a specific place, as the above mentioned symbolic landscape elements will have a major impact on human and visual and cognitive perception. The existences of such objects and the possibility to use them in economy have been widely discussed in connection with the brand site, which is most often used in connection with the concept of regional identity (Петров, 2008; Гончарик, 2011). Exploration of regional identity is impossible without a historic and cultural exploration of the specific place, which coincides well with the stages of landscape identity assessment, where a historic and cultural exploration explains the existence and location of landscape structures, individual landscape elements and their groups, as well as sequentially reflects all man's relationship with nature. Researches on landscape identity are based on the regional exploration of transformation processes, as well

as the effects of urbanization of sense of place on the landscape identity (Carter et al., 2007; Stedman, 2003). Landscape investigators note the multidisciplinary and multidimensional structure of the concept of identity, where the importance of landscape social and nature is closely connected with level of perception, and their role in human daily activities (Massey, 1995). On the other hand, landscape investigators assess public identity as the source of landscape changes, by using the method of photo–elicitation and interviewing (Stewart et al., 2004). Landscape investigators note the importance of political and economic processes in the changes of landscape identity. Landscape identity is also influenced by the mutual relationships of social and ethnic groups. Landscape investigators for describing historical events use a matrix, where they describe the stages of the development in the context of political and economic systems, the dominant ethnic and social groups, functional changes, the appearance of new symbols in the landscape (Murzyn–Kupisz and Gwosdz, 2011). The assessment of historic structural elements of landscape identity is based on a comprehensive study of a history of the place – from the beginning of landscape formation, where morphological and climatic factors are of great importance, and finally to the place of each man–made elements, where the changes of landscape structure and the changes of individual elements of the landscape is the a result of human activities, reflecting the country's political, social and economic situation. Landscape identity is a multidisciplinary concept, because it is used by politicians, history scholars, geographers, architects, as well as by landscape architects. The concept of identity is tightly related to the definition of landscape, where the landscape is an objective reality, section of the land surface, encompassed by natural components and formations, as well as the combination of man–made elements (Ramans, 1967). The development of Latvian landscape identity includes a close interconnection between natural, social, political and emotional factors, which by continuous interactions form the image of Latvian landscape. It is not possible to exclude any of several influencing factors, so it must be recognized that in order to define and assess the landscape it is necessary to reflect the multifaceted landscape structure. Many landscape investigators point out that landscape is the product containing natural and human elements that continuously changes due to natural processes and human activities. It can be concluded that the identity of the landscape is changing. This means that perception and definition of landscape will be binding only for a specified period. This highlights the need to create a unified landscape detection method, which will be useful for future research and will help to compare results over time, perceiving the landscape identity as a model. The use of theoretical models in landscape investigations is a new research direction that makes it easier to perceive the existing links and processes concerning landscape and see the consequences of individual actions (Stephenson, 2008; Krause, 2001). Consequently, the aim of the research is to develop the method of landscape identity assessment which is based on a multidisciplinary approach, by performing expert surveys concerning various scientific disciplines, as well as population surveys.

Materials and Methods

The chosen research object is the theoretical model of the research of Latvian landscape identity as the aim of the research is to create the method of landscape identity assessment, which is to be used for future research on landscape identity assessment concerning the coastal landscape of the Baltic Sea and the Gulf of Riga. The research was carried out at Latvia University of Agriculture in 2010.

Assessment of landscape identity is closely related to detection, identification and definition of landscape formation elements, because landscape elements are the key to the perception of identity and they play one of the decisive roles in formation of landscape identity. Being based on the structure of identity multidisciplinary research, the landscape formation elements are divided into three groups: visual (preserved natural and man–made elements or parts thereof), historical (once existing, disappeared or destroyed natural and man–made features), and cognitive (human memory and associations, traditions, symbols, experiences, adventures, etc.). The method of landscape identity assessment is based on the sequential research and determination of landscape formation elements of each group, combining cartographical and descriptive methods and approaches using them for each stage of the landscape research sphere.

In assessing historic formation elements of landscape identity, the following stages should be distinguished.

1. Defining historic development stages. According to the available data on the transformation processes and events of landscape development, separate stages are defined, where the content of the event, action or process and their consequences – changes in the landscape – are described. Here, it is important to assess whether the former events can still be seen in the landscape as individual elements or as landscape structure. For representation of historical data, a historic landscape development matrix is used in which the events and changes in the landscape are described by the following points: historical development period and the appropriate actions, events, processes and corresponding changes in the landscape, landscape elements, which have completely disappeared, current landscape elements or landscape structure, which are wholly or partially preserved (Table 1).

2. The research on spatial development is based on the comparison of cartographic and photo material of different time periods (Van Eetvelde and Antrop, 2009). It is important to mark the landscape elements of the long–term existence as a specific place name or the specific structure (Carter et al., 2007). Cartographic material research is attached to the landscape historical development matrix, including in the matrix the obtained data during the

investigation of cartographic materials in correspondence with the development stages. Most often these elements form the core of the landscape identity.

The landscape historic formation elements which were determined at the end of the first stage shall be divided into two groups: fully or partially preserved, and completely disappeared. The completely disappeared landscape elements or landscape structure should be included in the associative part of population surveys, in order to determine whether these landscape elements form the identity of the invisible (which is not less important) cognitive aspect of landscape. Fully or partially preserved landscape elements should be incorporated into the research sphere of visual landscape forming elements when performing the field research and estimating the value of the visual.

Assessment of visual formation elements of landscape identity. The investigation of visual formation elements of landscape is one of the stages of assessment of landscape identity. In landscape investigations for visual landscape assessment the following criteria should be used: the visual availability, scale, naturalism, type of use, diversity, and coordination (Ode et al., 2008).

Assessment of visual formation elements of landscape identity includes the following stages:

1. Field research. The obtaining of the required data for the assessment of visual formation elements of landscape is performed in nature by the analysis of individual landscape space according to pre–prepared assessment matrices. By field research the coordinates of the point of view are identified, location is marked on a map, a spatial sketch is drawn, a short description of landscape is presented, including key words. Landscape assessment is divided into two parts: assessment of the common subjective visual landscape and assessment of the dominant landscape elements. For subjective assessment of the landscape the following parameters should be observed: the visual availability, scale, topography, color, material, texture, variety, rarity, sensation, movement, naturalism. The predominant landscape elements are divided into the following groups: construction, individual architectural elements, roads, land surface, land surface overgrow, hydrology.

2. Data processing and analysis of results. A field survey is the basis for the identification of typical and unique landscape elements and landscape structures. The data are collected and processed in the SPSS environment. The measurement for aggregated data – their nominal value. All matrix questions are of closed question type. For the questions which have only one response option, the data are coded and marked with numbers. But for the questions which have several response options, a dichotomous analytical method is used – each response option provides a separate variable with a column, option codes: 1 – there is an answer, 0 – no answer. For the analysis of the results, both primary and secondary data analysis are used. Primary data analysis – empirical distribution – shows the feature under investigation at a repetition rate – the number of times the version is found in the study. Secondary data analysis – analysis of contingency – determines whether there are correlations between the presence of different nominal data. The data are summarized in Table rXc, where r is the number of rows, but c is the number of columns. Set the significance level of 5% error probability (confidence level 95%). For decision making X2 and Kramer's coefficient are used. The collected data are used for drawing up expert survey questionnaires and population survey questionnaires.

Assessment of cognitive formation elements of landscape identity

The multi–dimensional nature of the concept of identity makes it necessary to include the investigation of cognitive formation elements of landscape identity in the method of landscape identity assessment (Bell, 2009). Assessment of cognitive formation elements of landscape identity can be implemented only with the help of the public and expert surveys, and it includes the following stages:

1. Questionnaires Preparation. It is based on the two previous stages of the investigation. The potential formation elements of landscape identity (revealed during the research on historical materials) which split into two groups. The disappeared landscape elements that can be still remained in people's memories, which can be clarified by the questionnaire. The preparation of questions without images takes place. Historical landscape elements are assembled according to the functional groups, where the corresponding elements are marked in descending order. The second group of questions consists of issues with landscape imagery where the respondent shall mark the most relevant elements of the identity in descending order – they are totally or partially preserved landscape elements, which have been surveyed in nature by performing the assessment of visual formation elements of landscape identity. There is also a separate group of questions, the aim of which is to clarify the associative aspect of landscape identity what it is not possible to be determined by the stages of assessment of historic and visual formation elements – people's memories, traditions, songs, beliefs, etc.

2. Data processing and analysis of results. Questionnaire data are collected and processed in the SPSS environment – is the same method like in visual formation elements part.

Results and Discussion

The end result of the method of landscape identity assessment is a landscape model of identity that reflects the multidisciplinary approach to the research and includes the tripartite nature of identity – investigation of historic, visual and cognitive formation elements of landscape identity. Sequential appliance of the method is of great importance, as the obtained data and results of each stage are included in the following stage, reaching up to the formation of landscape identity model. The research feedback shall be provided by reviewing historical development, by comparison of the results of visual research and surveys, and for the conclusion using the landscape identity model.

The results of assessment of historic formation elements of landscape identity are combined in the historic landscape development matrix in which landscape elements are arranged by the time periods, changes in the landscape during these periods are defined, and finally the nowadays image of the landscape and the importance of historic landscape elements in it are defined. In addition to theoretical investigations, spatial landscape development is also performed. Availability of qualitative cartographic material during the research on landscape could be considered as a great success as without it investigation of spatial development is difficult to be performed. Cartographic material research is the basis for defining landscape historic structures and their development, making it possible to get information about shape, size, location and reachability of landscape elements. Landscape investigators and geographers admit the importance of historical aspect in their landscape investigations, as well as the importance of the investigation of landscape structure variability in the historic aspect, being one of the first exploration stages (Nikodemus and Rasa, 2005). In recent landscape investigations, are new concepts such as landscape biography, landscape of place, reading the landscape, continuity of landscape development (Zariņa, 2010).

Table 1

Historic development stages

Historic landscape development			Landscape nowadays	
time period	actions, events, processes, etc.	landscape changes	completely or partially disappeared landscape elements or landscape structure	remaining landscape elements or landscape structure
1. Events or natural processes arising from natural factors				
2. Events or natural processes arising from anthropogenic factors				

On the basis of assessment of visual formation elements of landscape identity, the survey results matrices have been obtained. The data processing shows the typical landscape features and elements, as well as the unique landscape features and elements. A visual field survey is based on landscape characterization, by using visual perception criteria. Characterization of landscape image is partly a subjective assessment, because it is based on the associative perception criteria. Within the framework of the method of landscape identity assessment, eleven criteria specifying the landscape visual image have been established. Each of criteria is divided in several subpoints.

Table 2

Visual perception characterization

Visual perception criteria	Characterization of criteria
Visual availability	unavailable, a narrow, limited, partly accessible, open, fully accessible
Scale	intimate, close, small, medium, large, wide
Relief	smooth, flat with some hills, gently wavy, hilly, dunes, hill, cliff, steep slope, valley, gully, gorge
Color	neutral, monochrome, nuanced, vivid, colorful, checkered, with some bright elements
Materials	natural landscape, wood, stone, plaster, concrete, bricks, glass, metal, synthetic materials, other materials
Texture	smooth, soft, fine, rough, sharp, fragmented
Diversity	uniform, easy, different, complex
Rarity	normal, typical, unique, rare, unique
Movement	dead, quiet, lively, uproarious
Naturalism	natural, natural with some man–made elements, anthropogenic environment with some natural elements, an urban
Senses	boring, neutral, pleasant, safe, calming, interesting, inspiring, provocative, intrusive, unpleasant, unsafe

The specifying elements of visual accessibility are: landscape location, length of landscape line, and landscape width. Not less important are relief forms, which directly affect the view and the visibility and landscape diversity (Fisher, 1996). Of great importance are the features of visual perception, which characterizes spatial environmental

uniqueness (Ziemeļniece, 1998). As a characterizing value we perceive the landscape scale. Each of the scales of perception includes its own regularities, its own ways of expression, possibilities to investigate and to use investigation results (Melluma and Leinerte, 1992; Krause, 2001). The change of the perception scale causes the change of the number of details and elements that feature the landscape identity (Forest landscape…, 1989). Visual perception criteria are also color, texture, and landscape materials. These criteria, in relation to man–made elements, reflect to a great extent the manifestations of traditions in the landscape and are the forms of aesthetics of physical manifestations (Ode et al., 2008). Other visual landscape specifying values are: landscape naturalness, diversity, and rarity. Landscape diversity is often emphasized as the visual quality indicator (Nikodemus and Rasa, 2005). Diversity is distinguished by two groups – the structural diversity and diversity of landscape elements. The emotional factor – feelings – is also important for creating a common image. Feelings can range from boring to inspiring and unsafe (Landscape character…, 2002). The survey matrix of landscape visual image includes the combination of visual landscape assessment criteria which are introduced by several authors to make these criteria be adapted to Latvian conditions.

A visual investigation of the landscape also includes the matrix of identification of landscape elements, where landscape elements are divided into six groups and subpoints indicating the most common landscape elements (Landscape character…, 2002) (Table 3).

Table 3

Dominating landscape elements characterization

Groups of landscape elements	Dominating landscape elements
Construction	ruins, separate buildings, farms, construction groups, locality, village, suburb, small town, residential neighborhoods, a city's built heritage, industrial buildings, military construction, port, railway station, other buildings, no building
Individual architectural elements	poles, electricity and other forms of communication towers, fences, walls, support walls, monuments, bridge, dock, observation tower, a lighthouse, wind generators, other elements, no element
Roads	trampled down paths, crisp surface pedestrian trail, a hard surface pedestrian trail, footbridge, earth road, loose surface road, hard surface road, highway, railway, other roads, no road
Land surface	rocky bank, sandy bank, coastal grassland, bogged up area, moss, agricultural land, lawn, meadow, loose surfaces – playgrounds, solid surfaces – playgrounds, other types of land surface
Earth Surface overgrow Greenery	grass clusters, individual shrubs, bushes groups, individual trees, tree clusters, groves, forests, allotment, alleys, squares, parks, gardens, orchards, buffer plantings, other greenery, no greenery
Water elements	marsh, ditch, stream, river, pond, lake, quarry, swimming pool, water, sea, other water elements, no water element

Construction character, intensity and stylistics determine the culture–historical kernel of identity, which represents particular human activities in space. Construction is characterized not only by individual architectural elements and their groups, but also by landscape structure (Briņķis and Buka, 2008). The individual elements of the architecture can include a functional load, as well as symbolic and aesthetic elements. Symbolic elements are often a key to the identity of the landscape that are most exposed to both visual and cognitive level. Roads in the landscape are defined as a view point range. Type of road and cover clearly defines its workload and level of use. Land surface is the landscape background, which may be very typical of a particular landscape or area unique. Land surface provides information on the way the land is used, which is also one of the landscape characterizing values (Nassauer, 1997; Nikodemus and Rasa, 2005). Here it is important to note the historical or traditional land usage types, looking for link with the present day. Plants which cover the land surface are one of the landscape elements, which possess a strong seasonality, so that its evaluation is dependent on the seasons. Plants are the indicators, which points to the naturalness of the landscape, climatic conditions, specific locations and the traditions of landscape architecture. Water elements in the landscape are often the landscape diversity factor, which attracts not only plant and animal community, but also people's attention and desire to be near water. The predominant landscape identity formation element helps to determine the type of landscape, and is the basis for drawing up a questionnaire.

The importance of subjective perception is emphasized in defining the landscape itself. The definition of landscape used by European Landscape Convention is: 'An area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (European…, 2000). So, the definition of landscape includes not only the natural and human interactions, but also human perception and its importance. However, subjective

perception of the landscape by each individual shall be taken into account. The importance of population surveys is highly evaluated by many landscape investigators who include in their researches landscape associative perception (Bell, 2009). Investigation of cognitive formation elements of landscape identity are corresponding to researches on the regional identity and sociology studies, where the importance of associative symbols, an individual's memory and self–awareness, traditions, folklore and cultural contexts is great (Петров, 2008; Гончарик, 2011). The results of population surveys and expert surveys reflect the concealed part of the landscape identity and reveal cognitive formation elements of landscape identity. The groups and the structure of questions are arranged with the aim to provide the corresponding thematic order of the questions that would help respondents to understand the aim of the questionnaire and not to get confused when giving answers to various kinds of questions.

The result of the questionnaire is the determination of the groups of cognitive and visual formation elements of landscape identity. The questionnaire is developed in different blocks – a group of questions without pictures in order to find out people's memories, feelings and images of the subconscious landscape that are cognitive formation elements of landscape identity; and a group of questions with pictures in order to find out visual formation elements of landscape identity. The expert survey has been compiled by analogy, but the resulting data were analyzed separately to compare the results.

Conclusions

The method of landscape identity assessment which is based on multidisciplinary approach has been worked out. The method can be used in landscape research with the aim to define the identity of the landscape and to create a specific landscape identity model. The method of landscape identity assessment is considered to be universal and to be used in various landscapes of Latvia. The groups of the main formation elements reflect the tripartite nature of the landscape identity and characterize the landscape identity from different angles, including historical, visual and cognitive landscape perception research in one method. The methodology and the criteria provide observation of common principles in various Latvian landscape researches. Consequently, it is possible to analyze the landscape identity in the course of time. The drawback of this method is unpredictable results of the survey, which is influenced by several factors – from the weather conditions to the economic situation in general. The results may also be affected by the respondent's mood at the time of completion of the questionnaire, as part of the questionnaire focuses on the associative perception, which is variable and difficult to be described. Another drawback – associative responses – cannot always be successfully grouped for further processing. Consequently, a repeated data collection is of great importance. The method of landscape identity assessment can be used to monitor the changes of landscape identity. The results obtained can be used for working out the guidelines for the landscape design and development. Further research is related to the approbation of the method of landscape identity assessment for assessing coastal landscape identity of the Baltic Sea and the Gulf of Riga and working out landscape identity model.

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PRINCIPLES FOR PLANNING RESIDENTIAL AREA GREENERY

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Abstract

The article presents information on the greenery in the large-scale residential area courtyards built in the Soviet period. The data on the importance of the greenery in the large-scale residential areas of the Baltic States were analysed. The analysis was carried out on the large-scale residential area courtyards built in the second half of the 20th century in Pärnu, Jelgava, and Siauliai, which until present have not experienced any changes of the landscape. The research established that these courtyards can be characterised as the unused territory resources. Consequently, there is a necessity to resolve the topical issues of the greenery in the Soviet period large-scale residential area courtyards. From the theoretical aspect, the information gathered in the research on the greenery in the large-scale residential areas has revealed relevant suggestions for the improvement of the present condition. The variety of information reflects the significance of the greenery in the large-scale residential area courtyards that have to provide an aesthetically pleasant image of the territory for every inhabitant of the territory. The methods applied in the research describe the present condition of the Soviet period courtyards.

Key words: large-scale residential area courtyards, importance of greenery.

Introduction

The earlier researches established that the architecture, design, the common outdoor territory and functionality facilitate or on the contrary – slow down the development of mutual connections. For example, there have been conducted several studies that for a certain group of individuals a common outdoor territory is the most important place for everyday meetings and communication (Fleming et al., 1985; Ušča, 2010). It means that the quality of mutual outdoor territory affects the mutual social connections, for instance, in those territories with more greenery and trees the social activities of residents can be observed more often than in those territories with less amount of greenery (Coley et al., 1997; Sullivan et al., 2004). Consequently, the amount of greenery and the aesthetic quality is of great importance in courtyard planning process. The residential outdoor territory is one of the components that affect the health of inhabitants, and its quality can affect the level of inhabitants' satisfaction with the territory or their residential area. For example, an American urban planner Kevin Lynch, applying empirical researches, has made several significant discoveries in the field of urban planning, as regards, how the individuals perceive and travel around the urban environment, how the urban environment affects children, and how to use the human perception as a physical form, as a conceptual basis for a successful design of urban environment in the cities and regions (Bauls et al., 2003; Dimze, 2010; Jankava, 2010). A Swiss architect Le Corbusier proposed a new urban housing principle – large-scale residential buildings surrounded with greenery, with easy accessible fresh air and sunlight (Treija, 2007). The Danish architect and urban planner Jan Gehl has performed several significant researches from the perspective of functionality and aesthetics on the public outdoor territory design and improvement that covers the transport traffic and pedestrian orientation in the cities (Grišins, 2001). The importance of greenery planning in Soviet period large-scale residential areas previously has not been widely studied.

Presently, the large-scale residential fund is rather neglected; therefore, it has resulted in multiple irreversible negative factors that slow down the development and improvement of these areas. There are various successful examples of large-scale residential area reconstructions in European Union, and their experience could be applied in the courtyard renovation processes in the Baltic States (Īle, 2011). For example, the renovated area Hellersdorf in Germany was a typical large-scale panel house area, and its territory was reorganized and landscaped with greenery (Treija, 2007). Whereas, the large-scale residential area courtyard built in the Soviet period in the Baltic States are presently free outdoor territories with vast lawn areas that have not experienced any changes in greenery and landscape, i. e., they are neglected. However, the quality of several buildings is slowly improving; nevertheless, the public outdoor territory continues to degrade, because it is still considered an issue of secondary importance (Treija, 2008). The courtyard territories are not usefully and functionally exploited, which would ensure the well-being of the large-scale residential area inhabitants (Īle, 2010). The research established that over the last years the greenery in the Soviet period large-scale residential area courtyards was neglected, as a result, because the heritage of greenery planning was not maintained, there are either no greenery, or only slight characteristics of once rich and flowering greenery systems left until the present time. The major part of these territories currently do not form a pleasant image of the outdoor territory, where the most important aspect, alongside with the infrastructure, was, in particular, the large-scale residential courtyard greenery. The author has performed a research on the landscape

development stages in the large-scale residential areas of the Baltic Sea region. The present article discusses one of the most important aspects – the greenery. Consequently, the aim of this article is to explore the condition of landscape planning in the Soviet period large-scale residential area courtyards in the Baltic States.

Materials and Methods

The research on the condition of the greenery planning in the Soviet period large-scale residential area courtyards was carried out in the summer and autumn period from 2009 until 2010. To determine the present condition of greenery in the large-scale residential area courtyards, the comparative analysis and monographic (descriptive) methods were applied. The comparative analysis used in the research was based on the current Baltic Sea region Soviet period large-scale residential area observation and investigation according to the defined criteria. The analysis was used to establish the present condition of the greenery. The analysed large-scale residential courtyards were chosen according to one common characteristic – they were to be the large-scale residential area courtyards built in the Soviet period. To establish the present situation the author of the article investigated three Baltic State cities – Pärnu, Jelgava, and Siauliai. In every city 10 Soviet period large-scale residential area courtyards were chosen for analysis. Consequently, the study was performed on 30 courtyards in general, which is a sufficient amount of research in order to understand the importance of qualitative greenery in the Soviet period large-scale courtyards. The location of investigated courtyards was between the Mai and Papiniidu streets in Pärnu, on Satiksmes and Lielā streets in Jelgava, and RAF residential area courtyards, and the surrounding residential courtyards near Tilžes and Ežero gates in Siauliai. The present situation and the condition of greenery in these areas were established according to the criteria set by the author – the functional use of the greenery, the aesthetic value, and the amount of greenery. To obtain the precise data, the defined criteria were evaluated according to specified values, where +2 means "fully agree", +1 – "rather agree", 0 – "average", -1 – "rather disagree", and -2 – "fully disagree". To evaluate the functional use of the territory in every courtyard, the analysis was carried out to determine how rationally the greenery is used for dividing different functional areas, and whether they can perform their function as intended. To establish the aesthetic value, the visual condition of the greenery was evaluated. It was studied, if the presence of greenery improves or lowers the aesthetic quality of the courtyard landscape. The amount of greenery was analysed in relation to the free residential territories of the courtyard in every analysed city. As a result, a comprehensive description of the greenery in every courtyard was prepared. To interpret the data obtained, the monographic (descriptive) method was applied, which was based on the scientific findings and theory. From the theoretical aspect, the principles for planning greenery were researched, studying their relation to the Soviet period large-scale residential area courtyards. Based on the previous studies, performed by the author, on the development of landscape in the large-scale residential courtyards in the Baltic Sea region, alongside with the information used to determine the present situation, an informative material was obtained on the experience of other countries in planning and maintaining the greenery in the large-scale residential area courtyards.

Results and Discussion

The characteristics of the greenery of the analysed courtyards

To determine the importance and the present condition of the greenery in courtyards, the criteria defined in the research for the analysis of Pärnu, Jelgava, and Siauliai, are accordingly systematized (see Table 1). The research established the present condition of the greenery.

Table 1

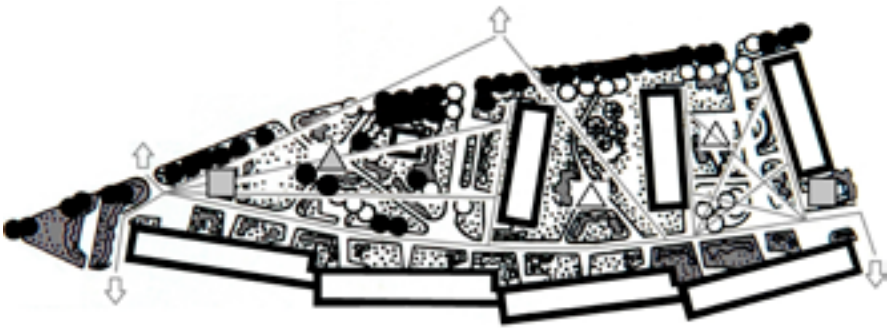
Current condition of greenery in courtyards analysed according to the criteria defined

Analysed city courtyards	Functional use of greenery in courtyards					Aesthetic value of greenery in courtyards					Quantity of greenery in courtyards				
	Evaluation degree					Evaluation degree					Evaluation degree				
	+2	+1	0	-1	-2	+2	+1	0	-1	-2	+2	+1	0	-1	-2
In Pärnu	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-
In Jelgava	-	-	-	+	-	-	-	+	-	-	-	-	+	-	-
In Siauliai	-	-	-	+	-	-	-	+	-	-	-	-	+	-	-

Source: table and data created by the author, "+" evaluation degree, "-" not established in the research.

The results obtained present that the greenery in the courtyards of Jelgava and Siauliai are of lower aesthetic quality and poorer greenery exploitation possibilities than the courtyards in Pärnu. After the analysis of the territories the research revealed that the greeneries in Jelgava and Siauliai do not form a qualitative landscape in the residential outdoor territories. Mostly, the maintenance of greenery is neglected. Although the public spaces serve as important parts of living environment, their use significantly differs from the initially desired. The reasons are both social and economical. In the original projects, the initially planned landscape and

greenery mostly were not realised, the outdoors were not appropriately taken care of, and their landscape was not renewed, which led to territory degradation. As a result, these territories have obtained an image of neglected, useless, and unaesthetic environment, which often is looked at as an unused territory resource which is then built up, losing the originally planned public space quality of the large-scale residential environment (Treija et al., 2010). This is supported by the results obtained from the research on the cities of Pärnu, Jelgava, and Siauliai. One of the most typical examples of the analysed courtyards that have lost the visually aesthetic attractiveness over the years is the courtyard on the Lielā street in the city of Jelgava, and it is located in the city centre. The amount of the greenery planned in the Soviet period has changed significantly nowadays (Figure 1).



Source: by Пучин, Пиешиньш, Лусе (1977)

Figure 1. Jelgava city courtyard planning system in Soviet period:

1 – main pedestrian traffic directions; 2 – presently non-existent greenery massifs; 3 – grown trees; 4 – presently non-existent grown trees; 5 – loud resting area built in the second half of the 20th century; 6 – quiet resting area built in the second half of the 20th century; 7 – recently non-existent transport and economic area.

Comparing the past and the present situations in the previous example, there are presently no quiet resting places for residents, no row-type growing tree plantations in the northern direction, no greenery rows at the building entrances; they are presently used only as parking places. This is supported by the acknowledgements established in other researches. The free space between the residential buildings, previous greenery areas and children playgrounds, were used for commercial activities. The increasing amount of cars causes problems for the courtyard outdoor territory exploitation possibilities, because it eliminated the recreational function. In the process of privatization when the residential area was divided into private zones, the courtyards were used as parking lots and were built up by local services, consequently, it distorted the primary idea of the architects that originated from Le Corbusier's concept of the greenery surrounded large-scale residential areas. The problem is topical in the Baltic States cities (Liepa-Zemeša, 2008; Treija and Bratuškins, 2003). The quantity of greenery in the Soviet period large-scale residential area courtyards is sufficient, but it is necessary to functionally improve and reorganise the greenery systems in these territories. Many courtyard green zones are constructed without carefully considered projects, which resulted in trees being planted very densely and too close to buildings, creating shade which disturbs the growth of bush and grass, leaving the ground naked and trampled. These trees also damage the substructure and roofs of buildings, moisten walls, and branches hit the windows. The courtyards are uncared-for and unorganised – the lawns are trampled, bushes are overgrown. There is a lack of resting places, playgrounds and dog-walking parks (Jelgavas teritorijas plānojums..., 1999). The research established that such characteristics are mostly found not only in Jelgava, but also in the analysed courtyards in Lithuania.

Greenery planning principles for large-scale residential areas

The progressive urban-builders began looking for new city structures already in the 19th century, planning the green structures in close proximity to residences as obligatory future city elements. In the beginning of the 20th century the city was understood as one or two apartment buildings located among multiple gardens. In the 30's of the 20th century several theories evolved in relation to the basic living unit in the multi-storey residential areas of the new city. The creation of these theories can be related to contributions by several Soviet urban planners. Beginning from the end of the 50's the mass-building of apartments in the Soviet Union was organised, based on the residential community housing principles. Beginning from the 1958, in the apartment mass-building quarters and areas, the greenery occupied around 40 – 45% of the territory. The traditional perimetral quarter housing with the corridor-type streets were replaced by freely located buildings surrounded by green gardens. The greenery becomes an essential part of

the living area. It is necessary for creating microclimate and hygienic conditions, to create an environment for recreational purposes, and an outstanding city landscape (Buka and Volrāts, 1987; Lūse, 1971). The aesthetic value of greenery does not depend on how varied is the greening material, how large is the flowerbed space, and on the amount of planted trees. It is determined by the location of greenery, the mutual organization according to the principles of art and architecture composition, as well as the appropriate choice of plants, observing the conditions of planting area (soil, lighting, wind direction, etc.), the territory exploitations type and the economical issues both in the greening process and in the choice of greening material and exploitation. Correctly built and well-cared greenery makes the residential territory not only pleasant and beautiful, but also healthy (Amatniece et al., 1973). Incorporating a building within the greenery and making the area closer to nature is one of the most common modern architecture tendencies. In the modern republic it is also a continuation of national traditions maintained for hundreds of years. Every building or house's main accessory are the trees. Oak-trees, lime-trees, or birches have been safeguarded for generations on the edge of a field or even in the middle of it (Šusts, 1966). Therefore, the aesthetic value of large trees, especially pine trees, saved in the housing composition, is priceless. Their rich forms and vertical shapes contrast with the simple geometric horizontal shapes of residential buildings, and they are irreplaceable in the nature's environment composition, making it richer (Bajārs, 1979). In the Danish territory planning, there often apply a method of restricting the city green zone lanes and locating linearly ordered city satellites in the neigbourhood territory (Briņķis, 2005). Construction and maintenance of the mosaic-type greenery structures in the territory planning is essential both for safeguarding the resident's emotional perception and the psychological well-being, for realization of aesthetic necessities, and for maintaining the biological diversity in the territory (Jelgavas teritorijas plānojums, 1999). Restructuring and constructing new green zone structures simultaneously with new buildings and roads, the urban environment could improve in quality, even if the territory of greenery is diminished (Stahle, 2002). Based on the analysis of the scientific findings, the established greenery structure in the large-scale residential areas is illustrated in Table 2.

Table 2

The structure of the large-scale residential area greenery

Greenery types	Types of exploitation	Common characteristics
public use greenery	community gardens, squares, and boulevards	combining greenery into united massifs (community centre greenery, residential area gardens, and greenery for physical training)
limited use greenery	near pre-school children institutions, schools and health protection territories	
specialty gardens	greenery shelter belts	

Source: by Briņķis, Buka (2001); Buka, Volrāts (1987)

Trees near buildings should be planted so that the insolation of the building, and pedestrian and transport movement would not be disturbed, and so that constructions of building are not damaged (Saistošie noteikumi Nr. 09 − 11..., 2009). The tree foliage purifies the air from hazardous gas and smoke, blocks dust, and forests protect cities and residential areas from wind, even out temperature variations and regulate other climate and meteorological conditions. Building walls, cobblestone and asphalt accumulate warmth in the summer, they act as accumulators. In the sunny side, buildings overheat in the summer, and trees, providing shade on the walls, can improve the well-being of residents. A tree in a courtyard is a decorative construction which sometimes, like a centre of gravity of a certain space, optically lies on buildings. Trees with rich foliage (maples, chestnuts, etc.) create total shading and act as umbrellas; their roots do not receive moisture; therefore, they look for water around the crown area and suck the water from building substructure, drying the land.

The latter is affected by building disposition, sometimes causing wind whirlpools mainly in community residence courtyards. It is also important to determine the duration of shading in different areas of courtyards, because it is essential when choosing plants with particular lighting requirements. The blossom period depends on the intensity of the lighting. Plants will not blossom in a fully shaded area; whereas, the more sunlight gets through to plants, the more beautiful they will bloom (Vikmanis, 2005). The research established that the amount of the asphalted and paved areas is significantly larger in the courtyards landscaped in the Soviet period, and it takes over the major part of the territories allocated for recreation. Consequently, the landscape in the courtyard is to be planned in a way that the resting and playground areas would provide hygienic, functional, and aesthetically pleasant environment, diminish the amount of dust and noise, provide benches for sitting, places and equipment for playing, a green lawn with a decorative pavement, etc. Planning a courtyard composition in a large-scale

residential area, the architect has to consider not only the existing three dimensions, but also the fourth dimension – the time. Plants in the courtyard greenery grow over time, thus changing the features of courtyard's landscape. The construction of green zones should agree with the social character and should provide good conditions for people from every age group, for different group and individual activities, for children development, and for economic processes (Amatniece et al., 1973; Dāvidsone, 1988). The information obtained in the research on the rational renovation of the greenery in the degraded courtyards is illustrated in Table 3.

Table 3

The greenery planning principles in the large-scale residential courtyards

Greenery renovation aspects	Courtyard landscape comprises		Greenery renovation aspects, requirements, and characteristics
ecological expertise in courtyards	data on climate, ground-water depth, types of soil, soil base, amount of storm-water		it is necessary to consider the direction of prevailing winds by months, shade zones, appropriate greenery for lighting requirements
improvement of microclimate conditions in residential courtyards	greenery that protects the territory from the heat from building fronts, and apartments from overheating	greenery for protecting pathways, squares form insolation, for soil protection from insolation	provide variety of vegetation, plant trees in groups that form habitats, or in lines, because they can bare the impact of the surrounding environment; build hedges and flower beds in a united system
aesthetic quality of greenery in courtyards	multiple types of hedges that form different combinations and variations; maintenance of grown trees and at lest 30% of the new greenery is to be made of 10 – 15 year old planting materials	repetition of colours and shapes creates an illusion of organization; plants with architectonic shapes, with their defined contours, texture or shapes of leaves stand out in any area	the type and appearance of greenery is the most important aspect in facilitating the exploitation intensity of residential areas; the hedges can be located freely in the territory or be specially cut, fruitful, high, low, thick, sparse, wide, narrow, fast-growing, combined with stone or land walls; they serve as shelters from winds and for territory demarcation
greenery planning in courtyards	greenery shelter belts are used to demarcate the unpleasant views and to shelter the area from prevailing winds; wide greenery shelter belts diminish the traffic noise	a variety or plants are used to demarcate different functional areas, to create pleasant atmosphere in sitting areas; trees give shades, bushes shelter from winds and provide good, warm and moist climate for the plants in the soil	the greenery has to be evergreen and with rich foliage, as well as fast growing; in open areas, to protect the territory from winds, the greenery is planted in rows; in this case, the best option is to choose trees with smaller foliage, because they absorb the wind, but trees with rich foliage cause turbulence, therefore, are not advisable; such wind-breaker shelters provide 6 time wider lee areas than the height of the trees used for sheltering

Source: by Auders (2006), Hesejons (1998), Kruše et al., (1995), Lūse (1971), Vidlunda (2009), Vikmanis (2005), Горохов (2005).

The next most important development step of these areas, involving its inhabitants in all processes, is the reconstruction of the mass-housing. There are multiple possibilities in the large-scale areas to perform physical changes. The development of these objects can critically affect the social structure of the property. The choices made can affect the way how the buildings are used and their maintenance process. It is an essential criteria for a successful regeneration (Towers, 2000). Therefore, there is a necessity to construct specific residential area conceptions, which intend the trees to be planted not one by one in free spaces, but in a unified systems located throughout the residential area. Only this could achieve sustainable effect. The residential area and the quality of the environment are of great importance in the development process of every city (Karpova, 2008; Kruše

et al., 1995; Vidlunda, 2009). The development in the territory that is important in the urban landscape, and that is an essential part of the public outdoor territory, as well as the areas that are to have a large-scale development, is to be performed according to the plan accepted by all the parties involved. The creation of attractive residential outdoor territories for its inhabitants will improve the quality of the greenery in courtyards (Liepa-Zemeša, 2008; Kruuse et al., 2005). Consequently, a rationally planned and organized landscape of the residential area can be achieved.

Conclusions

The facts established in the research illustrate the present condition of the analysed Soviet period large-scale residential area courtyards. There are multiple inconsistencies that need to be eliminated. The principles established in the research are to be applied to improve the condition of the greenery and its planning processes in the Soviet period Baltic States courtyards. The landscape in the analysed courtyards in Jelgava and Siauliai need to be re-planned, thus, improving the aesthetical quality and facilitating rational exploitation of the courtyard greenery. Whereas the greenery in courtyards in Pärnu should be maintained as originally, but new modern and useful greenery elements should be added. Such improvements would enrich the landscape of the courtyard and would provide a certain atmosphere in every season of the year. It is essential to maintain, expand and improve the green zone resources in the large-scale residential area courtyards. The importance of green zones to be aesthetically pleasant hides in the fact that it models a certain landscape space with its own character and features. In many analysed courtyards the quantity of the greenery is sufficient, but it needs to be visually improved and reorganized. The research established one characteristic that affects the general greenery system of every analysed courtyard. Residents of these territories plant their own trees or other plants, according to their own preferences and taste, thus causing different negative consequences in the landscape of the territory. Such actions should not be approved because they divide the area into several unrelated courtyard territories, and do not provide a united greenery system, as well as generally do not agree with any of the basic planning principles. Consequently, it causes the landscape to develop unevenly. To prevent such actions, the architects should consider the opinions of inhabitants prior to reconstructing the courtyard, as well as to provide specially allocated territories where the residents would be able to plant their greenery according to their own taste. This solution would significantly improve the quality of the landscape in courtyards and would rationally integrate into the whole greenery system. This is also an important issue for improving both the microclimate, and the aesthetic quality, and it prevents the division of the landscape into multiple unrelated areas of the large-scale residential courtyards.

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VISUAL QUALITY EVALUATION APPROACHES OF SACRAL LANDSCAPE OF LATGALE

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Abstract

The aesthetic quality of landscape is one of the most threatened values in our environment. The methodology chosen to evaluate the landscape for the first time has to be precise and effective. The objective of this study was to find the most appropriate method for the first time evaluation of sacral landscapes. The paper compares two methods – the Scenic beauty estimation method, and the Q sorting method for evaluating the scenic beauty. Comparison of the two methods was made in the winter of 2010 – 2011. The Scenic beauty estimation method is effective for getting a quick estimation of general scenic beauty. The Q method gives the estimation of general scenic beauty and the explanation of perception priority. The visual quality is deeply connected with perception. Placing perception in numbers leaves some doubt, but it is quite an effective way of observing the main visual qualities in the perception of spectators. Both methods give the first impression of the landscape elements. But Q method gives more significant results than the Scenic beauty estimation method.

Key words: sacral landscape, visual quality, evaluation methods.

Introduction

The sacral landscape of Latgale is unique, it has a different development history than the rest of Latvia. Latgale is the region in Latvia richest with lakes and that makes landscapes so picturesque.

The aesthetic quality of landscape is very difficult to define and also to evaluate. These qualities are easier to destroy and more difficult to protect than the ecological quality. There are methods for restoring the aesthetic values of landscape, the visual diagrams method and the 3D visualisation (Kašparova and Sklenička, 2008). It is important to preserve, not destroy and then restore.

Why is it important to think about the visual quality of landscape? Firstly, the visual quality is needed for the life quality, it provides us with positive emotions. Secondly, the landscape includes the cultural heritage that reminds about our achievements, the recreation places that give us energy, and the sacred places that offer meditation experience.

We can understand quality very differently. The landscape quality encompasses everything from simple everyday needs to spiritual and emotional needs. This research is about the visual evaluation of landscape. All of us love beautiful people, things, and sceneries. Scenic beauty involves planning, materials and, most importantly, time – long term planning.

There are different ways of reading landscapes. For a long time, the methods used by students of landscapes, notably landscape architects and geographers were highly individual (Taylor et al., 1987). It is possible to use different paradigms; some of them are expert, psychophysical, cognitive, and experiential. The landscape analysis has actualized quite late. The reason for it could be the spreading of man-made landscape, and that makes our responsibility for surrounding to grow. Systematic visual landscape quality assessment has been invested in and has matured in the last half of the 20th century. It has come to play an important role in environmental management and policy and it has become a well-recognized field of scientific research with a substantial literature base (Daniel, 2001).

No typology of landscape is used in this research, because the focus of research is on sacral landscapes. All these landscapes are man-changed; they are cultural landscapes with social significance. The sacral landscapes are defined mostly by prominent features and valuable landmarks – churches. Sacral landscape in Latgale is a resource that we need to assess.

K. Unwin (Unwin, 1975) describes three phases of landscape evaluation:

1) landscape measurement: an inventory of what actually exists in the landscape;
2) landscape value: an investigation and measurement of value judgements or preferences in the visual landscape;
3) landscape evaluation: an assessment of the quality of the objective visual landscape in terms of individual or social preferences for different landscape types.

Today, the assessment of visual quality has become more important in gathering data to be used in planning studies (Bulut and Yilmaz, 2008).

The chosen methodology has to be precise and effective, because the landscape changes all the time. The landscape changes are seen as a threat, a negative evolution, because the current changes are characterized by the loss of diversity, coherence and identity of the existing landscape (Antrop, 2005).

The objective of this study was to find the most appropriate method for the first time evaluation of sacral landscapes.

Materials and Methods

The sacral landscapes of Latgale were evaluated using two methods Scenic beauty estimation method (Fairweather

and Swaffield, 2001), and Q method developed by William Stephenson. Comparison of the two methods was made in the winter of 2010 – 2011.

The photos were taken by the author in the summer of 2008 in good whether conditions. All photos depict the sacral landscapes of Latgale. They are taken from different viewpoints. 30 photos out of 450 photos of 35 sacral landscapes were randomly chosen for evaluation. Each chosen photo is from a different sacral landscape. Photos with a close view on the church, a closer view on some details of church garden, a picturesque landscape seen from the church, and the sacral landscapes from a distant viewpoint were chosen for the study. The same 30 photos were used in both methods. Despite a range of attempts to develop alternative ways of representing landscape experience to subjects, photography remains the most widely used technique in the research of landscape perception (Fairweather and Swaffield, 2001).

80 respondents were observed within the research. Using each method, 40 people of different ages (between 24 and 57) and from different regions of Latvia were observed. The respondents were from different interest groups. There was no time limitation for evaluating the photos.

The Scenic beauty estimation method asks respondents to rate landscape scenes, represented by colour slides, on a 0-to-9 scale where 0 is a low scenic beauty and 9 is a high one.

There were two phases in using the Q method. The first was assessing the scenic value. The respondents had to arrange the photos as it is shown in Table 1. During the second phase the respondents were asked to explain the choice of six top and bottom scored photographies. They had to explain the choice in their own words and using as many expressions as they wanted.

Each photography value in both methods was found by getting average value by Microsoft Excel.

Table 1

Photography arrangement using Q method

Number of pile	1	2	3	4	5	6	7	8	9
Number of photography in pile	1	2	3	5	8	5	3	2	1
Score for photography in this pile	-4	-3	-2	-1	0	1	2	3	4

Results and Discussion

The psychophysical paradigm, like the expert one, is used more for the landscape management purposes and for analyzing a landscape. Two psychophysical paradigms were used in this research – the Scenic beauty estimation method, and the Q method. The Scenic beauty estimation method has primarily been developed and tested in the context of the scenic beauty assessment of forest (Daniel and Schroeder, 1979).

Numerous researchers have used regression procedures to produce prediction models for scenic beauty (Blinn, 2000). To start with, it is important to analyse the existing situation. There are several methods for the process of analysis, such as 'Scenic Beauty Assessment' or 'Law of Comparative Judgment' – a new version of scenic beauty assessment suggested by Yu (Wang et al., 2008).

The Scenic beauty estimation method and the Q method gave similar results in arrangement of photography by evaluation.

The data presented in Figure 1 and Figure 2 indicates that even if the results of both methods are similar, distribution of landscape scenic evaluation using the Q method is much wider. The Q method gives a more explicit representation of respondents' perception. Only three values are mainly used in the Scenic beauty estimation method by the respondents. The whole evaluation scale has to be used in the Q method.

The most important are the top and bottom scored photographies. The Scenic beauty estimation method helps to find the same result as the Q method. But then some other method needs to be used to find out why? Without answering this question the evaluation of landscapes looses its purpose.

The Q method in its second phase answers these questions. The explanation of choice gave the characteristics of landscape with high scenic beauty in the observer's perception and explained the negative sides of landscapes with low scenic beauty.

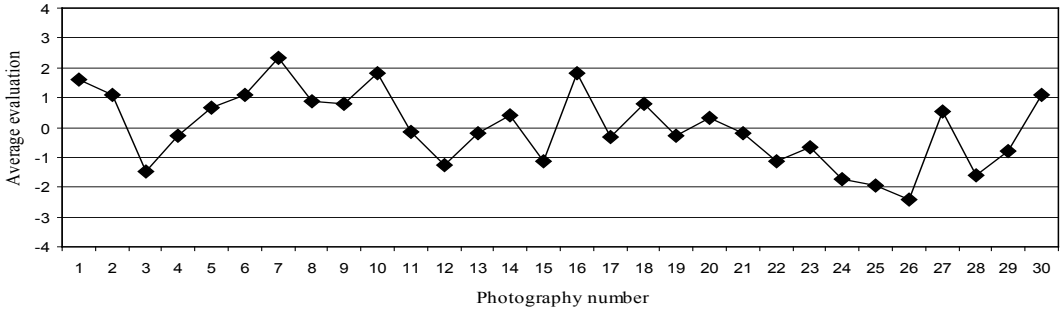

Figure 1. Average values of landscapes using the Scenic beauty estimation method.

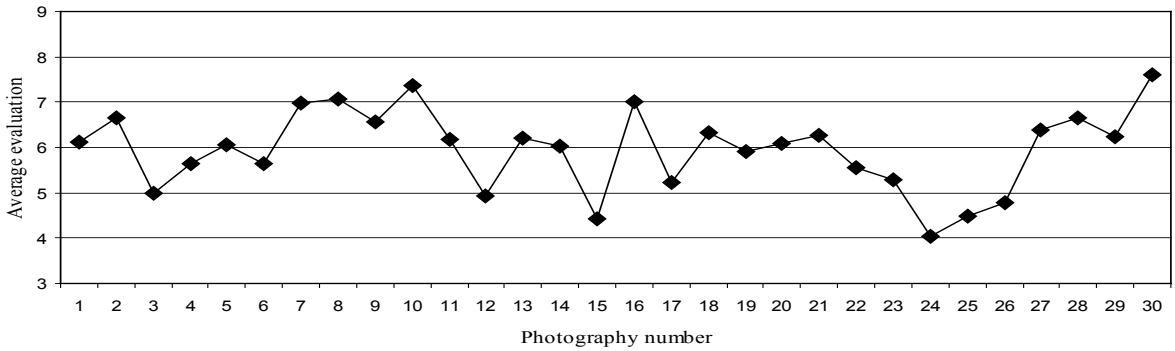

Figure 2. Average values of landscapes using the Q method.

The landscapes with high scenic beauty were mainly described with the presence of beautiful and interesting architecture (31%), such as wide landscape (21%) and spruce landscape (16%). The respondents have pointed out that in evaluating landscape by photography a viewpoint is important (Figure 3). The sacral architecture with its symbolic and historic meanings adds a value to the scenic beauty of landscape.

The landscapes with low scenic beauty were mainly described as having a bad viewpoint, underlining, the possibility of finding some value in them (Figure 4). In some cases a landscape loses its value due to some particular elements, like gloomy, abandoned buildings and neglected meadows. The absence of dominant sacral architecture is also important. The landscape loses its visual quality if the sacral architecture is hidden within.

It is important for the economic development of Latgale how landscapes are perceived by the observer. The aesthetic values can influence the tourists' perceptions of the tourism destination, and their excursion experience (Wang et al., 2008).

The visual quality is deeply connected with perception. Placing perception in numbers leaves some doubt, but it is quite an effective way of observing the main visual qualities in the perception of spectators. In my opinion it is important to involve people and ask them – 'why do they think so?' as much as possible.

What is common for the top scored photos and what we can learn from the bottom scored ones will be studied in the further research.

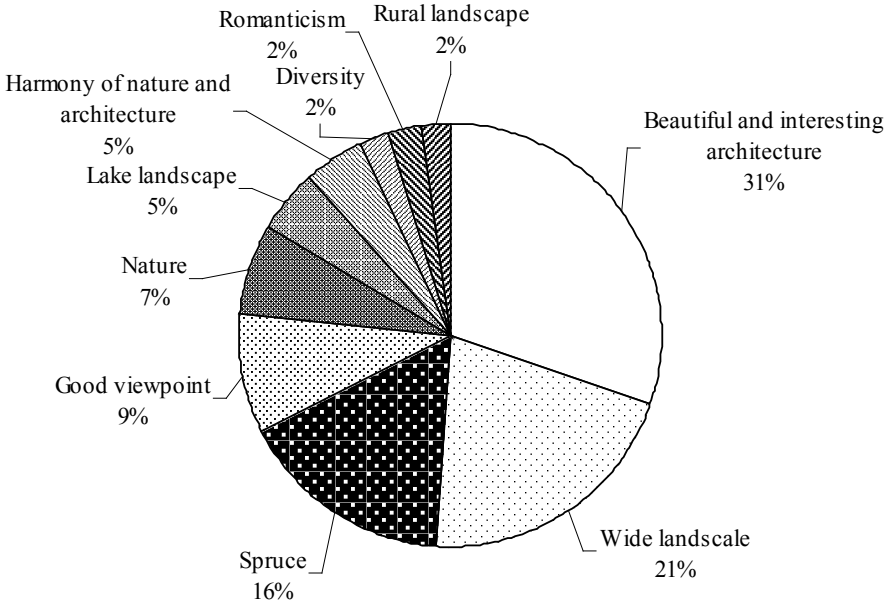

Figure 3. Characteristics used for describing landscapes with high scenic beauty.

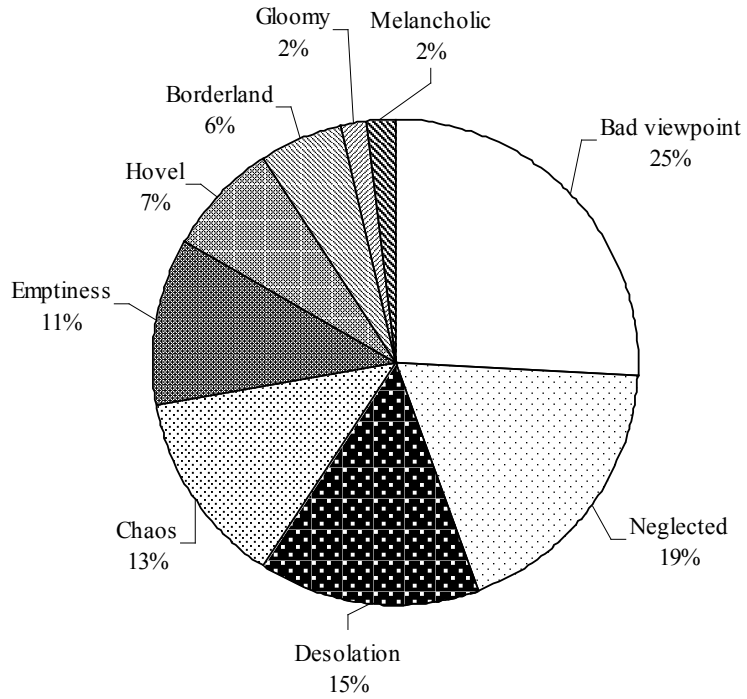

Figure 4. Characteristics used for describing landscapes with low scenic beauty.

Conclusions

1. Both methods give the first impression of the landscape elements that are important in improving the visual quality of landscape.
2. The Q method gives more significant results than the Scenic beauty estimation method in evaluating the scenic beauty of landscape.
3. The Q method is effective for the observing the spectators' first-time perception of landscape.
4. Further researches are needed to assess the importance of individual elements in explaining the preferences for certain landscapes.

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THE MEANING OF HISTORICAL PARKS IN THE SETTLEMENT LANDSCAPE ECOLOGY

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Abstract

The research was accomplished within the framework of the doctoral thesis, with the aim to clarify the role of Latvian Manor Park in the settlement landscape ecology. Significance of the Latvian Historical Park in the settlement landscape ecological processes in Kuldiga district was discussed and analyzed. To achieve set objective of the research, there was developed the landscape ecology assessment methodology of the settlements in the influence of the historical parks based on generalized scientific cognitions and researches in the landscape ecology, and scientific researches of the population loads and historical park value. The developed method was applied by surveying the selected historical parks in the settlement, and by assessing biodiversity factors, urbanization load, and landscape ecological networking compatibility degree.

As a result, the selected settlements of historical parks were marked in the district of Kuldiga in the landscape ecological map, highlighting the importance of both national and European level. The results indicate significance of the historical parks in the settlement landscape ecology and that the role of historical parks in the settlement landscape ecology is essential, which ensures the natural basic resources air, water and soil quality. In the settlements, the historical parks existence is high value and quality environmental guarantee, which would have been managed according to the proposed principles of landscape ecology science.

Key words: historical park, landscape ecology, settlement.

Introduction

Within the framework of the Doctor's thesis 'The Development Opportunities of the Latvian Historical Parks', during the research as one of the historical parks resources and development contributing factors is mooted the landscape ecology. Exactly the contributing factors of the historical parks sustainable development, including landscape ecology, is one of the aspects of human and environmental relationships, which is implemented in the interests of people in order to secure better quality of living conditions. In the research, applying the monographic or descriptive method, which bases on existing scientific evidence and theory, information on the Latvian manor gardens and parks, biodiversity and its significance in the populated environment landscape ecology, was gathered and analyzed Latvian manor parks or gardens, as it was said in Western Europe in the 18th century, but still in the middle of 19th century in Latvia (Janele, 2010), are one of the most important settlement heritages and elements of green structure. Historical park management level and the dynamic of settlements indicates landscape ecological linkage conflict or whereas the full cycle ran smoothly, as well as today's unintentional natural resources and sustainable environment, society, including promoting tourism and economic elements.

In the world countries, a number of landscape ecological planning methods are developed and used. Latvian landscape ecological researches mainly associated with forest landscapes and protected areas are dominated by Latvian scientists Oļģerts Nikodemus (Bells and Nikodemus, 2000; Nikodemus et al., 2001) and Aija Melluma (Melluma and Danilāns, 1975; Melluma and Leinerte, 1992) researches. Cooperating between the British Forest Commission, the Latvian State Forest Service and the Latvia University, in 2001 a research was characterized for 'Landscape Ecological Planning of Latvia', under which Simon Bell and Oļģerts Nikodemus directed 'The Development of Landscape Ecological Planning Guidance' (Bells and Nikodemus, 2001). This methodology and related knowledge are taken as the basis for 'The Landscape Ecological Planning Methodologies of the North Vidzeme Biosphere Reserve' development, where increased attention was paid to the estates and manor complexes of buildings, because in Latvia they have ecological and cultural value, and they are important for tourism development. An important research, evaluating the early 21st century Latvian new settlement development of suburban areas, landscape ecological and aesthetic interact, was realized by Daiga Zigmunde in her Doctoral thesis 'The Aesthetic and Ecological Interaction of the Latvian Rural Urban and Inference' (Zigmunde, 2010). In the landscape ecology researches of Latvian settlements, in the view of the population density and historical parks biodiversity factors, and Latvian Ecological network plan, which has been developed in the framework of the World Conservation Union (IUCN) European program (Sepp and Kaasik, 2002) has not been performed yet.

The main aim is to clarify the historical parks role in the landscape ecology in the settlements. In order to achieve it, the following tasks are defined:

- to develop an assessment methodology for the identifying the historical parks significance in the settlement landscape ecology;
- to identify and analyze the biodiversity aspects of the cultural and historical parks;
- to identify and analyze the role of landscape ecology in the settlements;

- to evaluate the landscape ecological process connectivity of the settlement, in the view of historical parks

The work methodology was developed based biodiversity, classification of settlements, ecological linkage and networking researches, consequently there has been reflected the nowadays historical parks role, in the influence of all mentioned aspects achieving researchable, practical and important progress contributing direction of the Latvian manor parks. Nowadays situation assessment of the historical parks using a methodology developed aspects, highlights the existing conflicts, problematic and unconscious heritage that are the settlements set of values and sustainable development contributing factor. The results of the research will be used to achieve the objective and the targets of the doctoral thesis.

Materials and Methods

In Latvia landscape ecological planning process, the same as in Norway (Maintenance…, 1993), it is recommended that additional attention should be paid to individual farms, manor houses and related agricultural lands, roads and alleys, which are historical relics. This is particularly important because currently in Latvia no landscape analysis has been done in this aspect. Kuldiga district territory was selected as a research object, which, since the 2009 public administrative reform, has been divided into Kuldiga, Skrunda, and Alsunga districts. To date, Kuldiga district is the only one that has developed a landscape ecological networking plan for a so large-scale area, including European-level ecological networking components.

To achieve the aim, in the mentioned districts there were identified and marked all manor parks and drawn up criteria for significance assessment of the settlement landscape ecological historical parks. In this methodology it was important to choose such factors that reflect the nature of the situation. Therefore, basing on landscape ecological planning methodology, the scientific evidence and theory, there were distributed three components of landscape ecological processes:

- biodiversity of the historical parks;
- urbanization load of settlements;
- connectivity level of the landscape ecological process.

Each distributed component plays an important role in landscape ecology movement as well as each component is interconnected and dependent on each other. The projective components of research interrelationships point to basic values and conflicts of the current situation.

To determine the level of biodiversity in the historical parks, those biodiversity contributing aspects were taken into account which in the historical parks is mostly associated with the presence and quality of ancient trees, management level and frequency of use and load factors, as well as the general environmental conditions. The biodiversity of historical parks was assessed visually, in the view of all above-mentioned aspects.

The settlements establishment types and structure are determined according to the typological differences and size, as well as their relative position nature and the interaction level. Nowadays, in the country there exist two types of settlements: urban and rural (Brinkis and Buka, 2001). In this research, considering the Latvian's towns population structure breakdown of the quoted authors, there were estimated urbanization load, which, in its turn, directly affects both the landscape ecological process compatibility degree and historical parks biodiversity. Choosing the criteria of landscape ecological process compatibility degree the landscape ecological methods described in scientific researches were taken on the basis. There was visually assessed historic parks territory linking degree with the surrounding biocenosis according to landscape ecology linking breakdown.

Projective processes of landscape ecological components were described by giving a value scale: high, medium, or low, which expresses an appreciable component load or weight. The developed evaluation methodology was applied to survey the objects in a nature, visually observing and describing each research area in a free-form, consequently achieving the assessment of the landscape ecological process component. The obtained results were summarized in a matrix, and the conclusions about the significance of the settlement landscape ecology were drawn up.

Results and Discussions

Over the past 20 years, in the Latvian manor park management and development there is a situation which characterizes the chaotic political situation which directly affects property ownership, its fragmentation, as well as cultural historical heritage protection issues, which in its turn has led to aesthetic decline of Latvian cultural landscape disarray. But the historical park biodiversity in the effect of some mentioned aspects, through the oblivion and uninhabitance prism is experiencing self-regulation system and micro environment triumph. Ecosystem stability becomes stronger in proportion to the increase in species diversity. Therefore, biodiversity is also recommended for human-caused landscape.

The result of generalization and evaluation of the landscape ecological processes were developed historical parks assessment methodology was developed that in further research was applied to survey objects in nature (Table 1).

Table 1

Criteria of the historical parks significance assessment methodology in the settlement landscape ecology

No.	Components of landscape ecological processes	Evaluation scale	Characterization
1.	Biological biodiversity degree	high	In the park there has not been made any of the optional activities and it has survived a direct aggregation with the surrounding natural biocenosis; there is met many typical and rare species, and many forms of habitats.
		medium	Park is managed partly, without undermining the ecological processes, for example, dead trees have not been cut, the fallen trees are not removed, the soil is not subject to regular mass loads, but an annual clean-up work is done, as well the park linkage with the surrounding biocenosis is impaired.
		low	park suffers from anthropogenic activity such as noise, soil erosion, the landscape full functional transformation; there has been made uncontrolled disposal, such as trimming trees and shrubs, without involving professionals; it has a regular impact of chemicals and weak and / or impaired linkage or it is fully isolated from the surrounding biocenosis
2.	Settlement urbanization load	high	settlement with a relatively larger population and relatively thereby populated areas than in rural areas, densely concentrated construction and well-developed infrastructure - roads, transport networks, communications systems and all types of social guarantees
		medium	the settlement has a typical centre and densely concentrated construction in a small territory with the infrastructure, communications systems, some socially important institutions such as the teaching authority, bus station, etc
		low	rural areas' populated area with concentrated building in a small area, with one or more historically significant objects in it, such as a church, manor houses, etc., that in most cases is the centre of the settlement
3.	Landscape ecological compatibility degree	high	the area where the particular species representatives is able to move freely between suitable biocenosis of them, such as favourable vegetation type for food or shelter searching (the historic parkland area adjacent to existing forests and / or grassland areas)
		low	area where the species individuals are restricted movement between the selected biocenosis, such as the park area is fenced, it has no linkage with the adjacent biocenosis

The assessment methodology of the historical park significances in the settlement landscape ecology view the analyzed aspects, specifying to each component importance in the settlement environmental quality.

Basis for identification and analysis of the landscape ecological movement was taken the Kuldiga district ecological networking map, developed in 2002, 'Development of National Ecological Networks in the Baltic Countries in the Framework of the Pan-European Ecological Network' (Sepp and Kaasik, 2002). With the framework of the mentioned research, the networking elements of European, state and regional level- core zones, buffer zones, and corridors were marked in the drown maps. District environmental networking design is based on landscape ecological planning principles, depending on the areas of biological and landscape diversity. In Kuldiga, Skrunda Alsunga district territories there are located 22manor parks, which were marked in the Kuldiga district ecological networking plan; additionally were marked the settlements according to subdivision described in the research methodology (Figure 1).

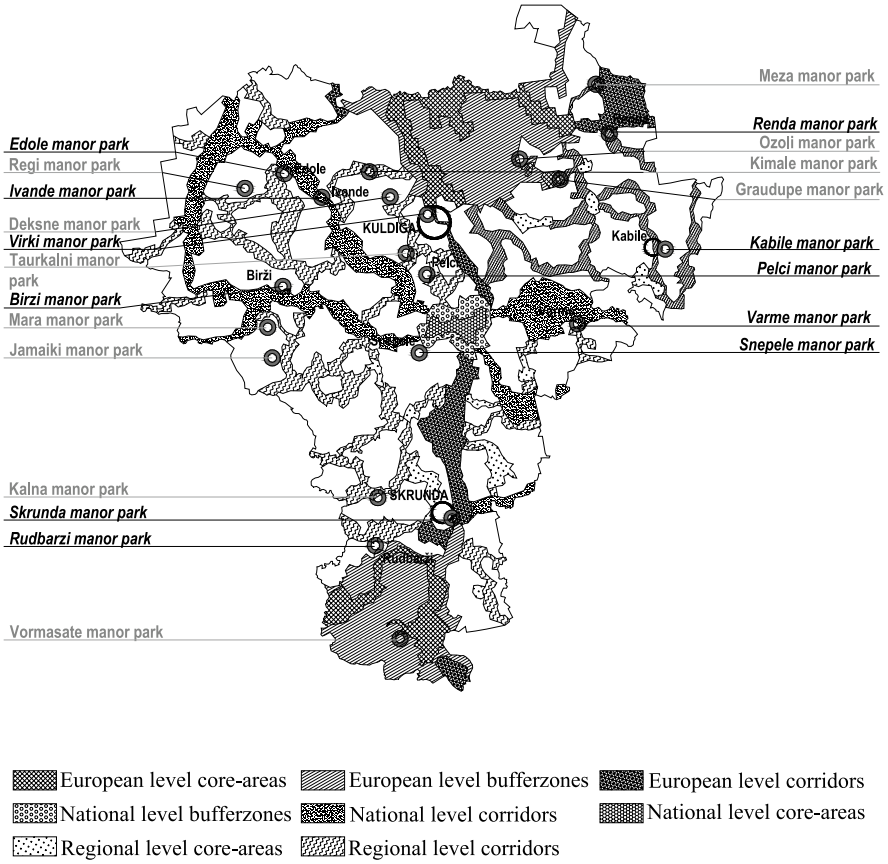

Figure 1. The ecological network map and the plan of the historical parks of the Kuldiga district.

The marked historical parks and settlements in the ecological network plan demonstratively show the interaction significance in the providing of the ecological processes, which mostly bases on biodiversity. Historical Park is one of essential elements of the Kuldiga ecological network. The settlements are the providers of the environmental quality and the population wellbeing, particularly at a high level of the urbanization load, preserving the ecological connectivity of the landscape. The district was divided into 11 settlements, where are historical parks. The second part of the 11 manor parks are allocated in the areas which leastwise do not have the characteristics of the village. Unfortunately, one part of these parks is located in the areas surrounded by arable lands where consequently is created area isolated by habitat, if only the linkage with the similar biocenosis nearby is not provided.

The results, respecting the principles of the developed methods, were summarized in a matrix, where were biodiversity, population type, environmental compatibility, and ecological network level which affects the park area of the 11 manor parks were specified (Table 2).

Table 2

Characteristics of the economical processes of the historical parks of the settlements

No.	The name of manor park	Biodiversity level	The type of the settlement	Landscape ecological linkage	Ecological network level
	Birzi manor park	medium	low	high	National level corridor
	Edole manor park	high	low	high	National level corridor
	Ivande manor park	medium	low	low	National level corridor
	Kabile manor park	medium	medium	low	Regional level corridor
	Pelci manor park	high	low	high	Regional level core-area
	Renda manor park	medium	low	high	European level corridor
	Rudbarzi manor park	medium	low	low	European level bufferzone
	Skrunda manor park	low	medium	low	European level corridor
	Snepele manor park	medium	low	high	No level
	Varme manor park	medium	low	high	National level corridor
	Virki manor park	medium	high	low	European level corridor

The landscape ecological processes characteristic matrix of significance of the settlements historical parks indicates to the values of the park biodiversity and the level of the landscapes ecological connectivity in the impact on population density. But the ecological network level specifies the importance level of the objects under the context of Europe.

Latvian manor parks are mostly designed by English-style Park models, which were introduced in the East Baltic from the British Isle, at end of 18th century. Parks were built surrounded by very extensive natural areas, ultimately bringing all park elements close to natural configurations, strongly denying any geometrical shapes thus highlighting the diversity of nature and nobility, pointing to the power of nature and human life temporality. In today's situation, a large part of the parks as a result of abandonment and the large areas management problems have lost their meaning, but, basing on stylistically natural principles, have acquire new habitat, which contributes to the landscape ecological processes. Without any interruption, carrying or restarting such type of park management, strictly sticking to the park primitive building style, according to the cognition of Michael Boland exactly the parks which are based on a English landscape model, they really aren't a suitable Many of their sites. Parks aren't sustainable, self-replicating, or ecological landscapes, though they may look natural to our eyes Ecological parks, firstly, reflect a holistic, integrated vision of the earth, secondly, no longer depend on picturesque aesthetics to communicate the idea of nature, thirdly, are conceived as part of an integrated urban whole, fourthly, use sustainable design, construction, and management practices to reduce resource inputs and waste outputs, fifthly, serve as a vehicle for reconnection (Boland, 2001).

Contryside Commission has developed characterization of ancient woodland as an element of natural capital, where six old wood values have been indicated: wood source, historical value, biological diversity, carbonic source, high-quality landscape value or pictorially (Bell, 2003; Countryside Commission, 1997). The Historical park value elements may be considered as elements of values of old wood, except timber supply factor in a historic park landscape is unacceptable as the economic benefits. Promoting biodiversity habitats are landscape ecology providers, under conditions where the species is not hampered movement between the existing ecosystems. Biodiversity has been functionally linked to ecosystem services. For example, species diversity generates ecological stability at the ecosystem and landscape level, particularly in changing environments (Termorshuizen et al., 2006). In the landscape occurring ecological and / or cultural values often indicate high biodiversity (Bennett and Kalemani, 2006). Ancient parks and green areas function as a united system, providing accommodation and food base of many typical and rare species. Exactly this is the reason why it is very hard to us to accept things that from the view of ecological point is very good, for example, fallen trees, natural meadows, but from the defined point of visual and cultural - they are unacceptable and refusal. However, in those places we have unacceptable, the greatest diversity is found, which is important for sustainable environment guaranty (Kruše et al., 1995).

Historically, the first Latvian towns emerged in 17th-19th century around the castles of German landlords that more served the military functions, and geographically were located at more convenient location. The nature and lifestyle of the population of nowadays towns and villages is characterized by the natural environment. It is not as urbanized as the big cities, it retains the natural uniqueness and is not only a result of human activity. In these settlements cultural and natural objects provides the basis for the development and contributes to the population feeling of belonging. By the time for the foundation of the city, parks and gardens was a symbol of great status. Parks have an increasingly important role in habitat ecology in everyday life bringing people closer to the nature. Although ecological processes in cities are the same as in rural areas, some of them, such as invasion by alien species, are more prevalent in urban than in rural conditions (Niemela, 1999). Landscape ecology is the science of studying and improving relationships between urban development and ecological processes in the environment and particular ecosystems (Wu, 2006; Wu and Hobbs, 2007; Wu, 2008). The mentioned ecological network elements are the main landscape ecological cycle providers. If in the settlement, in spite of urbanization level, some of eco network elements are not provided, there is broken the process of biological connectivity. From the point of view of landscape connectivity it is defined as a grade in what the landscape promote or inhibit the movement of species between existing plots.

Core areas are territories where the primary function is biodiversity conservation (Jongman and Pungetti, 2004). In the settlements, due to a historic park biodiversity, it also can serve as a core zone. Parks in most of the settlements are located in the middle ensuring good linkage between other natural areas, like surrounding forests, grasslands, water bodies, it is one of the most important landscape ecological providers. In the historical parks occurring biodiversity: plants and animals are dispersed by both wind and water, with the help of other species, or by their own movements. Migration is a special kind of dispersal, directed to a certain site. Dispersal is essential in population survival and the functioning of biotopes (Jongman and Pungetti, 2004). In order to ensure the species migration and survival, they naturally have set their own routes, which scientists have termed as the corridors. These are areas of suitable habitat that provide functional linkages link between core areas (Jongman and Pungetti, 2004). In the settlements is possible to create small habitats as meadows, slopes, hedges, free growing trees and shrubs, water bodies, "green" facades and roof greenery. This settlement creator of green structure is essential sense, even in European corridors development, because in its proper deployment can achieve good linkage

between natural areas, as with other settlements plantations and surrounding natural areas.

Buffer zones allow a smoother transition between core areas and surrounding land use. The size and utilization of buffer zones depend heavily on the particular needs of the specific ecosystem and its local population (Jongman and Pungetti, 2004). It has great environmental importance, because there is a mutual interaction between adjacent ecosystems. The best way how to evaluate it is on the borderline between field and forest or historical park, which specifically is found in small towns and village areas. In Latvia both in Soviet Union time and in the last years with the increase of the European Union support happens quick processing plant establishment of the agricultural lands and its related products which threaten protected areas, including historical parks, biodiversity and thereby the landscape ecology. The greatest risk of the habitats and occurring species in them are chemical pollution, pesticides utilization, noise caused by industrial buildings and equipment and other factors proposed by human.

The history of nature conservation and of urban ecological networks started as a reaction to the industrial revolution. The approach is based on the understanding that an inappropriate use of the environment can establish serious and long-term negative environmental, social, economic, and cultural impacts for the ecosystem and landscape. Natural resources are not distributed randomly throughout a landscape. Every landscape, whether pristine or developed, has nodes of unusually high conservation value that span the entire range of biological hierarchy, not only particular physical habitats. For example, such nodes would include a county park. These nodes should receive top priority for protection, but to function in perpetuity, sites must be buffered, interconnected by corridors, and permitted to interact with surrounding natural habitats (Barnes, 1999). This particularly applies to the rural towns that in the result of the agriculture massivization are insulated from the natural environment - forests, rivers, etc., forming the ecological system of habitat fragmentation.

The English Heritage organization in one of the many interviews asks the question: 'Why the heritage is so important?' and 'What can harm heritage?' (English Heritage, 2005). Answering to the first question, there has been mentioned several key factors that most directly relate to economic and social aspects. The list of answers to the second question is very long, because in the cultural environment development we should specially think out about the ecosystem and protection of the natural and physical resources. As few unhealthy conditions, exactly mentioned in publications and Latvian problems reflecting, we can mentioned some inorganic fertilizer method utilization, establishment of agricultural area and new object near to the parks, prior evaluating the situation realizing the research of the landscape ecology. In the Human created landscape the historic parks biodiversity is favorable and preserved, ensuring the movement of species between the surrounding biocenosis.

Conclusions

1. Developed assessment methodology of the settlements historical parks significance structurally discovered relations between historical parks and settlements, pointing to the key values and threats of landscape ecology processes.
2. Degree of biodiversity in the greatest part of Kuldiga district is assessed as medium. The main negative aspects is park landscape transformation with human-related activities and weak aggregation with surrounding biocenosis which leads to conclude of the disrespect of the settlement historical landscape pointing to public disinterest and the lack of awareness of the consequences. These aspects more are met in the process events dictated by Soviet Union.
3. The settlements urbanization load is subordinated to the type of settlement, but today's situation where rural areas are progressively less populated, the load decreases, leaving the consequences to the ecology of the landscape in a positive sense. However, in the impact of these processes, the social environmental quality, unfortunately, is reduced despite the increase in biodiversity quantity and landscape ecology quality.
4. Kuldiga district landscape ecology compatibility degrees are not mediocrity. In most cases, a historical park is an organic green structure supplement for the settlement, together preserving link with the surrounding biocenosis. It is positive that in the landscape ecological network these historical parks are essential rare and new biotopes maintainers and developers, even in the European level of the landscape ecological movement.
5. The objective of the research has been achieved basing on historical parks biodiversity of Latvian settlement and interaction of the ecological network. Nowadays, historical parks have an important role in the settlements' ecological and life quality aspects.

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THE HISTORICAL DEVELOPMENT OF WATERMILLS AND SMALL-SCALE HYDROELECTRIC POWER PLANTS LANDSCAPE IN LATVIA

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Abstract

The change in landscape is a never-ending process. In this article information regarding watermills and small-scale hydroelectric power plants historical development in Latvia has been summarized. The research was conducted from September 2010 till April 2011 with the aim of summarizing information regarding impacts to landscape from changes occurring from 12th century till 21st century. The research had a detailed view about the usage history of the watermills, small-scale hydroelectric power plants buildings, and energy producing constructions. The fundamental changes in energy producing mechanisms and legislation regulations changes that have an impact on river open space landscape, and on landscape use in surrounded territories of watermills and small-scale hydroelectric power plants landscape were analyzed and studied carefully. The territories were described and analysed using historical, monographic, and comparative methods. The paper gives possible descriptive historical classification of these industrial landscape elements. The historical progress and legislation evolution untill the 21st century has also been summarized.

Key words: river, landscape, classification, cultural landscape.

Introduction

Waterscapes near rivers are closely connected with local human activities and social needs. From ancient times, people lived nearby rivers, used the water and afterwards the power of water energy in their lives.

The aim of the research was to summarize the information regarding the changes to landscapes occurring from 12th century until the 21st century.

The Latvian watermills territories were researched in recent years and the outcome of this scientific based research was published in 1985 in the book by A.Teivens 'Latvijas dzirnavas' (Latvian Mills), the researches on watermills ware made by The State Inspection for Heritage Protection with field studies methods, and the materials by different authors are now in Latvian Inspection for Heritage Protection documentation centre archives. The studies with a goal to research the ecological impact on environment, the possibilities of using hydroelectric power from rivers in Latvia and impact from small-scale hydroelectric power plants stations to fishery in Latvian rivers were undertaken after 1990. All the research work done until this one does neither look on these territories and water reservoir landscape as an element of social landscape development nor the rural or urban landscape as functional and aesthetic culture heritage elements.

The historical review of the watermills and small-scale hydroelectric power plants can help to review and understand better the previous and existing situation in Latvian landscape in these ecologically, aesthetically and functionally sensitive territories. The aim of this article is to summarise the unique characteristics of changes in cultural landscapes, the reasons why these territories are gradually disappearing and why traditional landscapes are still valuable for the future. The focus is upon the Latvian situation. 'Cultural landscapes are the result of consecutive reorganization of land in order to adapt its use and spatial structure to suit the changing societal demands in a better way' (Antrop, 2005). To understand the current character of watermills and small-scale hydroelectric power plants landscapes it is necessary to analyze their usage and development in historical context.

Materials and Methods

The research is based on the case study of the watermills and small-scale hydroelectric power plants territories in Latvia territory. The elements of Latvian landscape have been described and analysed by using historical, monographic, and comparative methods. The literature used has been: books, Latvian archive documentation, and the scientific publications. The historical construction systems in Latvian watermills are described in several materials in Latvian language by J. Raits and R. Virsnieks (1944), and A. Teivens (1985), but in a literary language with accurate description of the functional and emotional aspect of watermills - by A.Zemdega (2004). Several publications include a review on some particular watermills research including researches on manor and houses territories. The author I.M. Janelis (2010) has published a book 'Manor Gardens and Parks of Latvia' which include several manor house maps with watermills ponds and building place territories from archive documentation materials.

Results and Discussion

Climate and Relief conditions

In the construction of water reservoirs for watermills or small-scale hydroelectric power plants, a significant and basic rule is to consider the local climate, relief, and soil material. In literature there are some cases but those have been deemed as inadequate handicraft work in local conditions: 'in information given about watermills during the ownership of Jesuits, a lot of checks were conducted

at the sites and information exists in documents about territories affected by the flood and damaging the dams and even destroying the watermill buildings' (Teivens, 1985). This information shows that craftsmen for above-mentioned constructions did not know the local conditions, because those works were destroyed by nature. Territory of Latvia is located in the south of Europe continent and is one of the Baltic countries. The climate in this territory is changing all year long and has four climatic season types. The temperature varies from minimum approximately - 30 °C in winter season (December up to February) to a maximum of approximately + 30 °C in summer season (June up to August) (Latvijas, 2011b). The rivers in this area bear a high level of water in spring season (March up to May) and lower level in autumn season (September up to November) (Latvijas, 2010). The rainfall in Latvia varies from 600 to 700 mm throughout the year (856 mm in year 2010) (Latvijas, 2011a). Only 2.5% of the total area is relief forms higher than 200 meters above the sea level. The highest points in relief are 311.6 m in Vidzeme region, 289.3 m in Latgale region, and 189.5 m in Kurzeme region. The territory is mostly slightly waved or flat. The first Latvian classification of relief division into districts was made by Ģ. Ramans in 1935 (Maldavs et al., 1981).

Historical Review

The watermills' building history has been described in several publications; however, it is not known when the first watermills were built in Latvia. Their origin has not been studied by archaeologists, and the written history is incomplete. The basic building material until 17th century was wood. Some part of watermills was located in urban areas, and in the rural landscape territories together with castles. In rural landscape there has been no territory with castle defensive wall, that is why some watermills have remained in rural territories, and also because the country noblemen constructed watermills for themselves suiting rural manors needs. To weigh the pros and cons from war time and risks of destruction, the watermills' surrounding territories did not use the strong stone walls for protection against invasion. The climate and the long standing local customs of construction contributed to the development of a characteristic building style: a low and wide long building with joined interlocking corners and covered by a huge, straight rectangular roof. The roof was covered with thatch, reeds or wood shingles. In more recent times tiles were used. When the rural mills were built by the local craftsmen, the same basic architectural style was retained (Teivens, 1985). The formation of landscape in watermills surrounded territories was in connection with manor house or castle, for example, the Birini castle in Vidzeme region was one of the greatest manor centres in 18th century with construction of watermill pond and castle building in one composition with reflections of the castle on the water surface of the pond (Janelis, 2010). Whereas in Pastende manor, the watermill building and dam are far away from the central castle. The watermill pond creates an aesthetically pleasant landscape in composition with the main road to the manor house (Janelis, 2010). The welcoming landscape is drawn and seen in the book of Stavenhagen 'Album Kurländischer Ansichten' (Album of Kurlands Illustrations) (Stavenhagen, 1866). 'The watermills construction from Vitruvius 1st century B.C. described as an example did not change a lot until 19th century, and in many countries the construction was of the same kind – standardised. In Latvia also the constructions for watermills were built by analogy from three types: undershot wheel, overshot wheel and breastshot wheel' (Teivens, 1985). 'The building material was stones from fields in combination with wood constructions. When the watermills ware built of stone, it was common to use the local field stone and rarely limestone. The robust nature of the construction material necessitated building in a low massive style. The old stone rural watermills adopted the previously described basic forms of long buildings. Thus amidst the tall trees in the countryside the watermills of masonry construction blended harmoniously into the country landscape and resembled other farm buildings. Quite often the sites of country watermills have been described as places of special beauty' (Teivens, 1985). At the end of the 18th century the regulations for new watermills constructions were strongly recommended, and one of the laws stated that 'Every owner of the manor on his owned river from both riverbanks can build unlimited number of watermills and take the tax from other millers. It does not enable him to overflow the neighbouring fields. If the water from watermills overflows the neighbouring fields then in the time of haymaking the dam of watermills has to be opened for normal field management' (Teivens, 1985). The biological power from humans and animals was used in watermills until 19th century thus forbidding the possibilities for faster development. 'There is a viewpoint that cultural development of society is connected with energy power usage of its citizens' (Galiņš et al., 2008). According to data from the year 1802, in one region of Latvia which is known as Kurland province (Kurzeme Gubernja) 192 watermills were located (Teivens, 1985). With the development of industrialisation in 19th century, the attention to power industry got intensified. First technologically and technically reliable solutions came out in the year 1820. In this time there showed up a new term called 'turbine'. In future the power industry mechanisms would develop very fast because of demand for greater energy power resources (Galiņš et al., 2008). Untill the end of 19th century, the mechanisms of watermills made use of the waterwheel from wood but afterwards Fensis type of turbines were used (Siļķe, 2008). 'The first hydroelectric power plant station for electricity production was built in Smiltene manor on Abuls river in year 1901. The electricity was used for local Smiltene town lighting system' (Siļķe, 2008). Before First World War, in Latvia regions Kurland, Zemgale and Vidzeme together there were around 1400 watermills, but after the War in Latvian statistical yearbook in the year 1920 it was mentioned that there were 473 working watermills, and across various regions the number was

divided as: in Kurland – 88, in Zemgale – 48, in Vidzeme – 232, and in Latgale – 105 watermills. Approximately in the year 1930 in Latvia there were 666 watermills in working condition. These watermills had different functions – not only flour milling, but also timber sawing, wool fulling-mill, pearl-barley milling, etc. After the year 1863, after abolition of serfdom in Latvia regions, local country noblemen tried to limit the development of farmers' property with different clauses in homestead leasing and selling contracts, with prohibition of new watermills being built in these territories (Teivens, 1985). Active development of small-scale hydroelectric stations took place in the last century; 1950s, the period after the Second World War, when there was an urgent requirement to secure farms with own produced electricity. The new stations were built, and old watermill buildings and dams were reconstructed. By data from 'Seļektro' bureau (a company which worked with the electricity power management in Latvia), 'in 1949 Latvia managed 60 small scale hydroelectric stations with total power of 5.4 MW and generated a total power of 4.0 MW' (Siļķe, 2008). In post-war period till 1960, in Latvia 20 small scale hydroelectric stations were built, of which the two largest were Aiviekstes HES (Hydroelectric Power Plant - started to work in 1925) (Latvenergo, 2011a), and Ķeguma HES (called Ķeguma HES-1 - started to work in 1936) (Latvenergo, 2011b). In the middle of sixties and at the beginning of seventies, some large hydroelectric power plants – Pļaviņu HES in 1965 (Latvenergo, 2011c), Rīgas HES in 1974 (Latvenergo, 2011d), and Ķeguma HES-2 in 1976 (Latvenergo, 2011b) - were developed on the river Daugava in addition to various electricity transmission lines. 'Work of the small-scale hydroelectric stations became unprofitable and in time from 1963 to 1977 all small hydroelectric stations were liquidated' (Siļķe, 2008). Also from those small-scale hydroelectric stations, which operated effectively, devices were dismantled; buildings and constructions were broken down by usage of various crowbars, sometimes by an incongruous organization and in a state of anxiety. A similar fate was suffered also by many watermills (Siļķe, 2008). Therefore reducing the main type of operation – grinding – to a minimum, many of the beautiful landscapes having formed around the watermills were lost. Roads, bridges and sluices crashed down, the flow of high waters broke through the barrages of the mills, beautiful and spruced up buildings of mills turned into ruins, the picturesque and clear watermill ponds as well as other reservoirs became overgrown with bushes. In the erstwhile Soviet Union era many people who under the guidance of knowledgeable masters carried out constructions of mills and barrages, maintained and operated over a few centuries, were left in destruction as can be observed in Latvian archive materials and pictures from Subate watermill (Ancāne, 1994), Bikstu watermill (Puriņš, 1984). The same facts could also be observed in abandoned buildings and cultural landscape that has disappeared over a period of time.

After regaining the independence of Latvia and private property rights in early nineties, restoration of the small-scale hydroelectric stations was started in places of the former watermills, as a result of that many visitors are happy by putting neighbouring environment in order, have restored and used the buildings of mills and constructions for other purpose. Thus a part from the former water-mills, which for the present times is a small number, again uses water of the Latvian rivers and increases the energy produced on its own native ground (Siļķe, 2008). Examples of watermill building reconstruction are seen in Latvian archive materials, in pictures from Mūrmuiža watermill (Zilgalvis, 1997), and near these watermills the small-scale hydroelectric power plants was built in 2002 (Latvijas, 2008). The landscape has changed with new elements coming in contact with old watermills and complex buildings.

Legislation Review

After regaining independence in 1992, Latvian legislation was developed and the laws were made to manage the watermills and small-scale hydroelectric power plants and the surrounded landscape on small rivers. On 14 May of 1995, the regulation No. 54 'Par Latvijas Republikā ražotās elektroenerģijas iepirkuma cenām' (Purchasing prices from electricity produced in Republic of Latvia) (Latvijas, 1995a) issued by the Cabinet of Ministers came into force, and according to the law 'Enerģētikas likums' (Energy Law) (Latvijas, 1998), adopted in 1998, the purchasing price of electricity from small-scale hydroelectric power plants to a united electric power supply network was doubled. With this regulation from the year 1999 from 55 up to the year 2002 the number of small-scale hydroelectric power plants increased to 149. On 12 January 2002, the regulation issued by the Cabinet No. 27 'Noteikumi par upēm (upju posmiem), uz kurām zivju resursu aizsardzības nolūkā aizliegts būvēt un atjaunot hidroelektrostaciju aizsprostus un veidot jebkādus mehāniskus šķēršļus' (Regulation about the rivers (sections of rivers), on which it is forbidden to build and to renew hydroelectric power plant station dams (or to build any mechanical obstruction) introduced for the protection of fishery resources (Latvijas, 2002a) came into force. This regulation forbids new objects being built on 214 small and middle size rivers in Latvia. The duplicate electricity prices for small-scale hydroelectric power plants lost validity with the new regulation in 'Enerģētikas likums' (Energy Law) law (Latvijas, 2001). In 2003, a new regulation was introduced – the system of quota. 'These regulations stopped new electricity producing hydroelectric power plants building and renovation or transformation of old watermill territories. After 2003 only one small hydroelectric power plant was renovated' (Siļķe, 2008).

The legislation in landscape planning in territories surrounded with watermills and small-scale hydroelectric power plants has also developed. The law according to Latvian Culture Heritage protection come into force on 12 February 1992 'Par kultūras pieminekļu aizsardzību' (Law regarding protection of cultural monuments) (Latvijas,

1992) regulated the individual Cultural Monument Protection Zones - in rural areas it is now 500 meters, and in urban areas 100 meters from culture Heritage borderline but can be modified under situations where individual distance areas for Cultural Monument protection can be modelled. The responsible institution for inventory of Culture Heritage in Latvia is The State Inspection for Heritage Protection. In 2011, the number of State signification watermills is five, and the number of Local signification watermills is fourteen. There is no Culture Heritage protection for small-scale hydroelectric power plants in Latvia. Several laws regulate the spatial planning structure – 'Būvniecības likums' (Law for Construction) (Latvijas, 1995b) came into force on 13 September of 1995, 'Aizsargjoslu likums' (Zone Protection Law) (Latvijas, 1997) came into force on 11 March of 1997, 'Teritorijas plānošanas likums' (Law for Spatial planning) (Latvijas, 2002b) came into force on 26 June of 2002. On 19 April of 2007 came into force the law 'Par Eiropas ainavu konvenciju' (European Landscape Convention) (Latvijas, 2007). The definition of landscape in the Convention is clear and broad: 'Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' (Council, 2000).

Classification

The importance of aesthetics and scenery and not just economic and ecological functions and utility is also implied. Landscapes are seen as 'part of Europe's common heritage, which deserve protection and management'. The aims of the landscape Convention are 'to promote landscape protection, management and planning, and to organize European co-operation on landscape issues'. The European Landscape Convention essentially aims to bridge the past with future landscapes, but it is not very specific about how to proceed with it' (Antrop, 2005). Each traditional landscape expresses a unique sense or spirit of place (*genius loci*) that helps to define its identity (Antrop, 2000). In Europe, to understand the actual landscapes, M. Antrop brings out three periods in history that have to be recognized. '(1) Pre-18th century landscapes, which have still preserved many remnants and structures going back to a remote past. They will be referred to as traditional landscapes. (2) Landscapes of expanding industrialization and cities from the 19th century to the Second World War. Irreversible breaks with the past happened in many domains of society and culture, thus changing life-styles and mentality towards the land and environment. Totally new landscapes were superimposed upon the traditional ones, which were often wiped away completely. These are the landscapes of the revolution age. (3) Post-World War landscapes characterized by increasing globalization and urbanization. These will be called the post-modern new landscapes' (Antrop, 2005). The perceived landscapes contribute to local or national identity (Sooväli et al., 2003) and at the same time landscapes are shaped by ideology and politics (Olwig, 2002). In Latvian industrial landscape, in watermills territories to understand the actual landscapes, four periods are recognized. The historical review shows the development of energy producing systems in Latvia.

In Figure 1 is shown the classification in periods. In every period new characteristic marks for this period came out. With reference to previous historical description these periods have recognizable characteristics.

	II period	**III period**	**IV period**	
	17th century - end of 19th century	End of 19th century – 20th century	20th century – 21st century	Period
	Waterwheel from wood	Turbine	Turbine	Mechanism
	New buildings from wood and stone	New buildings from wood, stone and bricks	New buildings from concrete, metal, stone, bricks	Buildings
	Flour milling	Flour milling, electricity producing for local needs	Electricity producing for global needs	Producing
	Dwelling house, timber sawing, wool fulling-mill, pearl-barley milling	Timber sawing, wool fulling-mill, pearl-barley milling metal working	Dwelling house, mill for tourism, recreation	Other functions

Figure 1. The watermills and small-scale hydroelectric power plants (HPP) in historical periods.

One of the fundamental characteristics is energy torrent (Figure 2). The energy before 19th century mainly was used in place where the energy was produced, but after scientific discoveries in energy production and energy delivery to the client's address, these types of landscape elements were changed. The social communication in working days near watermills is relocated to town centres, market centres and individual places of communication. Humans can move this branch of production and economy more freely.

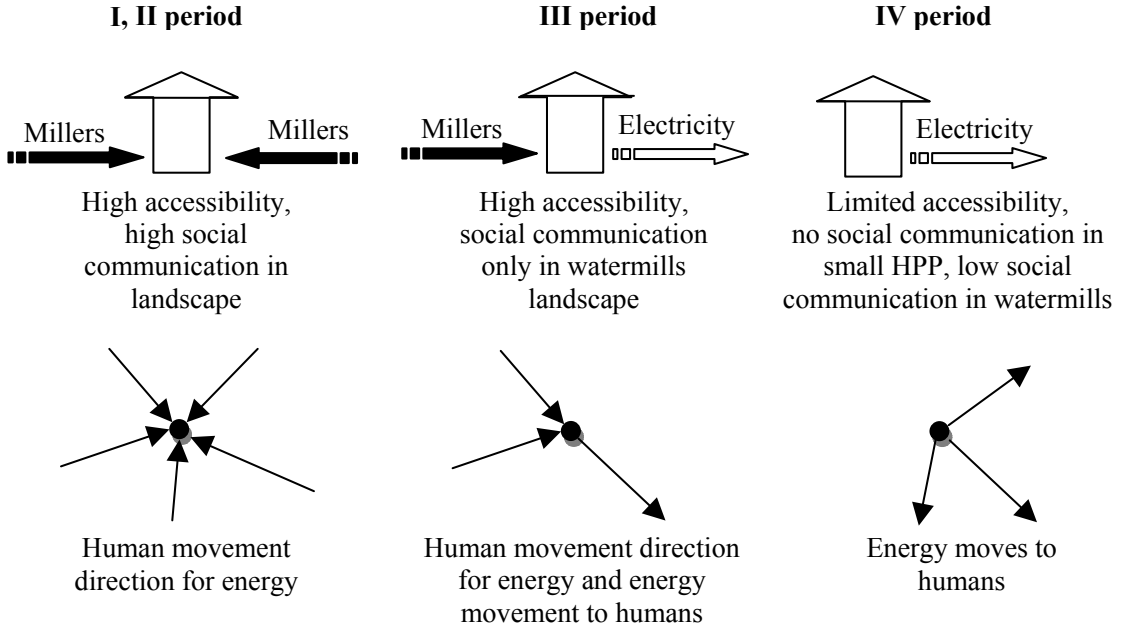

Figure 2. The accessibility, social communication in landscape, and energy movement structure according to historical periods.

Humans have always adapted their environment to fit better to the changing societal needs and thus reshaped the landscape. All the important driving forces are related to the population growth and the life-style is becoming increasingly more urban and more mobile (Antrop, 2005). In landscapes there has been more movement between far away objects and less movement near newly constructed small-scale hydroelectric power plant stations and reconstructed or inherited watermills.

Conclusions

Historical situation gives knowledge about existing landscape situation and will help to continue the research on Latvian industrial landscape in watermills and small-scale hydroelectric power plant station territories. The climate conditions are changing all over the year, the temperature conditions are more pleasant from May till September and are ideal for tourism development. The highest water level in rivers occurs in spring and autumn seasons during which the small-scale hydroelectric power plants appear like waterfalls with water spillage from splits of watermills or power plants. The history shows that different economical structure and development level of regions were seen in diverse number of watermills in various regions across Latvia. The fundamental changes in science reconstructed the landscape into a resource without close human connection to the nature, and changed the daily human life. In relation to historical changes, the development of landscapes in the territories of watermills and small-scale hydroelectric power plants can be divided into four historical periods. The system of law is dynamic, and the greatest changes can occur if the resources of electricity power will become exhausted. The landscape is losing the cultural landscape element – watermill – as a place to work and also a place where social communication can be developed. It is necessary to manage the landscape planning structure so not to lose the element of identity of Latvian landscape, existing approximately since the 12th century. It is possible to add several functions to the present watermills and small-scale hydroelectric power plants to develop the territories, as it was in ancient times, when the watermills had not only the function of mills, but also several other functions in one territory as mills and in another as water reservoirs having recreational significance.

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EVALUATION OF ART INTERVENTIONS FOR THE PUBLIC SPACE IN LATVIA SINCE THE 1980`IES

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Abstract

The main aim of this paper was to investigate the development of art for the public space as a result of the historical impact through which the artworks have been evaluated. The context of social, ideological and economical changes is related. The author examined principal art practices in the public domain and discussed the main types of artworks created for the public space in Latvia in the period between 1980 and 2010. Seven art events were selected to analyze the main occurrence of historic periods as certain paradigms. Empirical and qualitative data collection methods were used to clarify the development of art for the public space in the Latvian landscape taking into account the historical point of view. According to the typology of artworks the following features were investigated: the aim, the location, the form and the size, and the function of artworks. The majority of art for the public space occurred in the city environment and the financial support of the project played an important role.
Key words: public art, relational aesthetics, public space, landscape environment, paradigm.

Introduction

This paper deals with the development of contemporary art practice for the public space from the historical perspective in Latvia. In Latvia, public art has expanded over time, experiencing the social, political and economical changes, media and technology development.

Interventions mostly have been visual art forms, which were included in the research. Visual artworks traditionally exist in more or less permanent forms, while several other categories of contemporary artworks may be characterized as more short- term. The term 'public art' has appeared as an alternative to gallery art that emerged at the 1960s to revitalize urban space (Januchta-Szostak, 2010). Public art is an expanding practice and has become the subject of multi disciplinary academic research and creative practice (Sharp et al., 2005; Cartiere, 2008). In the 1980s expansion of public art begun with critical understanding of the public space on the international scale. Due to new processes of artwork interventions in the public domain, the artist Suzane Lacy (1995) introduced the 'new genre public art'. In the mid-1990s the term 'relational aesthetics' appeared as formulated by the French art critic Nicolas Bourriaud (2009). This concept engages social participation, and processorientated art. Therefore, the author proposes that it is necessary to examine art interventions for the public space in Latvia and to emphasize the modifications.

The objective of this study was to evaluate the main types of artworks included in the leading art projects. The research discussed the principal lines of historical development of art interventions for the public space in the period between 1980 and 2010 in Latvia. To investigate these aspects, first, public art practice in Latvian art was described. Second, paradigms of the significant contemporary art projects have been selected and financial trends have been taken into consideration. Last but not least, the typology of artworks was determined.

Part of the study results were discussed in the 24th session of the Permanent European Conference for the Study of the Rural Landscape (Alle, 2010a) and in the 69th Scientific Conference of the University of Latvia in Landscape Research Section (Alle, 2011). The complex historical impact sets new trends to art expressions and activities in the public space. Public art development in the global context has been analyzed by the author in the annual 16th International Scientific Conference 'Research for Rural Development 2010' (Alle, 2010b).

Materials and Methods

The given research is based on a historical perspective and, an empirical and qualitative approach to clarify the development of art for the public space in Latvian through the review of books, magazines, catalogues and scientific publications which discuss art interventions in public space.

According to the main historical events detected between 1980 and 2010, the most typical art projects have been selected as paradigms. The selection of the projects has been carried out pursuant to the following criteria:

- artworks placed in the public space or places which have become accessible to public due to artworks` location;
- major art projects which are broadly described and discussed;
- artworks introducing new approaches in relation to landscape (both urban and rural) and its setting; and
- innovative contemporary art projects, events, short-term artworks.

Pursuant to the described criteria, the following seven art events were selected: the Art Days in 1986, 1987, and 1988, the Open-Air Symposium 'Firkspedvale's Conversations' in 1994, the exhibition 'Piemineklis' (Monument) in 1995, cultural project 'Re:public' in 2003, Sculpture Quadrennial 'European Space' in 2004, contemporary art forum 'White Nights' in 2009, and the festival 'Staro Rīga' (the Festival of Light) in 2010. The inherent historical periods and financial support have been

investigated. The author has analyzed the above mentioned projects in order to determine the types of public art. The approach of the Polish architect Anna Januchta-Szostak (2010) has been adapted for further evaluation of artworks. A. Januchta-Szostak states the typology of sculptures and water elements she has researched but for the purpose of the given research a somewhat broader use of terms is needed. In accordance with the typology of artworks implemented in the framework of the selected projects, the following features have been evaluated: the aim of the project and artworks, the location, the form and the size, and the function of artworks (Table 1). To describe each feature, attributives from the conceptual art statements and analytic descriptions of projects have been employed.

Table 1

Typology of artworks

Features	Determination of the type of artwork
The aim of the project and artworks	Highlight the story or meaning of the place, highlight pomposity of the site, create a specific location / area accessible and understandable to public, to magnify or pay attention to the particular problem or the issues, social involvement.
The location of artworks	Composition: culminating, leading, stopping, closing, framing. Combination: integrated with the buildings, greenery, urban floor, separated. The type of location: ideologically charged space, empty, open spaces.
The form and size of artworks	One-object, multi-object, compact, diffused, transparent, vertical, horizontal, spherical, static, dynamic, kinetic, interactive, figurative, symbolic, abstract, realistic, graphical, textual, geometric, organic, site-specific, audience-specific, installations, perfor mative. Relation to surrounding: visible, inclusive integrated in surrounding, dominating.
The function of artworks	Commemorative, provocative, self-reflective, socially or politically engaged, symbolic, decorative, compositional, informative, educational, advertising, entertaining, integrating, disintegrating, commenting, arguing, expressing artists attitude /opinion. Social impact: polemic, comprehensible. Perception: welcoming, replied / renunciative.

Results and Discussion

In the beginning of the 20th century the most important and well known art forms for the public space were sculptures, monuments and memorial ensembles in Latvia. In the period of the Soviet Union, the erection of monuments was under a strong centralized administrative control and mainly reflected the Soviet political ideology. During the 1960s and 1970s when the political climate became a bit milder, different other forms of sculptures appeared. The movement, which showed the tendency to exhibit sculptures in the outdoor claiming that sculptures belong not only to the museums, was a widely spread phenomenon in Europe and America. This practice in Latvia started with establishing the Sculpture Garden by the Riga Castle in 1967. Popularity, among sculptors and broader audiences, gained stone sculpture plein-airs and sculpture symposiums. It should be mentioned that since 1972, the tradition of Riga Sculpture Quadrennials has incorporated outdoor expositions. It is a large-scale contemporary art exhibition considered to be a continuation of the creative contacts of sculptors established the first time by the Exhibition of Sculpture of the Baltic Republics held in 1958 in Riga.

In the mid-80s, so called 'Perestroika', a movement showing certain attempts to humanize the Soviet regime, swept also over Latvia and during these reforms revolutionary changes occurred. The Period of transit, from one political and economical system to another, was called a time of 'trespassers' by some art critics. Latvia experienced an intensive expansion of alternative art practices including the avant-garde art trends, installations and performances. Significant art events were evident during the 1980s. Artistic activities in social space were developed in the framework of the annual Film Days and Art Days in Riga. The Art Days as open days in artist's studios were started in 1959; it was an event more or less actively organized in the entire Soviet Union. These days in Latvia reached their apogee and highest social scope in the 1980s (Umblija, 2004) and the Art Days, which took place in 1986, 1987 and 1988, can be accentuated as most prominent. These days introduced the first manifestations in the public space with social-critical attitude and an attempt to communicate with the spectator. The Art Days incorporated the artist's creative and socially ironic objects or gestures and the task of the actions was to 'force people to think actively' (Traumane, 2010). In the 1980s artists expressed themselves best in groups or collectives. Among them 'Nebijušu sajūtu restaurēšanas darbnīca' (the Workshop for Restoration of Non-Existent Feelings) initiated by Juris Boiko and Hardijs Lediņš worked on performances, music records and writings.

The possibilities of art in public space after the restoration of the independence of Latvia

Art for the public space formation has been changing according to the socio-political, ideological and economical changes in the country since the 1980s. In spite of certain limitations imposed during the Soviet occupation period, art

field in general financially was rather generously supported, and Latvia inherited several well cultivated fields of art. During the transition period such problems as the termination of the State support for creative activities of artists and loss of prominent artists' status emerged (Borgs, 2010). But at the same time free flow of information and new forms of publication of art works appeared, importance of the role of curators` increased, creative teams were established. The impact of fast development of new technologies was evident. The role of the public space and relations with spectators was changing by the emerging of installations, performance and video art (Mazika, 2009). Due to changes related to the financial support, new possibilities were offered not only by the Soros Centre for Contemporary Art-Riga (SCCA-Riga) operating since 1993, but also by the State Culture Capital Foundation (SCCF, 1998) and different European Funds. In 1992 the Soros Foundation-Latvia was founded, which was followed by the SCCA-Riga thanks to the American philanthropist George Soros support (Borgs, 2010). Later SCCA-Riga became the Centre for Contemporary Arts (LCCA).

New artistic strategies are influenced by cultural discourses in the West by the re-establishment of the independence of Latvia. The social relations among art, society and media became topical. The researcher Māra Traumane (2010) has underlined that the public space in Latvia, as a stage for 'civil' actions and discussions existed episodically only during the 'Perestroika' period. Starting from 1991, it became a subject to regulation. The social environment was increasingly replaced by mass media and this process caused estrangement between the city environment and society. In the mid-90ies the 'public space' became divided between administrative institutions, which implemented art projects mainly in the city space, and self-organized formations which focused on social dynamics. Several art centres, non-profit art spaces, artists teams have been working. In certain occasions it should be taken into consideration that the land of some territories may belong to private owners.

The previously mentioned SCCA-Riga is supporting avant-garde art, Latvian contemporary art, gathering information on artists and projects, and is leading art projects and exhibitions. All together six annual art exhibitions took place between 1993 and 1998, organized by the Centre and accounted for the biggest events at the time. One of the exhibitions that dealt with the public space beyond exhibition halls was 'Piemineklis' (Monument) in 1995 under the curator-ship of Helēna Demakova. It can be looked upon as a symptomatic example of thoughtful and effective transformation of the public space and was an ambitious attempt to follow world art practice (Traumane, 2010). The purpose of the exhibition was to create installations in ideologically charged places. The impressive contemporary art show 'Geo-Ģeo' in 1996 was organized in the environmental landscape of the Open-Air Museum at Pedvāle by its curator Jānis Borgs. It was the first exhibition of such a kind outside Riga city space. The artworks displayed within the exhibition 'Ventspils. Tranzīts. Termināls' (Ventspils. Transit. Terminal) in 1998-1999 curated by Kristaps Ģelzis and Solvita Krese, which occupied Ventspils city environment inconspicuously and sought to interact with spectators (Borgs, 2010; Krese, 2007, 2010).

Besides the SCCA-Riga, several creative teams were established which incorporated social processes. Among the most considerable projects 'Open', E-LAB, 'K@2', and 'Bolderāja`s group' can be mentioned. The Open-Air Art Museum at Pedvāle can be mentioned as cultivated rural territory which is open-to-visitors. The Museum is a multifaceted culture and arts centre. It is a platform for the development of traditional and contemporary art with integration of natural environment, and cultural heritage. In 1991 the museum at Pedvāle was opened by the sculptor Ojārs Feldbergs, the owner of the land allocated as the museum's territory. There are local and international open-air art exhibitions, symposiums, and workshops held. 'Firkspedvale's Conversations' in 1994 under the curator-ship of Ivars Runkovskis (Čaupova, 2008), and the SCCA-Riga annual exhibition 'Geo-Ģeo' in 1996 were the main activities during the 1990s. Ojārs Feldbergs continued to work in the environmental landscape and organized diverse rituals, happenings, performances and other staged events. From 2001 to 2004 a particular theme was devoted to the cycle of four seasons by the programme 'Prime Elements of the World: Fire, Water, Air, Earth'. In 2007 Feldbergs initiated one of his most original interactive projects, the long-lasting action 'Experimental Stone Plantation'. It is based on the idea of creating a world-wide network of inspiring contacts among people of different countries. This project has become an international tradition of strangely ritualized process of 'stone planting and stone cultivation'. Feldbergs has planted his stone seeds from Pedvāle in Sweden, Finland, Belgium, Israel, Vietnam, Egypt, and several other countries.

Since the independence of Latvia was restored, the 1990s was a period of notable transition and the practice of public art remained segmented. During this period, art for public space was a relatively new phenomenon, which could also be seen as an indicator of the openness of public thought and perception. In Latvia it is possible to trace rapture in gradual development of art because of the historical impact. Until the end of the 1990s, the projects, which took place in the city environment, did not attempt to interact with the individual spectator (Traumane, 2010). It was rather a period of contemporary art expressions in public space to be exhibited to public, not focused on attending art events and 'getting society used to the new expressions of creativity' (Krese, 2010). During these attempts polemics, vandalism and incomprehension mounted. Information and study materials were absent to disseminate for public use, thus to ensure an effective dialogue among spectators, artists and art advocates.

Art events and creation of new public space

The art critic Solvita Krese (2007) claims that public art practice has been looking for new ways to open boundaries, involving other disciplines and trespassing the museum

frames since the last two decades. Public involvement and participation has become an essential element in contemporary art practice. Thus it is raising concerns of preservation of the national identity.

Further the actions organised as events are examined, and the conditions that have contributed to the involvement of people analyzed. New trends in public art were experienced in the international project 'Re:public' curated in 2003 by Solvita Krese and implemented by the LCCA, which took place in Riga suburbs. The project reflected on the social inclusion, highlighting local context and rituals of everyday life. Exactly everyday was used as material to make it observable and exciting (Krese, 2007). Since 2002 the Centre for Arts Management and Information (MMIC) has been in operation. The MMIC is the organizer of the Sculpture Quadrennial Riga; among recent projects 'European Space' in 2004 and 'Dictatorship of the Majority' in 2008 (both under the curator-ship of Aigars Bikše and Kristaps Gulbis) can be mentioned. The programme 'Generation Europe' was organized in 2005-2006 by the MMIC', and it incorporated an experimental space for creative venue 'Pink House', a colourful portable object within which meetings, discussions and other activities could be held. This highly attractive object was temporary placed in several European cities. The Centre searches for contemporary art impact to social environment, abandoned places and the city spaces affected by financial crises.

The capital of Latvia and regional cities are increasingly becoming broadly open to a diverse range of events in the cultural field including the tradition of the City or Town Festivals, as well as music and art festivals. For example, a popular festival is 'Staro Rīga' (the Festival of Light) which has become a traditional event of displaying various sources of lights in Riga, including but not limited to art objects, installations, multimedia artworks, and performances. The festival is initiated by the Riga City Council and has been gathering people since 2008, and corresponds with Latvia`s Independence anniversary celebration. By the same token the target of the contemporary art forum 'White Nights' is to increase the understanding of contemporary culture and can be described as a socially active event. The forum is part of international project 'White Nights Europe' covering Brussels, Madrid, Paris, Riga, and Rome. In Latvia the event was first organised in 2006 by the Department of Culture of the Riga City Council, and since 2009 it has been organised in collaboration with the LCCA. Part of the forum is integrated in the programme of 'Survival Kit', which reflects on changes in the social environment. This programme aims at realizing an attempt to bring different, less common trends into the public space.

Non-profit organizations and artists` initiatives, which emerge as alternatives to institutional work, have been incorporated. In the last decade, growth of several initiatives has been evident and such activities are integrated in sustainable city strategies. For instance, the interdisciplinary art group 'Serde' as the residency and workshop centre was founded in Aizpute in 2002 by the artists Uģis Pucens and Signe Pucena. Furthermore, the Art Centre 'Totaldobže', in the territory of ex-factory in VEF in Riga. Recently, the area around Miera Street has been turning into a creative neighbourhood and gathering place for new enterprises in Riga. Such processes are linked to gentrification due to which desire to creativity and intensive work in cultural sphere emerges.

The case study projects

Paradigms of the significant contemporary art projects have been chosen through the previous analysis of the inherent historical periods and seven case study projects have been discussed. The typology of artworks (Table 1) was used to evaluate the type of artworks implemented in each project selected and is reflected in Table 2.

Table 2

Evaluation of public artworks

Features	Description of the project and the type of artworks implemented
Name of the project selected: The Art Days: Riga, the sequence of the Art Days in 1986, 1987 and 1988, initiated and organized by the LSSR Artists' Union. The funding was provided partly by the art foundation of the LSSR, a certain financial and other support was rendered by the Riga City Executive Committee. Concern: local, the Art Days reached the culmination in the 1980s in the period of revolutionary political change. The Art Days carried a manifestation in exploring the public space and accustoming people and the city space to new expressions of art.	
Aim	Meeting point for art and its spectators and attempt to influence the public thought. A manifestation in exploring the public space, and accustoming people to new expressions of art.
Location	City environment: the squares and streets of the historical centre of the city (the Dome Square, also the pedestrian subway of the Central Railway Station), some city suburbs. Gallery spaces.
Form and size	Broad-scale actions, happenings, installations, sculptures, exhibitions, video and musical performances, record-art, musical demonstrations, dance, graphics, graffiti actions.
Function	Educational, symbolic, polemic, metaphorical, associative, reflective, ideological, provocative.
Features	Description of the project and the type of artworks implemented
Name of the project selected: The Open-air symposium 'Firkspedvale's Conversations': the Open-Air Art Museum at Pedvāle, 1994, organized by the Open-Air Art Museum at Pedvāle, curated by Ivars Runkovskis. Partial funding was obtained from the National Cultural Projects` Competition and partial from the SCCA-Riga. Concern: local, one of the major environmental art projects of the 1990s in landscape environment, it sought to search for new contextual relationships between human being and nature, between contemporary art landscape environment and historical context of place.	
Aim	Leading artists and representatives of the contemporary art, created their objects and installations, using environmentally-friendly materials.

Table 2 continued

Location	The natural environment, selected picturesque places within museum territory.
Form and size	Contemporary art objects, site-specific, installations, three-dimensional objects (formed as basis of a permanent outdoor exposition), performative, contextual, metaphorical.
Function	Self-reflective, symbolic, decorative, compositional, welcoming, revealing, ritualistic.
Name of the project selected: The exhibition 'Piemineklis' (Monument): Riga, 1995, organized by the SCCA-Riga, curated by Helēna Demakova. Funded by the Soros Foundation-Latvia and organised in collaboration with 25 financial, material and information supporters. Concern: local, the exhibition was the first attempt to demonstrate new art forms integrated in the city public space, taking into account the historical and ideological context of the given places, where the art works were installed.	
Aim	Conceptual framework was elaborated to follow the semantics of the monument, highlighting the meaning of the place where a monument was present or had been scheduled.
Location	City environment, artworks were located in places where a monument had been present or had been scheduled in the past, ideologically charged places.
Form and size	Large-scale, more intimate three-dimensional objects, installations, creation of situations, interactive, conceptual, metaphorical, site-specific, social and political meaning, contextual.
Function	Educational, polemic, psychological construction presented as an ideological, contradictory and fragmented structure, reference to the site's historical meaning, commentary, provocative.
Name of the project selected: Interdisciplinary international art and culture project 'Re:public': Riga, 2003, the section in Riga was organized by the LCCA, curated by Solvita Krese. The project was part of the international 'Re_public art' project, supported under the initiatives of the European Union programme 'Culture 2000'. The competitions of separate projects partly were financed from the State Culture Capital Foundation, and the Ministry of Culture of the Republic of Latvia. Additional 17 financial, material and information sponsors were found through funds, institutes, embassies, councils, and mass media. Concern: international, this project was one of the first that integrated European funds, and it aimed to broaden the scope of public art and included Riga suburbs. The exhibition 'Re:public' was one of the first steps forward the involvement and establishment of dialogue with society, with such people, who have no permanent contacts with art activities.	
Aim	The project carried the importance of local context and the involvement of local spectators. In several events, the public were the producers themselves, in others audience became actors in situations staged by the artists. The project was directed to a socioeconomic and a cultural politics area in Latvia and highlighted the relationship between the centre and the periphery of the city.
Location	The periphery of Riga, abandoned areas, public urban space, local neighbourhood.
Form and size	Local context, audience-specific, participation, creation of situation, communicative, interactive, integrating, politically engaged, performative, commercial, advertising, graphical, symbolic.
Function	Provocative, self-reflective, socially or politically engaging, advertising, commenting, gathering.
Name of the project selected: Sculpture Quadrennial 'European Space': Riga, 2004, organized by the MMIC and the Latvian Ministry of Culture in collaboration with the creative organisations of the participating countries of the project curated by Aigars Bikše and Kristaps Gulbis. The project was financed by the European Union programme 'Culture 2000' and a partial funding was obtained from the SCCF, Riga Municipality, and 49 other financial, material and information supporters. Concern: international, a revival of sculpture quadrennials. Contemporary art trends were employed.	
Aim	Contemporary sculptures and art processes were introduced to raise cultural awareness and to invite people to participate. Encouraged dialogue among spectators, artists, and professionals.
Location	City environment, gallery spaces, integrated with buildings, and greenery.
Form and size	Large scale, figurative, symbolic, abstract, mixed-media, social context, site-specific, installations.
Features	Description of the project and the type of artworks implemented
Function	Provocative, self-reflective, socially or politically engaging, symbolic, informative, educational.
Name of the project selected: Contemporary art forum 'White Nights': Riga, 2009, initiated and organized by the Department of Culture of the Riga City Council in collaboration with the LCCA, and partly activities were organised by the active culture organizations in Latvia, artistic leadership was carried by Solvita Krese. The forum was financed by the Riga City Council, and 13 information and financial sponsors. The individual projects were supported separately. Concern: international, the forum aimed to open up a new grasp of contemporary culture. The international project 'Survival Kit' was part of the forum that reflected on diverse survival strategies and changes of the city, community and global economical and social features. It brought up new and creative initiatives.	
Aim	Discuss the matter of artists' ability to influence the situation of crisis. Festive atmosphere.
Location	City environment, integrated with buildings, greenery and urban floor, and open spaces.
Form and size	Site-specific, audience-specific, installations, paintings, videos and animation, mail art, photography, comics and collages, performative, interactive actions, creative, contextual.
Function	Self-reflective, socially engaging, informative, educational, entertaining, integrating, gathering, commenting, polemic, comprehensible, invitational of the public to take part.
Name of the project selected: The Festival 'Staro Rīga' (the Festival of Light): Riga, 2010, organized by the Education, Culture and Sports Department of the Riga City Council and 'UNTITLED' Ltd., authors of the festival concept are the Head of Riga 2014 Office Diāna Čivle in collaboration with 'UNTITLED' Ltd. producer Mārcis Gulbis. Principally financed by the Riga City Council, 12 collaboration partners', the individual projects were co-financed separately. Concern: international, the festival highlighted globalization processes, encouraged the multimedia, use of new technologies for cultural events, and enhanced contemporary art forms expressed in the city space. It exemplified collaborative project between the City Council and enterprises involved in implementing projects.	
Aim	The festival gathers diverse artistic objects, artworks made using various technical developments.
Location	City environment: mainly the Old Riga, territory of the city centre such as parks, streets, squares. Separated, integrated with buildings, greenery and urban floor.
Form and size	Interactive light performances, three-dimensional objects, installations, multimedia artworks, audience-specific, kinetic, interactive, figurative, symbolic, abstract, graphical, organic.
Function	Ideological, socially engaging, self-reflective, symbolic, decorative, informative, educational, advertising, entertaining, integrating, commenting, comprehensible, welcoming, gathering.

These findings illustrate determination of the types of artworks that were most frequently used to describe. The conceptual model of each project reflects the most characteristic events of the respective time period, which have been integrated and accepted in the Latvian art scene. The financial support ensured an opportunity to implement large-scale projects; however, currently there is a tendency to implement small-scale projects and carry out artistic activities based on the encouragement of social engagement. Increased dynamics of art for the public space occurred in the city environment, therefore the majority of the selected projects took place in the city space. Part of separate artworks had a spatial context and site; however, several artworks 'found' their locations through the ideas presented by the artists. The majority of artworks were symbolic and either site or audience-specific. Art projects were situated in the public space, where people were attracted, and the space was arranged for gathering and interaction reasons. These were process-based events becoming more prevalent in the public domain. A stimulus towards creating dynamics of the landscape could be reached by the diverse selection of locations, forms and functions of artworks. The forum 'White Nights' and the festival 'Staro Rīga' displayed trends towards globalisation. The events incorporated cultural artistic activities into the city, approaching the principles of European infrastructure. The main aim of the projects was touristic, that is, to attract people, and ideological context was marked out as well. Recently small artistic initiatives have emerged which are based on the enterprises. These were formations, which appeared in the 'Survival Kit' programme, and were incorporated in the forum 'White Nights'. Pursuant to the arguments presented by the Latvian researchers, the tendency of public art is moving towards a social based public art and is taking into consideration the context of globalization.

In further research, it is necessary to specify the types of the relations between the used space and artwork. It is also required to analyse the economic obstacles from the point of view of the financial support provided to public art, which determines what kind of artworks appear in the public domain of the Latvian landscape.

Conclusions

1. The development of art interventions for the public space in Latvia are strongly linked to political, social and economical changes. By the change over time new artistic forms based on interaction, movement and involvement have become common. These features have to be taken into consideration for developing both urban and rural landscape design and also for community integration planning. Social involvement can be stimulated by the activities based on the events, thus activate attractiveness of the public space.
2. The financial support of the project plays an important role in the process of public art formations. After the funding provided by the Soros Foundation was ceased, since the 1990s art projects have struggled to attract any funding. Other possibilities were provided by the State Culture Capital Foundation, different European funds and sponsorship from enterprises. During the economic struggle since 2008, low-budget art projects and creativity have been the main components to continue artistic work in the public space. These incorporate inclusion of a social environment in more active way. The events incorporate cultural artistic activities into the city, approaching the principles of European infrastructure.
3. The majority of art for the public space occurred in the city environment, but taking into consideration the landscape elements. In the rural environment the most striking example is the Pedvāle Open-Air Art Museum.
4. Art for the public space has shown a connection between the place, people and the artwork. Multi-dimensional relationship has led to a broader understanding and more active expressing of the landscape. Location as a spatial context is present for highlighting the relationship among artists, artworks and viewers. On the one hand, taking into consideration the selection of the place, on the other hand, the perception of it.
5. The analysis of the research can be used for the strategic development of the public space, which includes artistic events. The data can be used both for the urban and rural sequential landscape planning.

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THE ESTIMATION OF THE EMISSION OF GREENHOUSE GASSES BY THE TREATMENT OF SEWAGE SLUDGE IN LATVIA

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Abstract

The report presents the assessment of emission of greenhouse gases (GHG) generated by the treatment, disposal and storage of sewage sludge in Latvia. The aim of the study was to determine GHG emissions from stored sludge because those were not previously estimated. The proposals for the further reduction of the GHG emissions are elaborated on the provided estimations of different treatment models. The calculations of GHG emissions are conducted by using acknowledged software and data from Latvian Environment, Geology and Meteorology Centre. Data from the year 2005 till 2009 about the amount of stored sludge were used by the authors for mathematical calculations in the year 2010. The long-term storage of sewage sludge and their disposal in landfills were detected as the main sources of GHG. It was detected that the average GHG reduction of 5 Gg per year can be ensured by using biological treatment of sewage sludge.

Key words: sewage sludge, greenhouse gases, biotechnologies.

Introduction

The aim of the study was to determine emissions of greenhouse gases (GHG) from stored sludge because those were not previously estimated. The assessment of greenhouse gases emissions conducted in 2009 in Latvia has shown no reduction in GHG emissions generated by wastewater treatment. On the contrary, reduction in GHG was identified as small from 1992 to 1999, but starting from the year 2000 it increased sharply. The biological decomposition of sewage with high organic pollution, sewage sludge and organic waste was determined as the main reason for increase in GHG emissions (The Inventory of GHG Emission in Latvia, 2009). Figure 1 shows that GHG emissions from wastewater handling have the greatest influence on total emission trend.

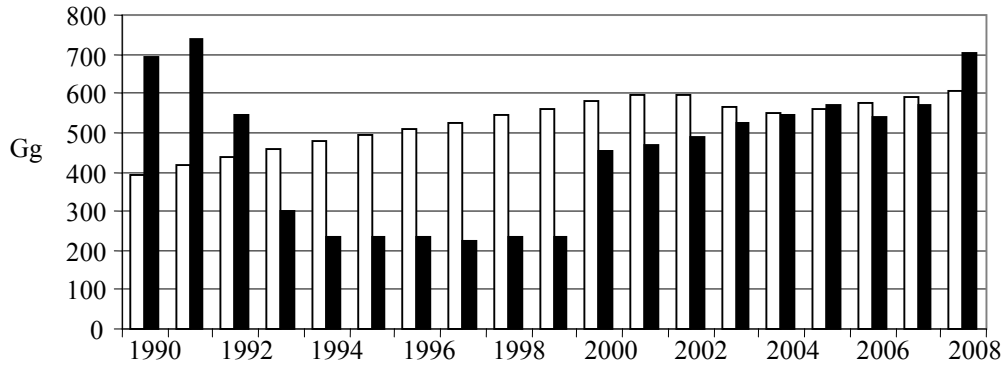

Figure 1. Emissions from solid waste disposal (□ – SWD) and waste water handling (■ – WWH) sectors in CO_2 equivalent (Gg) (The Inventory of GHG Emission in Latvia, 2009).

The aim of the purification of sewage is to separate solid parts, chemical substances, pathogens and other biological parts from sewage water, so the used water can be returned back into the environment. On average 8 – 10% of methane anthropogenic emissions come from sewage and sewage sludge anaerobic storage. Anaerobic circumstances are characteristic to 2-3 m deep storage places. Aerobic purification produces a comparatively small amount of methane. Table 1 shows amount of sludge produced by using best available techniques (Bendere et al., 2010) of sewage purification.

Table 1

Amount of sludge produced by using best available techniques of sewage purification

Processes	Amount of sludge from purification of 1 million litres of communal sewage	Amount of solid substance ,%
Pre-purification (physical methods)	2,500 – 3,500	3.0 – 7.0
Secondary purification (biological methods)	15,000 – 20,000	0.5 – 2.0
Final purification (physical and chemical methods)	~10,000	0.2 – 1.5

The development of sewage purification technology in Latvia includes growing and centralized sewage collection and purification by anaerobic as well as aerobic processes. Table 2 presents official statistic data and shows the produced sludge quantity (by dry mass (d.m.)) during last years in Latvia and types of its utilization (Latvian Environment, Geology and Meteorology Centre, 2010). The long-term storage, composting and mesophilic anaerobic treatment are the main methods which had been used for sludge treatment according to the stated requirements (Bendere and Arina, 2010).

Table 2

Quantity of produced, treated and utilised sludge in Latvia during 2007-2009 (tons of dry mass per year)

Year	Produced	Treated	Untreated	Used in agriculture	Composted	Incinerated	Stored	Other
2007	23,259	18,191	5,068	8,131	2,066	-	8,586	205
2008	22,486	18,093	4,392	5,249	2,784	1.93	10,943	927
2009	22,684	17,242	5,442	7,259	3,402	-	9,074	2,949

It is estimated that there are 88 agglomerations generating largest part of organic pollution with communal sewage containing non-organic compounds of nitrogen and phosphorus of increased concentration in Latvia. Industries producing sewage with high concentration of organic compounds are:

- pulp and paper production;
- meat production (slaughterhouses);
- alcoholic and non-alcoholic drink production;
- organic chemical production;
- food production.

As a result of biological purification of sewage, the sewage sludge is produced at the amount of about 25,000 – 30,000 t year^{-1} (during lasts five years). About 25 – 30% of sludge is used for agriculture, but 40 – 60% is stored at the place of its production. This open-stored biomass has growth of about 10,000 t per year and it pollutes environment with GHG, storage leakages, and polluted precipitation.

Summarizing the information on sewage sludge generation and usage during last five years within the project 'Elaboration of eco-effective standard documentation package for implementation of wastewater sludge treatment technologies in Latvia' (Bendere et al., 2010) it can be concluded that about half of produced sludge (by dry mass) is stored and not used regardless of the stated requirements – after three years of storage unused sludge must be disposed in a landfill.

Materials and Methods

The assessment of national GHG emissions is conducted by Latvian Environment, Geology and Meteorology Centre (LEGMC) according to the United Nations Recommendations (IPCC Guidelines for National Greenhouse Gas Inventories, 1996). Thus, GHG are assessed for following kinds of waste treatment:

- solid waste disposal,
- biological treatment of solid waste,
- incineration and open burning of waste,
- wastewater treatment and discharge.

For calculations of methane emissions, the mathematic software and data of LEGMC as well as studies of authors were used and analyzed (Bendere et al., 2010). Data from the year 2005 till 2009 about the amount of stored sludge were used by the authors for mathematical calculations in the year 2010. As data of LEGMC are general and do not correspond to detailed parameters, GHG assessments were made by using IPCC Guidelines with LEGMC data as basic information.

It was assumed that biogas amount discharging from sludge in an uncontrolled dumpsite is similar to that in the storage place within little depth as data of LEGMC were not directly applicable to calculate methane emissions from the stored sludge. According to the amount of sludge stored in respective year and according to emission factors of sludge, the annual emissions of methane were calculated using the following adapted formula (1):

Emissions of methane (Gg per year) = (1)

$$(MSW_T \bullet MSW_F \bullet MCF \bullet DOC \bullet DOC_F \bullet F \bullet 16/12 - R) \bullet (1 - OX)$$

where, MSW_T – total generated sludge quantity;
MSW_F – quantity of sludge disposed;
MCF – factors of methane emissions;
DOC – degradable organic carbon;
DOC_F – decomposited part of DOC;
F – proportion of methane from total amount of gases (0.5);
OX – factor of oxidation (0).

Respective data (Bendere et al., 2010) were used to assess the potential use of sludge for biogas production and possible amount of energy produced. The ratio of sludge converting to biogas was 0.6 m^3 kg^{-1} of dry content, and energetic value of the biogas – 23 MJ per m^3. Theoretical assessment of biogas was made according to formula (2):

$$E = q_1 \cdot q_2 \cdot q_3 \cdot M, \quad (2)$$

where M – amount of disposed sludge;
q_3 – amount of dry content;
q_2 – amount of biogas production for one dry content unit;
q_1 – calorific value of the biogas;
E – energy.

Results and Discussion

The estimation of used treatment methods

Two mostly used waste treatment processes are anaerobic decomposition (used for biogas production) and aerobic decomposition (used for composting purposes). The anaerobic treatment is mostly used for waste with higher humidity (sewage sludge, food and industrial waste). During anaerobic treatment within closed reactors, the estimated methane released ranges of average 5% of the initial carbon content in the material (IPCC Guidelines for National Greenhouse Gas Inventories, 2006). The development of sewage purification technology in Latvia includes growing and centralized sewage collection and purification by anaerobic as well as aerobic processes. In the present article the long-term disposal of sewage sludge or its disposal in landfills according to collected data is analysed as the main source of GHG emissions within sewage treatment. The production and closed tank storage of methane is assessed as a possible bio-technology for sewage sludge treatment. According to literature (IPCC Guidelines for National Greenhouse Gas Inventories, 2006), the leakage of methane from closed reactors and storage containers is less than 1%.

At the moment only simple sewage sludge composting methods are used in Latvia. Thus only small part of sludge can be treated by open wind-row or pile technology including dehidratation and stabilization phase of sludge before the process. Sludge with high humidity and biological and chemical pollution cannot be treated with the methods mentioned above, but other methods are not practised in Latvia. Figure 2 shows the amount of stored and disposed sludge, which in general determines amount of GHG emissions.

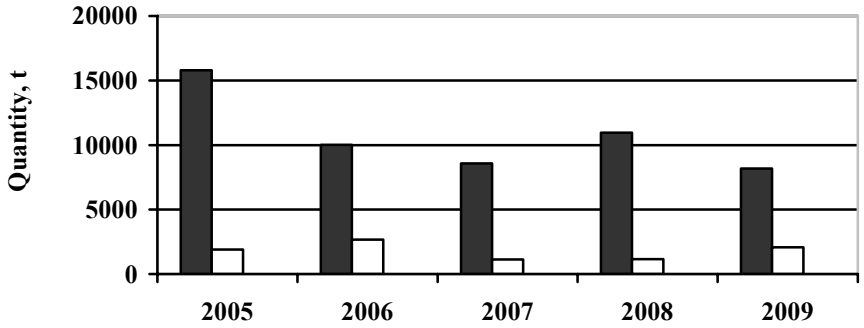

Figure 2. Quantity of stored (tons of dry mass per year) and disposed sludge in Latvia during 2005 -2009 (■ – stored; □ – disposed).

The results of calculations of methane emissions

The annual methane emissions from sludge storage places were calculated by using data and acknowledged software of LEGMC (Table 3). It was determined that about 5 Gg of methane generates from stored sludge annually, thus contributing to more precise emission planning at national level.

Table 3

Methane emissions from stored sludge

Year	Amount of stored sludge (15% dry matter, t)	Amount of methane produced (Gg)
2005	105,273	7.56
2006	66,733	4.82
2007	57,240	3.74
2008	72,953	5.18
2009	54,600	3.96

The produced methane is comparable to the average amount of gas (~ 4.5 Gg) annually produced from waste landfills. As there are no studies of elementary analysis for stored sludge, it was taken into account and used for the current study that according to Latvian legislation only sludge with dry content of no less than 15% may be disposed.

The sludge must be viewed as a new and additional source of energy, while not used it can represent losses of renewable energy. Therefore the amount of potential energy that can be obtained from stored and disposed sludge is presented Table 4. If compared to year 2005, the amount of stored sludge is still considerable, although it has a reducing tendency. In Latvia annually about 13 PJ of potentially usable biogas production energy from stored sludge is not used.

Table 4

The potential production of energy from treatment of stored and disposed sludge

Year	2005	2006	2007	2008	2009
Amount of disposed sludge (t)	12,689	17,899	7,588	7,725	13,881
Energy from disposed sludge (PJ)	0.026	0.037	0.016	0.016	0.029
Amount of stored sludge (dry content, t)	15,791	10,010	8,586	10,943	8,190
Energy from stored sludge (PJ)	0.20	0.13	0.11	0.14	0.11

The differences between potential energy from disposed and from stored sludge should be evaluated for development of effective sludge management.

Conclusions

1. The anaerobic treatment of sludge within closed reactors should be considered as a possible effective use of sludge in Latvia thus contributing to sustainable energetics and mitigation of the climate change.
2. An average of 0.13 PJ can be obtained from stored sludge in Latvia annually.
3. A substantial reduction in annual GHG emissions (about 5 Gg) can be ensured by treatment of stored sludge within closed biogas reactors.
4. In order to use IPCC Guidelines for national GHG assessment, it is necessary to measure GHG in the places where the biotechnology is used as well as measure GHG from closed reactors and open composting surfaces.

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PHILOSOPHIC METHODOLOGICAL BASES FOR EVALUATION OF EDUCATOR'S COMPETITIVENESS

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Abstract

Since the change of the paradigms of competitiveness is taking place now, the concept 'competitiveness' also changes its semantic meaning. In the article, the concept 'educator's competitiveness' is analyzed and scientifically substantiated according to different views. The aim of the article is to present the results of theoretical research, performed by author for several years in the field of concurentology, actualizing the new meaning of the concept 'educator's competitiveness' in the pedagogy science and education, and proposing an insight into the substantiation of the philosophic methodological basis for the evaluation of educator's competitiveness. In the article, the author applies the concept 'educator' according to its broader meaning. The research shows that there exists: 1) diversity in relation to the definitions and explanations of the competitiveness of an educator as a specialist; 2) three methodological approaches in the research of competitiveness: a biometric, a functional and a structural approach. According to the author's opinion, the structural approach would be the most appropriate for the development of the evaluation methodology, including the system of evaluation indicators, in relation to the components of an educator's competitiveness structure.

Key words: change of paradigms, an educator's competitiveness, methodological approach, a personality's competitiveness, a specialist's competitiveness, a structure of educator's competitiveness.

Introduction

In 1990s changes took place in all types of activities, including education. If at the end of 1990s the scientists tried to forecast, when these changes would, then now it is already possible to draw a conclusion that they would never have an end, because mankind has entered a new stage of its development. The changes that are taking place now actualize the significance of the competitiveness, including the viability, of a personality, a community's individual, a specialist in the changing environment.

As a result of changes that are taking place, the concepts 'a personality's competitiveness' and 'a specialist's competitiveness' become more and more important in pedagogy science. The concept 'competitiveness' becomes a scientific category in pedagogy. It is proved by the fact that at the end of the 20th century a new subtrend of research – concurentology – started to develop in Russia.

Research, performed by the author at the Institute of Education and Home Economics at the Latvia University of Agriculture, proves that within the last decade, as a result of the change of scientific and educational paradigms, the paradigm of competitiveness has also changed.

Using metaphors, we might say that, within the context of the old paradigm of competitiveness, a competitive personality could be compared to an image of a shark, which, in the process of achieving its goal, is able 'to swallow' anybody standing in its way and bothering it. Nowadays is the time, when a new paradigm of competitiveness is born that makes us radically changing our views concerning a competitive personality, which could be symbolically compared with a dolphin (Apressyan, 1997).

The processes that take place in the development of mankind's thinking enable to forecast that the time would come, when the old paradigm of competitiveness would be studied and analyzed only by philosophers, anthropologists, historians and representatives of other sciences in order to explain the development of humankind from the historical view.

Research, performed by the author and Dr.paed. Ilze Kalnina (Katane, 2010; Katane and Kalniņa, 2010), enables to draw a conclusion that a new type competitive individual is able to co-operate, to help others, to maintain the balance between I-ego and I-eco in his thinking and actions. He perceives his competitors as his potential partners for co-operation. A dolphin-type competitive personality can be a leader and at the same time also a member of a team, working together with others and co-operating with them. In the context of the new paradigm, a competitive personality in the process of its development, instead of competing with others, competes with itself — it combats its bad habits, shortcomings, disability or unwillingness to perform something important or necessary to do. It is a determined personality, possessing clear goals for future. The competitive personality of the new type is creative and flexible in its thinking and actions; therefore it is able to deal with the problems in the unusual, nonstandard situations. It is able to take decisions and to be responsible, and it is a personality one can rely on and to whom one can trust. Such a person is respected by others and he respects himself. Such a person is welcomed among friends and acquaintances, and he is demanded in the professional field.

Changes in all fields of human activities, different crises become the precondition for the fact that the representatives of different professions should learn to live and develop and to self-actualize as specialists under the changing labor market conditions. Nowadays particularly topical is the necessity to develop the methodology for the development and evaluation of an educator's competitiveness.

The aim of this article is to present the results of theoretical research, related to the development of philosophical methodological basis for the evaluation of an educator's competitiveness. In the article, the author uses the concept 'an educator' in its broader meaning (a preschool teacher, a teacher at a comprehensive school, at a music school, at an art school, at a sports school, at an establishment of vocational education, a university lecturer, a private teacher and a tutor, etc.).

Materials and Methods

Methods of research include studies of scientific literature and reflection of personal pedagogic/academic experience. The authors have a great deal of substantial experience in school pedagogy and higher education pedagogy.

Results and Discussion

In modern pedagogy science many authors have developed the scientific substantiation for the competitiveness of both a personality and a specialist, offering their point of view concerning this problem under research. The article covers the examples that, according to the author's point of view, should be directly related to the description and evaluation of the competitiveness of an educator as a personality and a specialist.

J. Bogdanova (Богданова, 1992) defines competitiveness as a stage of an individual's general and professional development that could be characterized by the personality's qualities.

According to A. Kurakov (Кураков, 2004) and V. Shapovalov (Шаповалов, 2003), competitiveness has its levels and their indicators: 1) in an educational establishments the competitiveness is characterized by identifying and describing the totality of an individual's features, qualities, including general competences; 2) in vocational education the competitiveness is characterized by describing the totality of a specialist's features, different qualities, including professional competences, within the context of the advantages of professionalism and competitiveness in the labor market. Both scientists point out that competitiveness is a socially oriented system, comprising abilities, features, qualities that 1) characterize the potential possibility for the individual to achieve success in studies, professional or non-professional sphere of life; 2) determine the adequate behavior of an individual under the dynamically changing conditions, and 3) ensure inner harmony, self-confidence and trust in others. The systematization of the features of competitiveness is not only a theoretical objective, but also the practical one in conformity with the criteria of socio-cultural development and each individual's self-development, which could serve as the self-assessment and self-development of the competitiveness of an individual as a personality and a professional.

Substantiation of the competitiveness of an educator as a personality

In the twenty-first century the scientists faced an important problem: what are the individual's personality features, abilities, knowledge and skills, and other indications, ensuring his competitiveness in the private life and in the sphere of professional activities, and serving as the indicators characterizing competitiveness.

The founder of concurentology in Russia, academician V. Andreyev (Андреев, 2006) presents his view on the personality's competitiveness, identifying the indicators that characterize a competitive personality. The scientist emphasizes that only the synthesis of several different features can ensure the individual's competitiveness. A competitive personality should be: determined; heuristic; decisive; flexible; self-rigorous and demanding towards others; independent; energetic; respected as an authority; optimistic; with practical experience; principled; communicative; with a leader's abilities; innovative; intelligent; revolutionary; a reformer.

V. Zemskova (Земскова, 2007) points out that nowadays the real life demands for the specialists who can think creatively and generate new ideas. According to V. Zemskova, in order the graduates of higher educational establishments would be competitive as specialists it is necessary to develop the following personality's qualities: readiness and skills to study independently; self-confidence; self-control; independent thinking, originality; critical thinking; readiness to apply new ideas and innovations to achieve the goal; communications skills; decision-making skills; co-operation skills to achieve the goal; the skill to listen to other people and to take into account what they are saying; the skill to apply independently and creatively already familiar algorithms and to find one's own ways of problem solution, as well as to perform their analysis and evaluation. These conclusions are significant also for the teacher education.

Several researchers to great extent relate a phenomenon of competitiveness to the qualities/features of a charismatic personality as a leader.

For example, V. Rumyanceva (Румянцева, 1996) writes that a leader is a person, who is ready to act in different situations, and it is not characteristic to every individual. Very often his actions are extraordinary, special and original. It is through behavior/actions manifests the leader's individuality, his uniqueness. Research, performed by V. Rumyanceva under the laboratory conditions, proves that a leader has an explicit motivation for achievements and success; the leaders' self-evaluation and the level of requirements set by them are significantly higher than those of others; the leaders differ from other participants of the experiment with a lower level of neurotism, anxiety, vice versa – they have considerably higher indications of emotional endurance.

Researchers from western countries (Charron et al., 1976) write that a leader possesses the following features: communicability; creativity; organizational qualities: skills and abilities; activity; intellect; moderate emotional expansiveness; emotional attractiveness, responsiveness,

authority; socio-psychological attractiveness and competency.

A. Kirsanov (Кирсанов, 2000) has presented his description of competitiveness: the competitiveness is a socially oriented system of a personality, comprising abilities, features, and qualities that: describe the personality's potential possibilities to achieve success in studies, professional or non-professional sphere of life; determine an individual's adequate behavior under the dynamically changing conditions; ensure inner harmony, self-confidence and trust in others.

On the basis of humanistic and ecological approaches, the author of the article (Katane and Kalniņa, 2010), in co-operation with Dr.paed. I. Kalnina, has developed the definition of a competitive personality, which could be related also to an educator's personality. Competitiveness is an integrative totality of a personality's qualities that ensures its viability, including the development and self-actualization, under the conditions of changing environment. The basis for the personality's competitiveness is experience. The competitive personality is characterized by the following qualities/features: 1) the characterizing indicators of personality orientation and self-conception, including the purposefulness and an action oriented towards success; the readiness to overcome difficulties and to take a risk; persistence, adequate self-assessment and daring to take a risk; 2) well-developed self-regulation, including volition, stress endurance, self-reflection, including analytical-evaluating and systemic thinking; personality's flexibility (flexibility in thinking, emotional sphere, behavior), the ability to make a decision; the responsibility for the made decisions and their consequences; 3) different competences, including also creativity as an ability, oneself - and environment-friendly thinking, attitude and behavior: observation of moral and ethical principles, the principles of environmental, including social environment (community), balance and sustainability, readiness for the co-operation with other people; 4) readiness to change oneself in order to maintain the balance with the changing environment, readiness to start changes in the environment on the basis of environment-friendly attitude and action.

Community, including pupils/students, their parents, colleagues, evaluates an educator both as a personality with its individual features and as a professional. A good and demanded teacher/university lecturer not only knows the content of a school subject/study course, but is also competent methodologically; he is able and can guide his pupils/students within the cognitive process, eliminating any obstacles, assisting in the solution of problems. Thus the indicators for the evaluation of an educator's competitiveness should comprise both the characterizing indicators of an educator's personality and the characterizing indicators of an educator as a specialist, a professional – it would enable to study and evaluate the educators' competitiveness in the modern changing environment, including the changing environment of labor market.

Substantiation of the competitiveness of an educator as a specialist

It is possible to observe two tendencies in the substantiation of a specialist's competitiveness; the tendencies are related to the liberal-rational and humanistic paradigms in education: 1) specialists, scientists of economics and other disciplines, on the basis of regularities, categories, conceptions, theories of economics, try to use transfers for the development of the definitions of a specialist's competitiveness; 2) the representatives of pedagogy and psychology sciences develop the substantiation of *a personality's competitiveness* and/or *a specialist's competitiveness* on the basis of humanistic and ecological approach in education.

The competitiveness of a specialist, also that of an educator, is related to his marketability in the labor market. L. Mitina (Митина, 2003), who has studied the problem of a teacher's competitiveness already since the beginning of 1990s, finds that there are at least three spheres of the development of a specialist's competitiveness: 1) activity sphere; 2) the sphere of interaction with the environment, including the interaction with other people; 3) the sphere of a personality's self-development, including the self-awareness and self-determination. L. Mitina points out within the context of educational aims concerning the education of modern teachers as specialists that a teacher is competitive if he is a marketable specialist in the labor market, able to self-actualize under the changing social environment, including the environment of professional activities/work environment**.** L. Mitina emphasizes an idea that a competitive teacher is able to align his career aims with the aims of his colleagues, a school as an organization; he respects a teacher's ethics, therefore is respected and welcomed, and thus 'marketable' among both pupils, their parents and teachers. S. Shirobokov (Широбоков, 2000), having studied the competitiveness of pedagogy students as the prospective teachers, emphasizes an idea that a teacher's competitiveness, first of all, is related to the concepts 'a teacher's marketability' in the labor market, 'a teacher's authority' and 'marketability in community'**.** The scientist, having compared the quality of the education of teachers as specialists in Russia and USA, defines competitiveness as relying only on one's own abilities and initiative that enables an individual to overcome the psychological barrier, depression, pessimism; the competitiveness enables an individual to find a way out of problems.

The author of the article finds that an educator's competitiveness is also related to the local, regional, national and/or international acknowledgment in the field of professional activities, an educator's professional thinking, values scale, as well as his attitude towards his pupils/students. It is important to point out – if, within the context of humanistic paradigm, the human-oriented approach is defined in pedagogy science and education as an imperative for an educator's activities, then within the context of liberal-rational paradigm it is the client-oriented approach, which should be respected by an educator as a competitive

specialist. According to this view, pupils and their parents are clients. Within the context of this approach, an educator, who would like to develop his competitiveness, should not forget his mission. It is important to know the historical origin of the word 'pedagogue', which we can find in Ancient Greek. An educator should keep in mind to whom he serves, namely, an individual who learns. From the aspect of liberal-rational paradigm, the quality of education depends on the educators' professionalism. Education has its value. Education is both the sphere of services, supplied by educational establishments, and a product with its costs, quality and with or without its demand. The observations prove that, unfortunately, as a result of present economic crisis and unfavorable demographic situation, there had been schools closed down, the groups of students cannot be formed in different study programs at higher educational establishments, thus exposing to danger also the sustainability of higher educational establishments. Under such circumstances the unemployment of teachers and university teaching staff becomes a reality; the educators' competitiveness actualizes according to its new meaning. Therefore in modern education, particularly in the environment of private formal education and non-formal education (interest related education), 'work is already oriented towards the client', otherwise there might be lost the demand for a particular educational/study program, a study course at a higher educational establishment or elective class, group in the environment of non-formal education, and thus also for 'the services' of a particular educator or even several educators.

A competitive educator (a teacher, a university lecturer), according to the new meaning of the concept, is a person, who is aware of his resources, the potential and possibilities for the development of his career; he is able to evaluate the present situation, in due time (beforehand) he is aware and can anticipate in the nearest future both the developmental opportunities, offered by the educational environment and the environment of professional activities, and the threats; he is ready for changes, self-education, improvement of professional skills, acquisition of a new qualification and changing of work environment, if necessary; he is not afraid to dare, to show an initiative and creative ideas in order he could change something in the educational or professional environment, where he is working, to make this environment more sustainable; he is able to perceive his competitors as partners for co-operation and to work in a team; he is able to align his career aims with the aims of community, organization, where he is working, as well as with his colleagues' aims; he takes care of the quality of his work and is responsible for the results, he asks not only of his pupils/students, but is also self-rigorous; he is not afraid to take upon himself the responsibility, additional duties, if it is demanded by a situation, he can become a leader in a social group at his workplace or become a competent leader to fulfill a particular task; he can adequately evaluate his professional skills and also 'offer his services' in order there would be a demand for his professional activities.

Client-centered approach has also its disadvantages, because very often teachers and university teaching staff face the tactless and unacceptable attitude and behavior of pupils and students due to the governing principle 'a client is always right'. The democratic and humanistic educational environment is developed, when there is mutual respect, understanding and the skill to accept the other person, to acknowledge him as a personality and a partner for co-operation in order the pupil-centered or the student-centered approach would not turn into the facilitator of the egocentric youth's permissiveness, because it is important to respect also an educator as a personality and a specialist.

In order to facilitate and study the development of the competitiveness of the representatives of different professions as specialists, including educators, the necessity to define the essence of a specialist's competitiveness actualizes in pedagogy science.

I. Saratceva (Саратцева, 2005) describes a modern competitive specialist as follows: a competitive specialist is a moral, healthy, independent, determined, professionally competent personality, able to evaluate the situation objectively and to make the optimal decisions; this personality is oriented towards the self-development of its human essence, being aware of the meaning of life; this personality strives for one's cognition and self-actualization.

J. Bogdanova (Богданова, 1992) writes that a specialist's competitiveness is determined by the individual's general developmental level; a specialist's competitiveness depends on his qualitative indications in professional activities and obtained qualification.

The USA scientist K. Hansen (Hansen, 2008), specialist of the career support system, has developed a conception of a quintessential career, where she substantiates several functional indications of a competitive personality within the context of a career development: communicative skills (verbal and written communication); teamwork/ interpersonal skills and abilities; leadership skills; observation of professional ethics; good capacity for work, including endurance, effort, self-motivation, diligence, healthy ambitions, initiative, venture, positive attitude towards work; driver's skills; logic, intelligence, competence in education and/or professional activities; organizational skills; business skills, which are applied by people to start their own business, including the ability of self-determination, project administration skills and abilities, the talent for self-management and marketing oneself as a specialist; self-confidence; critical thinking and the skill to deal with problems; flexibility; analytical skills; the skill to use new technologies, programming (computer languages) and/or foreign language skills; persuasion skills, the skill to offer/sell one's ideas; creativity in dealing with problems.

In Japan a competitive specialist means a specialist, who is able to achieve the set goals in different and rapidly changing environment, managing to deal with a large number of professional tasks, and who possesses certain

individual qualities. The studies of Japanese experience provide an opportunity to discover something unique, but the most important is that it is an approach, which is successfully approbated in the practice of Japanese vocational education and career education for the preparation of new specialists and the facilitation of the development of their competitiveness. When evaluating the specialist's competitiveness, a particular attention is paid to the specialist's ability to make decisions, plan, maintain the dialogue, organize people, and implement the control over the activities of junior employees (Katane and Kalniņa, 2010).

S. Rachina (Рачина, 1998) emphasizes that the competitive specialists: should be able to act under the new socio-economic conditions; should possess professional activity; should be able to make competent decisions independently, choosing alternative variants and to act strategically; should be able to take a risk; should have flexible thinking and behavior; should rely on themselves; should be independent; should be responsible; should show initiative; should be mobile; should have quick reaction under the changing conditions.

Methodological basis for the evaluation of the competitiveness of an educator as a personality and also a specialist

The research, performed in pedagogy science at the level of tendencies, enabled to identify three methodological approaches in the studies of the competitiveness of a personality and a specialist. They are as follows: 1) the scientists study and describe the manifestation of the competitiveness of a personality/a specialist in action; 2) the competitiveness is substantiated as a totality of the qualities of a personality/a specialist; 3) the competitiveness is substantiated, studied and evaluated as a complex multicomponent structure (Katane, 2010; Katane, Kalniņa, 2010). Having applied the method of transfers in pedagogy and educational ecology, the author of the article has theoretically named these three approaches as follows: functional approach, biometric approach and structural approach in the studies of competitiveness (Katane, 2010).

Several scientists, on the basis of structural approach in the studies of competitiveness, have developed and substantiated the multicomponent structural models of a specialist's competitiveness.

For example, the USA scientist G. Floren (Floren, 1998) in her book 'Disclosure of Information: Actualize Yourself' identifies the following components in the structure of competitiveness: the component of communication skills; the component of social openness and flexibility; the component of inner resources and integrity; the component of self-organization and self-regulation; the component of self-development and learning competences (the context of lifelong learning).

B. Parygin (Парыгин, 1994) identifies the following components in the structure of competitiveness: psychologically physical component; the component of personality orientation; the component of individual qualities; professional component; the component of the psychological readiness to take part in the competition; the component of social experience.

V. Shapovalov (Шаповалов, 2003) identifies the following components of a personality's competitiveness: paradigmally forecasting component; informative content component; operational or activity component; motivation and values orientation component; the component of emotions and strong volition. Theoretically each of the components is an independent substructure that is subordinated to the general laws of a personality's development and at the same time comprises the unity of self-assurance, action and social relations. Paradigmally forecasting component envisages the determination of the personal perspectives of competitive behavior (CP behavior), the self-development according to the ideal model of competitive behavior. Informative content component forms the totality of knowledge, related to 'I-conception', determining the strategy and tactics of competitive behavior, decision-making, self-assessment, communicative and regulative activities. Operational or activity component develops the cognitive, communicative, regulative and other types of skills and abilities, determining the correspondence of competitive behavior. The component of motivation and values orientation reflects the personality's values orientation, striving for moral self-development, positive orientation towards different socially important activities, the need for self-actualization, self-approval, self-expression, self-development. The component of emotions and strong volition comprises responsibility, independence, initiative, and self-confidence, compassion, self-control.

When substantiating the structure of competitiveness, some authors combine structural approach with functional and biometric approaches, i.e., when identifying several components in the structure of competitiveness, they point out also the describing indicators or the evaluation indicators of these components. For example, very important for the studies of an educator's competitiveness is also the structural model of competitiveness, developed by L. Mitina (Митина, 2003), where she identifies and substantiates the following components: 1) the component of personality orientation (psychological content and developmental conditions), where the author identifies three sub-components: personality's orientation towards itself, towards other people, orientation towards objects or orientation towards the achievement of a particular goal, including also the professional self-determination, self-development, etc.; 2) the component of personality's competency, where the author identifies several types of competency and substantiates the structure of competencies, as well as the manifestations of competencies and the spheres of proving competencies in the individual's actions; 3) personality's flexibility; in the substantiation of this component, the author pays particular attention to the self-regulation of emotions, warns about the emotional burnout,

emphasizes the significance of stress endurance under the conditions of haste and changes nowadays; the author substantiates the significance of taking situational decisions and acting, writes about the factors of behavioral influence, as well as the mechanisms of human self-regulation; the author pays particular attention to the substantiation of the concept intellect, writes about the intellectual qualities, including mobility, dynamic, flexibility.

The author of the article grounds her development of the methodology for the evaluation of an educator's competitiveness on the structural approach, because it integrates also the biometric and functional approaches. The author of the article has developed the structural model of an educator's competitiveness, identifying five components of competitiveness: 1) component of personality orientation, including professional orientation; 2) component of self-conception, including the self-evaluation of professional identity and oneself as a professional; 3) component of self-regulation, including volition, emotions and personality's flexibility; 4) component of competences, including professional competences; 5) component of individual qualities (for example, intelligence, charisma, sense of humor, creativity, different characteristic features, health, etc.), and indicating that the basis for the development of an educator's competitiveness is experience.

The significance of experience within the process of a competitive specialist's development has been emphasized in works of several scientists, defining the type of experience: 1) organization of individual experience (Шаповалов, 2003); 2) experience: general, professional (Борисова, 1996); 3) social experience (Парыгин, 1994); 4) diverse life experience, including experience of formal and non-formal education, socialization and culturalization, professional activities (Katane and Kalniņa, 2010). There is a difference only concerning the scientists' point of view – some scientists include experience in the structure of competitiveness as a component, whereas others believe that experience is the basis or foundation for the development of competitiveness.

The structural model of an educator's competitiveness, developed by the author of the article, may serve as a basis for the development of a more detailed methodology of evaluation.

Conclusions

1. During the last years the change of the paradigms of competitiveness takes place; as a result, competitiveness becomes a scientific category in pedagogy science.
2. There should be two aspects included in the substantiation of the concept of competitiveness of a specialist, including an educator: 1) the substantiation of the competitiveness of an educator as a personality; 2) the substantiation of the competitiveness of a professional as a specialist of a particular field.
3. It is possible to observe two tendencies in the substantiation of the competitiveness of a specialist, also that of an educator: 1) specialists, scientists of economics, on the basis of regularities, categories, conceptions, theories of economics, try to use transfers for the development of the definitions of a specialist's competitiveness; 2) the representatives of pedagogy and psychology sciences develop the substantiation of a personality's competitiveness and/or a specialist's competitiveness on the basis of humanistic and ecological approach in education.
4. There are three methodological approaches to the substantiation of a personality's competitiveness and also to the substantiation of a specialist's competitiveness: functional approach, biometric approach and structural approach.
5. It is possible to identify five components in the structure of an educator's competitiveness: component of personality orientation, including professional orientation; component of self-conception; component of self-regulation; component of competences, including professional competences; component of individual qualities. The basis for the development of an educator's competitiveness is experience. The structural model of an educator's competitiveness, developed by the author of the article, may serve as a basis for the development of a more detailed system of evaluation indicators.

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PROFESSIONAL EDUCATION TEACHER FURTHER EDUCATION

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Abstract

The requirements for education, school and teachers become increasingly varied and complicated. The Latvian education system needs to be changed. The aim of the education reform is to establish a qualitative, accessible, competitive education system. The role of the teacher in studies changes with the economical and labour market changes. It determines new requirements and makes the knowledge, skills and competences of teachers change. To foster the development of teacher skills and acquisition of information, it is necessary to promote further education of teachers.

The involvement of Latvia in the today's global processes makes it necessary to substantially reconsider the aims and tasks of the education system – to ensure modernization of the education system and attain the introduction of new education content and methods. The article theoretically and empirically analyses and summarizes the further education experience of teachers at the Centre for Lifelong Education of the Latvia University of Agriculture in 2009/2010. The research target group – professional education teachers. The aim of the article is to justify teacher further education as development of professional and pedagogical competences in ensuring a modern and qualitative study process. The novelty of the research is related to the idea of the professional education reform and optimization of the network of professional schools.

Key words: further education, knowledge, skill, competence.

Introduction

The democratization process of the society emphasizes the question about a more active involvement of education institutions in solving the urgent problems of the society. The dynamic changes in the modern society encourage a purposeful improvement of the education system. Education is one of the fields that is expected to be typical of very high standards. The creative activity and knowledge of a human are those to determine the development of the society.

Orientation of the practical activity towards knowledge is one of the topicalities of the modern society. Education cannot exist apart from the development tendencies of the society provided that the mental potential of the society is one of the main preconditions for surviving in the modern world of rapid changes and being competitive in the field of education. Human mental potential is the most important resource in Latvia, which will determine the development progress of the society.

At present, teacher professional development is topical, as education funding from the state budget and teacher salaries in Latvia tend to drop. Not only is teacher professional development topical, but also adequate ensuring of the pedagogical personnel in education institutions matters, which is related to the changes in the age structure of teachers and measures for the optimisation of schools.

The aim of the article is to justify teacher further education as development of professional and pedagogical competences in ensuring a modern and qualitative study process. The need for further education as a new reality needs to be studied. Further education is one of the opportunities for professional development of teachers. It is the most accessible and flexible solution for working teachers to regularly and systematically follow up the latest trends in pedagogy, to promote accessibility of such education that is based on the needs of individuals, and to enquire what knowledge, skills and competences teachers should improve.

The article proposes the practically implemented solutions for the further education problems of teachers, justifies the analysis, interpretation and assessment of the obtained results.

Materials and Methods

The study of teacher further education is based on the methodical principles and methods of action research applying particular case study. For analysis, qualitative and quantitative methods have been used – analytical review and empirically descriptive method of data acquisition to study and interpret teacher action, as well as the method of data grouping. Analysis of education related documents and assessment overviews of the work of teachers have been provided. Personal experience has been reflected as well. The obtained data have been analysed in accordance with the theoretical principles of the research.

The scientific article analyses theories that propose the awareness of the necessity to ensure a modern education process. The theoretical base of the research is developed basing on statements of different foreign and Latvian education researchers, psychologists as regards adult learning, as well as on macro-level documents such as the Declaration of UNESCO Education for Sustainable Development, the European Qualifications Framework for Lifelong Learning and education related laws of the Republic of Latvia. The sources used in the research were as follows:

- statements about the knowledge society in works

of foreign authors and Latvian scientists – M. Castell (2000), P.F. Drucker (1994), I.V. Nikishina (Никишина, 2007);
- theoretical studies of education improvement - J. Dewey (1994), A. Rauhvarger (Rauhvargers, 2003);
- polysemy of the notion of competence has been analysed using scientific approaches of several authors (Arnold, 1997; Keller and Novak, 1993; Maslo, 2006).

The research was carried out in 2010 within the framework ESF project 'Professional Education Teacher Training at the Latvia University of Agriculture', Contract No 2009/0283/1DP/1.2.1.1.2./09/IPIA/006. The article analyses issues related to the assessment of the need for further education, by general education teachers. To study the strategy of teacher further education and enquire the level of competence improvement, a survey was carried out summarizing assessments of 119 respondents on the implementation of further education courses and influence on the improvement of the work of teachers. The article theoretically and empirically analyses and summarizes the further education experience of teachers at the Centre for Lifelong Education of the Latvia University of Agriculture in 2009/2010.

In the survey, 119 teachers from all regions of Latvia took part. The respondents were asked to answer 11 questions related to the quality of further education courses, usefulness of the obtained education, organization of work, assessment of teachers performance by the attendants of study courses and other issues.

The analysis of the composition of teachers involved in further education reveals that the courses were attended by 128 professional education teachers – including 82 females and 46 males. The ages varied from 25 to 65.

MS Excel statistical functions, data grouping, as well as research methods of analysis and synthesis have been used to process and analyse the research data.

By the help of quantitative and qualitative research methods, the obtained data are arranged to compliment one another and thus ensure a more meaningful view of the research results. The conclusions have been drawn on the basis of logically constructive method.

Results and Discussion

Forming a democratic education area in the contemporary Europe, which corresponds to the tasks of the 21st century, education has to become a component of the process of qualitative changes. Not only is education the process and the final result, but it is also a resource for achieving personal aims and those of the society.

A competitive public development can be ensured by qualitative education and coordinated action of the teachers involved, which have obtained such learning experience that allows assessing situations comprehensively and act freely and adequately.

The Latvian National Development Plan knowledge is classified as a resource or growth. Our main resource to attain the public and individual standard of living typical of the developed countries is knowledge and wisdom of citizens, as well as proficient and purposeful application of knowledge and wisdom (Latvijas Nacionālās attīstības plāns 2007-2013, 2006). The Latvian National Development Plan emphasises that quality of education and willingness to learn are closely connected with the role of education in the general society and cognition of every individual together with the ability to adequately value the importance of education.

Putting forward knowledge to be the determinant resource for national growth, the human as the creator and carrier of knowledge becomes the main driving force and beneficiary of the development.

On a global scale, researches on education for sustainable development are especially topical in the latest years. In 2002, the UN General Assembly adopted a Resolution UN Decade of Education for Sustainable Development. The decade refers to the period of 2005-2014. Every individual should have opportunities to learn in order to expand their knowledge, skills and attitudes for being able to adapt to the changing, complicated and interrelated world (Education for Sustainable Development UNESCO, 2010).

Integration into the European Union common education area is provided for according to the European Qualifications Framework (EQF).

The documents emphasise the idea of the necessity to increase professional and research qualifications of teachers to develop a competence that ensures competitiveness no only on a European level, but also on a global level, thus promoting the increase of the prestige of teachers and other actors of the education field.

Change of the education paradigm represents a new education policy which devotes the leading role to the abilities of teachers to re-orientate for being able to work in changing conditions. The role of methodical, systematic and interdisciplinary knowledge of teachers rises substantially. Such knowledge is necessary for a reasonable and advised pedagogical activity. The knowledge society demands substantial changes in the contemporary pedagogical methods. Pedagogy needs to solve the problems of the rapidly changing society. In future, pedagogy as a science will be necessary for practice which is becoming increasingly complicated (Gudjons, 1998).

The philosopher J. Dewey (1994) linked education ideas with the ideas of a democratic society. He has stated that education is a social process. It indicates a certain ideal of the society, a certain model of life of the society.

Changes in the society are linked to changes in the cognition of teachers, their lifestyle ad reconsideration of values. A teacher has to be an active personality that is interested in creative thinking, self-development, improvement of the education environment, as well as is willing to do all of it purposefully. Education is an essential instrument for the development of individuals, society and state.

Analytical thinking skills, the capability of teamwork, independence, self-initiative, professional, methodical and

personal competence tend to become of increasingly higher importance (Aizsila, 2009).

The requirements for the level of proficiency and its development of teachers become increasingly multiform and complicated, as they need to catch up with the rapid acquisition of knowledge, different study approaches, as well as they need to be open for innovations. Today education is not only teaching and learning, but it comprises also lifelong education, mobility, integration, further education, self-assessment and other branches. Establishing a democratic education area in the contemporary Europe, development of the society, social cohesion, the ability to change and develop is necessary (Izglītības attīstības pamatnostādnes 2007-2013).

During the learning process, experience is gained in the centre of which active human activity and individual knowledge construction and application is put according to personal needs, interests and aims. The notion 'experience' is understood as the subjective reflected knowledge, skills and attitudes towards the action. The reflected experience is a new state of readiness for action (Luhmann, 1990).

The opportunities of obtaining qualitative education and improving it on a regular basis are largely connected with the national education policy enforced by provision of appropriate documentation and, especially, implementation in the reality.

Every particular period of time puts forward certain requirements for the human professional activity. The teacher profession is one of the most complicated and responsible fields of professional activity, as the job of teachers influences the lives, value orientation and the need for self-realization of lots of people (Aizsila, 2008).

Today there are lots of debates abut the education quality, teacher professional competence, prestige in the society and attraction of new teachers to the education institutions. Within the pedagogical discussion, the notion of competence is topical, as scientific literature presents diversity of views as regards the understanding, interpretation of competence.

F. Orthey (2002) points out that the application of the notion of competence in everyday life encourages perceiving it as an ability that ensures a better, more qualitative action in order to achieve aims of personal importance. This understanding reveals the positive opportunity of the individual to act under specific conditions in different situations of life, and competence is referred to as an ability which can be developed and improved continuously.

Competence is the readiness and ability to perform certain actions which require knowledge and skills for an adequate action in a particular situation (Keller and Novak, 1993).

R. Arnold (1997), in turn, emphasises the link of the notion of competence with the subject of action, and indicates the fact that the notion of competence should be viewed according to the approach of personality entirety, the ability for self-organization of a subject, as well as the fact that competence can be developed. According to the above mentioned, the notion of competence comprises comprehensive, principally unlimited positions of individual activity.

Competence is the one to determine the twofold human nature – the individual abilities to apply and improve what has been acquired. It is related to a set of abilities to be acquired during activity and can be improved continuously (Habermas, 1981). Competence encompasses the necessary knowledge, professional experience, understanding and ability to apply the knowledge in certain activity (Pedagoģijas terminu skaidrojošā vārdnīca, 2000).

Studying the notion of competence, it can be concluded that it is related to personality autonomy, conscious activity, as well as interactions within the personality socialization processes. Competence should be perceived as a procedural, integrative principle that encompasses the cognitive, psychical and social aspects of human activity. It can be discovered and assessed only within activity – creative realization of multiform situations – the education process, performing the duties, solving extraordinary problem situations, communication with others. Competence expresses a justified proficiency, responsibility for ones own actions and the ability to make decisions. According to the above mentioned, it can be concluded that competence is a combined notion with a comprehensive content. The level of competence indicates the individual abilities to create and apply knowledge innovatively.

From the theoretical analysis, it can be concluded that teacher professional development is an important factor for the development of the society. When education funding from the state budget is cut, the necessity arises to find resources for professional development apart from it. Latvia as an EU member state is invited to make use of one of such opportunities – encourage teachers to participate in international turnover, for example, projects, exchange of experience in other countries, as well as teachers can attract additional resources from the European structural funds.

There are lots of discussions about teacher qualification, knowledge, improvement of skills and competence. Education for qualitative professional development is ensured by a scrupulously elaborated further education strategy which corresponds to the proposed aims and tasks. When choosing a strategy, it is necessary to consider the possibilities and needs of the target group, course parameters – tasks, content, duration, organizational forms of studies and the expected result.

When obtaining further education, teachers face new pedagogical conceptions, technologies, methods, novelties of study subjects as regards development and use of e-resources and other issues. Acquisition of knowledge, development of thinking skills, activity, growth, obtaining of experience are considered to be important aims. D.Prett (2000) believes that interrelationship is the most important driving force for human growth, but direct personal experience is the most effective type of studies.

Those that work in the education system have the opportunity to expand their knowledge during studies in

further education study programmes organized by Centre for Lifelong Education of the Latvia University of Agriculture. The article analyses the development of competences of teachers working in the field of professional education within the general education block.

One of the questions asked was as to find out why the respondents had chosen to attend further education courses.

The majority of teachers – 79 (66%) - state that they attend further education courses to improve their professional skills. Other reasons – 15 respondents (12%) are connected with improvement of professional skills, requirements of the employers, involvement in ESF project, acquisition and strengthening of knowledge – 27 respondents (22%).

As regards the question about whether the aim of the course programmes had been achieved, 87 (73%) of the teachers gave a positive answer 'yes', but 33 (27%) of the respondents indicated that the aim was achieved partly.

The question whether the attendants had had an opportunity to actively participate in the implementation of the courses, 116 (97%) of the teachers answered with "yes', but 4 (3%) of the teachers stated that they had had such an opportunity partly.

A wide choice of forms of studies was proposed, and the respondents were asked to indicate three the most suitable forms of studies (Figure 1).

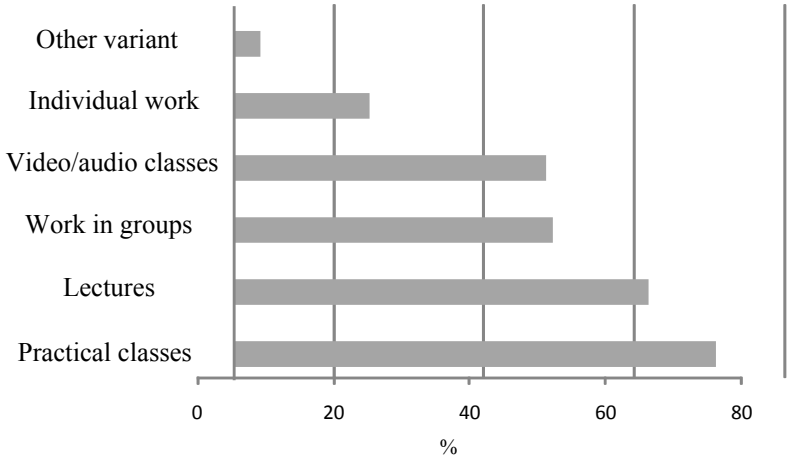

Figure 1. Most suitable forms of studies, %.

The respondents were asked to answer where they would apply the knowledge acquired in the further education courses. Some of the responses included the following: in the improvement of the study process of the subjects taught (32 respondents), in pedagogical work (31 respondents), in life and everyday activities (26), in self-development (15), in Master's thesis (10).

The feedback of teachers as regards the methodical materials, quality of courses and assessment of work is reflected in Table 1. The respondents were proposed four criteria to assess the implementation of the further education courses.

Table 1

Assessment of methodical materials and implementation of the courses

Methodical material and implementation	Assessment, %			
	Very good	Good	Average	Poor
E-learning materials	53	44	3	-
Usefulness of information	39	55	6	1
Organization of the courses	56	39	5	-
Microclimate of the courses	80	17	3	-

The organization and implementation of the further education courses were generally assessed as very good and good. Competence of teachers was assessed as very good by 92 (82%) of the respondents, but the attitude towards the attendants was praised by 111 (93%) of the respondents.

Interest was attracted by the new communication opportunities of e-learning. The attendants indicated, in their suggestions, that it would be useful if an information technology specialist could be present during the classes as well. It was recommended that the courses should be organized according to regional principles and within shorter periods of time. The teachers express their willingness to meet representatives of from the Ministry of Education and Science.

The obtained data allows concluding that it is important for teachers to improve their knowledge, skills and competences as regards the subjects they teach.

Conclusions

1. Teacher further education is oriented towards the introduction of the latest information technologies in education, increasing the quality of education, as well as formation of an educated society.
2. Education is influenced by common development tendencies of the society – the socially economical and demographic situation in Latvia.
3. Further education and improvement of further education is one of the priority directions of the European education strategy. Teacher professional mastery can influence the quality of the education process, as well as achieve the aims and tasks of the education institutions.
4. The results of the research justify the positive effect of the further education study programmes of the Centre for Lifelong Education of the Latvia University of Agriculture on the development of the competence of teachers. The teachers strengthen and expand their knowledge, skills and develop their professional competence which is manifested by the improvement of education quality.
5. Teachers should be open for innovations in order to ensure the competitiveness of education, as well as correspondence of education to contemporary requirements. The financing of European Union structural funds for education and science is planned so as to achieve the strategic aim of the Latvian National Development Plan – to promote a balanced, knowledge-based and sustainable development.

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