RĒZEKNES AUGSTSKOLA
INŽENIERU FAKULTĀTE

REZEKNE HIGHER EDUCATION INSTITUTION
FACULTY OF ENGINEERING

VIDE. TEHNOLOĢIJA. RESURSI.

V Starptautiskās zinātniski praktiskās konferences materiāli
2005.gada 16. - 18.jūnijs

ENVIRONMENT. TECHNOLOGY. RESOURCES.

Proceedings of the 5th International Scientific and Practical Conference June 16 - 18, 2005

Rēzekne
2005

ISBN 9984 – 779 – 06 – 8

VIDE. TEHNOLOĢIJA. RESURSI: 5.starptautiskās zinātniski praktiskās konferences materiāli 2005.gada 16. - 18.jūnijā. - Rēzekne, 2005. - 338 lpp.
ENVIRONMENT. TECHNOLOGY. RESOURCES: Proceedings of the 5th International Scientific and Practical Conference June 16 - 18, 2005. - Rezekne, 2005. - 338 p.

ISBN 9984 – 779 – 06 – 8
Tirāža 80 eks.

Zinātnisko rakstu krājumā iekļauti V starptautiskās zinātniski praktiskās konferences "Vide. Tehnoloģija. Resursi" referāti. Referātu tematika saistīta ar vides aizsardzības problēmām, teoriju, praksi un pieredzi vides aizsardzībā, vides kvalitātes parametriem, to kontroli, novērtēšanu un izmantošanu, dabas resursiem, cilvēka ekoloģiju, ekoloģijas un kultūras attiecībām, ekoloģisko izglītošanu, pārstāvēti referāti, kas ir saistīti ar datorzinātņu un matemātikas pielietošanu vides un citu nozaru problēmu risināšanā.

Proceedings include papers presented at the 5th International Conference "Environment. Technology. Resources." The themes of the papers are – the environmental problems, theory, practice and experience in environmental protection, environmental quality parameters and their control, assessment and improvement, natural resources, ecology of human nature, ecology and culture, ecological education. A separate section of the conference includes papers on applications of computer science and mathematics for solution of environmental and other problems.

RA Izdevniecība, 2005
Atbrīvošanas alejā 115, Rēzeknē, LV 4601

SATURS

INFORMĀCIJAS TEHNOLOĢIJAS UN MATEMĀTISKĀS METODES VIDES ZINĪBĀS

ILGTSPĒJĪGĀS LAUKSAIMNIECĪBAS PROBLĒMAS

ISBN 9984 – 779 – 06 – 8

VIDES KVALITĀTE UN AIZSARDZĪBA

ISBN 9984 – 779 – 06 – 8

VIDI SAUDZĒJOŠĀS TEHNOLOĢIJAS

ISBN 9984 – 779 – 06 – 8

CONTENT

IT AND MATHEMATICAL METHODS IN ENVIRONMENTAL SCIENCES

PROBLEMS OF SUSTAINABLE AGRICULTURE

ISBN 9984 – 779 – 06 – 8

ENVIRONMENT QUALITY AND PROTECTION

ISBN 9984 – 779 – 06 – 8

ENVIRONMENTAL FRIENDLY TECHNOLOGIES

ISBN 9984 – 779 – 06 – 8

INFORMĀCIJAS TEHNOLOĢIJAS UN MATEMĀTISKĀS METODES VIDES ZINĪBĀS

INFORMATION TECHNOLOGIES AND MATHEMATICAL METHODS IN ENVIRONMENTAL SCIENCES

ISBN 9984 – 779 – 06 – 8

APPLICATION OF MATHEMATICAL MODELS FOR THE SIMULATION OF THERMAL COMFORT CONDITIONS IN A LIVING ROOM

MATEMĀTISKO MODEĻU LIETOJUMI DZĪVOJAMĀS TELPAS TERMISKĀ KOMFORTA APSTĀKĻU MODELĒŠANAI

STAŅISLAVS GENDELIS, ANDRIS JAKOVIČS

Laboratory for mathematical modelling of environmental and technological processes,
Faculty of Physics and Mathematics, University of Latvia
Zeļļu Street 8, Rīga, LV 1002, Latvia
Phone: + 371 7033783, *fax*: + 371 7033781, *e-mail*: stasis@modlab.lv, http://www.modlab.lv

Abstract. *The paper deals with the distributions of temperature and averaged turbulent airflows in living rooms in 2D and 3D approximations using Ansys/Flotran and Ansys/CFX software respectively. The distributions are calculated depending on the placement and temperature of heaters, heat transfer coefficients of the building structures and ventilation conditions. The authors analyse the influence of these factors on the air circulation and the related heat flows through building structures. The thermal balance of a room and its dependence on various external factors is also considered. As thermal comfort conditions' parameters are analysed, the airflow velocities and indoor temperatures with its gradients. It is shown that it is possible to save heating consumption, at the same time maintaining the conditions of thermal comfort in the room.*

Keywords: *Mathematical modelling, thermal comfort conditions, living rooms, temperature, airflows, heating, heat consumption, heat losses.*

Introduction

The placement of the heaters and their operating temperature essentially influence the distribution of temperature in the living rooms. Such a distribution strongly depends on the behaviour and intensity of airflows, which determine the thermal convection, controllable and uncontrollable heat fluxes through the openings of ventilation and gapes in the room's walls (e.g. crannies in window-frame), as well as heat transfer through windows, floor and ceiling. Under such conditions the heat consumption for maintaining thermal comfort increases essentially, which, in turn, leads to an increase in the heat transfer coefficient U (W/m^{2}K) of heat transfer through boundary constructions, especially through the external wall [1].

Heat transfer in a thermal boundary layer essentially increases with growth of heat flux through structure and airflow intensity near it. As a result, the thermal resistance (R_i) of boundary layer can considerably differ from the standardized value [2] for vertical indoor boundary layer R_i = 0,13 m^{2}K/W. It is possible to regulate the intensity of airflows at the vicinity of boundary surfaces and corresponding thermal resistance by choosing an appropriate placement for heating facilities and ventilation openings, as well as by adding windowsills to the windows.

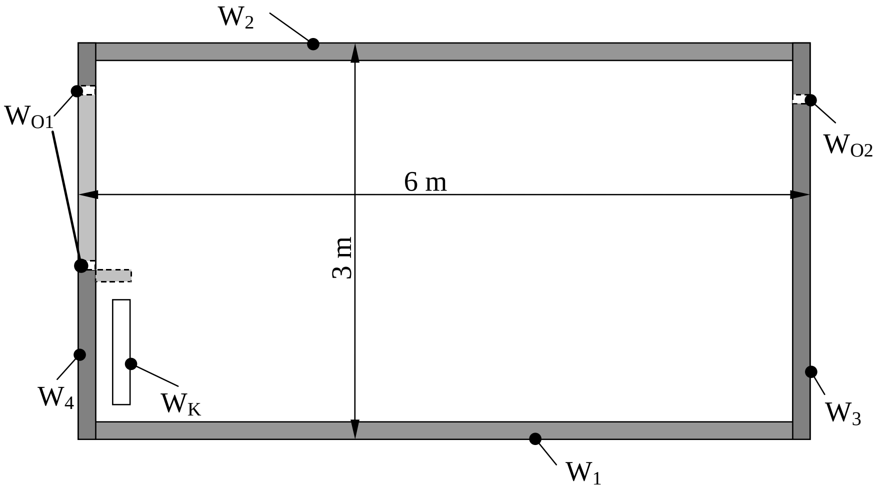
In such a way it is possible to reduce the coefficient of heat transfer and the total heat leakage of the building at a fixed heat transfer coefficient of the building structure. However, in case of great heat conductivity of walls and delayed air circulation (e.g. room's nooks), heat exchange there may be reduced, what is the reason for a decrease of the surface temperature – the dew-point and water condensation can be achieved there. Adverse thermal comfort conditions in a room are notably defined by uncontrolled airflows from openings in the window-frame; this usually is the cause of increased total heat losses.

Person's feeling of comfort is fundamental impressed by velocity of airflows, absolute temperature and amplitude of the vertical temperature gradient in the room. The optimal arrangement of heaters, accordant packing of window-frames and installation of controllable venting system allows maintenance of thermal comfort in the living room with reduced heat consumption. Influence of above mentioned factors is effective and detailed analysed by use of mathematical modelling approach.

ISBN 9984 – 779 – 06 – 8

Materials and methods

The calculations have been performed for the room shown in Fig. 1 filled with air. Only one of the walls (W_4) has a window and a boundary with the exterior air. Heat transfer coefficient for outer wall is 0,35 W/m^2K and it corresponds to building requirements established in Latvia [2], but for window it is 2,5 or 6,0 W/m^2K depend upon modelling variant. The problem is simplified assuming that the considered room is one of many, i.e., the heat flow through the side walls is practically absent. On walls convection boundary conditions are set with according surface heat transfer coefficients [2]. The temperature in the room above and below the floor is chosen from the condition of thermal comfort, T=20°C, while the temperature behind the wall W_3 is chosen essentially lower: T=15°C (e.g. in the hallway). The exterior temperature behind the outer wall W_4 corresponds to winter conditions, T=-10°C. The surface temperature of the heater (W_K) is set to constant 50 or 60°C. Crannies in window-frame (W_{O1}) and ventilation system's opening (W_{O2}) as well as windowsill is geometrically created only in several modelling variants and there opening boundary condition with constant pressure is defined.



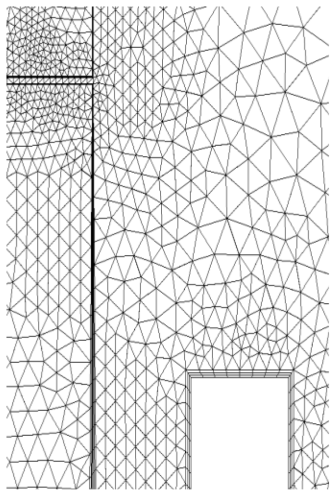


Fig. 1. **Layout of building structures in a room and illustration of discretisation**

The airflow in the room depends both on the convection created by the temperature difference and on the air exchange between openings in building structures (openings, ventilation system, etc.). To determine airflow characteristics, the following dimensionless numbers are employed [3]:

- Reynolds number, $\mathrm{Re} = v_0 L / \nu$ (v_0 is the characteristic velocity, L is the characteristic size and ν is the cinematic viscosity). Simple calculations show that in our case the Reynolds number is approx. 10^4, which corresponds to the turbulent airflow character;
- Peclet number, $\mathrm{Pe} = vL/a$ (a is the temperature conductivity). In current model it is approx. 10^5, which means that in the heat exchange there dominates convection;
- Prandtl number, $\mathrm{Pr} = \nu / a$. In the case of turbulent airflow the turbulent number (Pr_T) should be used. In our calculations Pr_T = 0,85 was used.

To describe the quasi-stationary behaviour of temperature and averaged turbulent flows, traditional differential equations are employed [4]:

- Reynolds averaged momentum equation;
- continuity equation;
- equations for specific turbulence energy k and dissipation rate of this energy ε;
- energy conservation equation.

The turbulent viscosity ν_T is calculated by using the k-ε turbulence model under traditional boundary conditions [5]: $\nu_T = c_\nu k^2 / \varepsilon$, where c_ν = 0,09 is an empirical constant. The temperature distribution should be determined both inside the room and in the building structures, because

ISBN 9984 – 779 – 06 – 8

the convection type boundary conditions $\lambda \cdot \partial T/\partial n = \alpha(T - T_\infty)$ are set for the temperature at the outer boundary of these structures. The solar heat radiation through the window is ignored in order to simplify the model. In the case of a model with openings there is airflow from/to the outside thanks to pressure boundary conditions at openings. For all surfaces, except openings, non-slip boundary conditions ($v = 0$) are used.

For the numerical modelling the software package Ansys/Flotran and Ansys/CFX was applied to obtain both the stationary temperature distribution and averaged airflows in the approximation of the k–ε turbulence model. The discretisation was performed with triangular elements of varying size; boundary layers are discretised with smaller hexagonal elements. The size of finite elements is from 10 cm in the middle of the room till 1 mm in the vicinity of the heater and the openings in the walls. Therefore, the total number of elements depending on geometry and the modelling variant varies from 0,5 to 1,2 millions. An example of finite elements discretisation near the heater and wall is shown in Fig. 1.

The boundary conditions of the third type (convection from walls to the outside and to other rooms) for temperature on all surfaces of building structures and the low viscosity of air essentially worse the convergence of iteration process. The time required for calculations with a 3 GHz computer for 2D variant is 15–25 hours and for 3D variants – up to 80 hours. The difference between the heat amount from heater and the heat losses from the outer surfaces and openings of the building decreases below 10% during each simulation.

Results and discussion

Some variants of the modelling should be considered, which evidently show the impact of particular changes in the geometry and heat exchange conditions on the physical fields, characteristic values of temperature and airflows. In this way thermal comfort conditions can be analyzed.

1. Adding the windowsill and reducing of heat conduction (variants 1-1 and 1-2).

In a room without windowsill and great heat conductivity of window (U=6,0 W/m^{2}K, one-glass window analogue) the airflow from the heater is directed upwards (Fig. 3a). In this modelling variant (1-1) heat transfer coefficient for window is chosen very high to qualitatively illustrate the exchange process. As one can see, the flow of warm air from heater's surface with temperature of 60 °C is moving to the window where the intensive heat exchange takes place thanks to low temperature near the window. Characteristic thermal comfort factors and according heat losses is shown in Table 1 – the average temperature in this room with relatively high heater's temperature is about 18 °C and average velocity in whole room is up to 25 cm/s. As one can understand, the highest values of airflows are close to inner surface of the window, in the middle of the room flows are about some centimetres per second. In its turn, the greatest heat leakage is connected with outer wall and window – approx. 80% of the total losses. It is clear that in this type of rooms the thermal comfort conditions as well as economy of heating power is not reached.

One of the ways to reduce the heat losses is to increase the thermal resistance of the wall and the window, thus reducing the temperature gradient and thermal losses. Another way is to change the geometry in such a manner that the airflow was mechanically deflected from external boundary structures. For example, it can be realised by employing of windowsills.

ISBN 9984 – 779 – 06 – 8

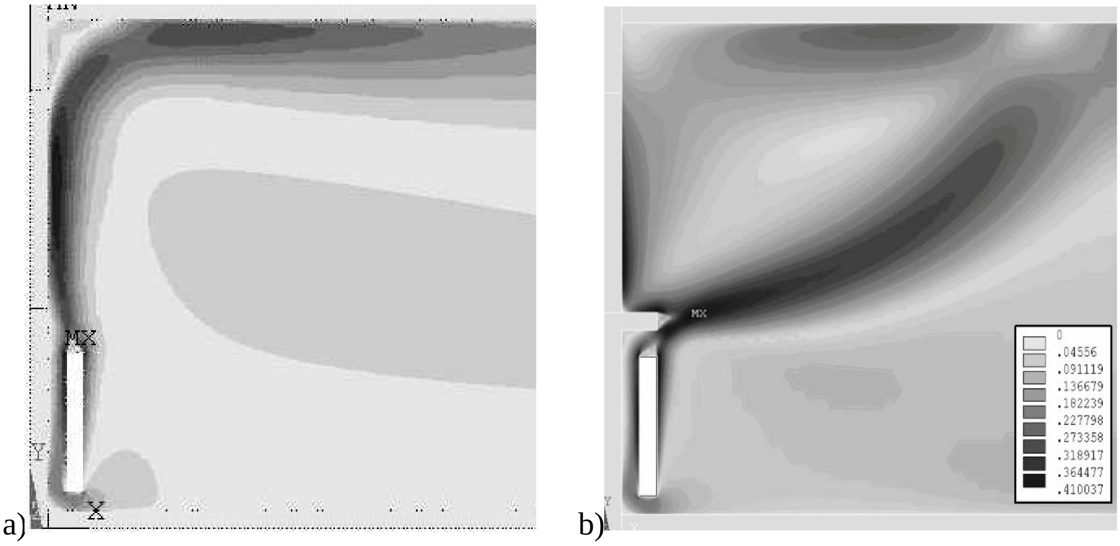


Fig. 3. **Stationary distribution of the velocity modulus in the modelled room. Images (a) and (b) correspond to variants 1-1 and 1-2 respectively**

Distribution of airflows and their behaviour in the variant with the windowsill and better isolated wall and window (1-2) is shown in Fig. 3b. The windowsill now serves as a mechanical barrier for the airflow and provides flow of the warm air in the centre of the room. A high velocity of air is observed near the surface of the window, which is attributed to the high horizontal gradient of temperature $\partial T / \partial x$ in this place, as the window is the most powerful heat conducting element in this model. Considering the motion of the air at the upper part of the convector, one can see that it is directed to the centre of the room, but relative inactive masses of warm air are present directly under the windowsill. Distribution of temperature in the area of the windowsill is shown in Fig. 4.

Table 1.

Characteristic factors and heat losses for different modelling variants

Modelling variant	Pressure difference between opposite walls ΔP [Pa]	Average temperature in the room T [°C]	Average velocity in the room v [m/s]	Average velocity v [m/s]		Heat losses through surface Q (normalized to 1 m width room) [W]				
				in the window-frame	in the ventilation opening	W_1+W_2	W_3	W_4	$W_{O1}+W_{O2}$	Total
1-1	-	18	0,25	-	-	14	27	156	-	186
1-2	-	26	0,15	-	-	8	28	118	-	154
2-1	0	22	0,1	0,13	0,10	6	6	80	34	126
2-2	5	1,5	0,32	2,3	0,47	-50	-10	19	337	295

If the heat transfer coefficient of the window is high and airflow is deflected from it, e.g., by the windowsill, then the temperature of the inner surface of the window can considerably decrease, as a result, the temperature difference between this surface and the air in the room increases thus leading to a risk of condensate formation.

ISBN 9984 – 779 – 06 – 8

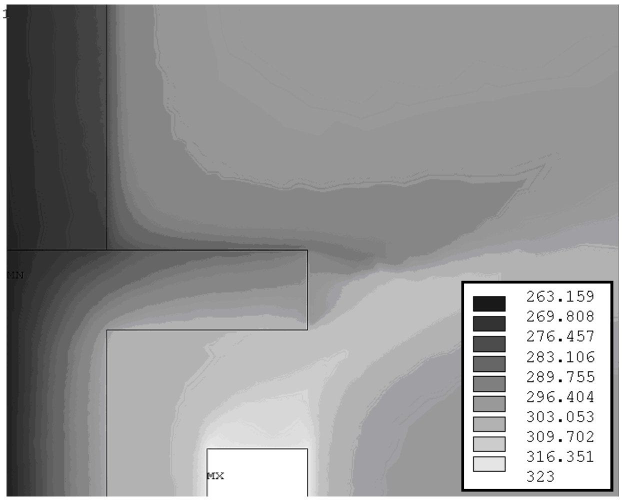


Fig. 4. **Temperature distribution near heater and windowsill in modelling variant 1-2**

As the flow of warm air deviates from the window, where the greatest thermal losses are observed, the average temperature in the room also increases. The temperature in this variant is 26°C (against 18 °C in variant 1-1). Thus, the general thermal requirement is also reduced (Table 1) – heat losses through external wall and window become only 75% from losses in variant 1-1. The mentioned temperature cannot be considered comfortable for people; however in real living rooms it is lower owing to convective thermal losses by air exchange. The maximum air velocity in the middle of the room is changed in comparison with variants without a windowsill and it not reaches 15 cm/s.

Detailed analysis of modelling results for living rooms with different boundary constructions' heat transfer coefficients, varying heater surface temperature, geometry configurations and corresponding comparison of heat balances is scribed in publication [6].

2. Convective heat exchange through openings in the walls (variants 2-1 and 2-2).

In the previous variants a closed room without openings for air exchange was considered. However, in reality, rooms are not isolated from environment and the airflows compensate the consumed oxygen that is necessary for breathing. Therefore, the following designed models include openings in the boundary structures (W_{O1} and W_{O2} in Fig. 1.) which provide the air circulation. Thus, there are also additional thermal losses that have not been taken into account in the variants considered above.

To demonstrate influence of crannies in low-quality windows packing on total balance and on thermal comfort conditions, two air exchange modelling variants with different boundary conditions are considered and analysed:

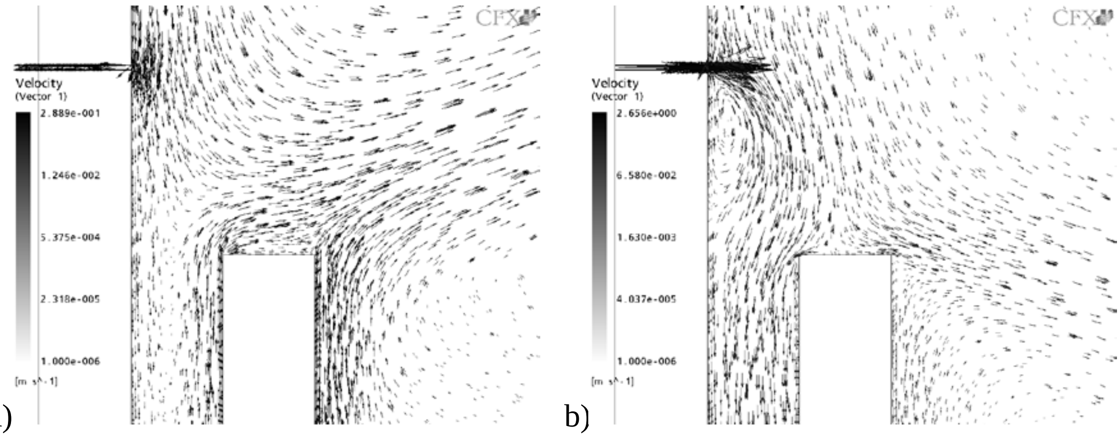
- with 0 Pa pressure difference, which is the case when between the opposite walls of the room there is no pressure difference;
- with 5 Pa pressure difference. A case is considered when outdoor air pressure is higher than in the ventilation opening. This is frequent situation for real buildings.

The location of two outer openings in the model is between the window and the wall. The sizes of openings should be small to correspond to the real room situation. In the model, 5 mm openings are employed. In the opposite wall one more opening is modelled which corresponds to a 2,5 cm wide ventilation system's opening. On the lines in openings that delimit the room from the environment, the pressure values are taken 0 and 0 or 0 and 5 Pa respectively, as well as the temperature equal to T_∞=-10°C on W_{O1} and T_∞=15°C on W_{O2} assumed for the corresponding surface under third type boundary conditions. To allow flowing of air through openings, non-slip conditions are not used on these lines.

In contradistinction to previous models with one-glass window, in variants 2-1 and 2-2 window with two glasses is used (U=2,5 W/m^{2}K) and no window-sill is created. As a result heat conduction losses trough it are reduced, hence total heat losses to outside decreases too (Table 1). Although cold outer air flows through crannies in window-frame exists even in case with 0 Pa pressure difference, thermal comfort conditions (temperature about 22°C and maximal airflow intensity in the openings is less than 15 cm/s) in a room are reached with heater's constant surface temperature 50°C. It is very essential that in this case, when conditionally calm weather outside room is set up, the fresh air flow necessary for breathing is provided; at the same time openings do not generate extra heat losses by convection.

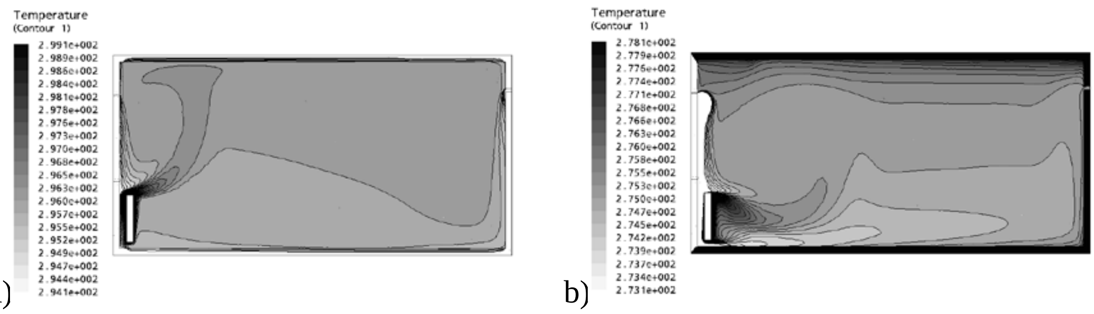
ISBN 9984 – 779 – 06 – 8

However, situation radically changes in model with ΔP=5 Pa (variant 2-2). In this case maximal airflow velocity in openings reaches 2,5 m/s and they are also intensive near heater. At the same heater's temperature (50°C) heat convection from its surface is increased more than 2 times thanks to high velocities of airflows in the room and significant low average temperature in it – only 1,5°C at outside air temperature -10°C (Table 1). Heat conduction losses through walls in this variant are only 7% and the room is heated by neighbouring rooms with constant temperature 20°C. Except for grown heat consumption, comfort conditions in this room become absolutely unsuitable for human living.
Moreover, character of air circulation between the outer wall and the heater radically changes – in case with insignificant air inflow (variant 2-1) there dominate upward airflows. However in variant 2-2 downward cold air flows from crannies in window-frame are determinant (Fig. 5). Such character of airflow substantially amplify vertical temperature gradient in the room in comparison with variant 2-1 – the floor is additionally cooled, but relatively warm air layer is remained only near the ceiling (Fig. 6); in this case thermal comfort conditions in the room are explicit uncongenial. Above mentioned analysis shows how conditions in the room are affected by uncontrolled air inflows trough crannies in the window-frame, e.g. temperature and airflows inside the room can be radically changed by the wind intensity and direction outdoors.



a) b)

Fig. 5. **Vectors of airflow near the outer wall and heater in variants 2-1 (a) and 2-2 (b)**



a) b)

Fig. 6. **Temperature distribution in a room in variants 2-1 (a) and 2-2 (b)**

Summary of characteristic average temperatures in the whole room (include air in the openings) and corresponding heat requirements for all modelling variants are shown in Fig. 7. As one can see, heat requirement in variant 1-2 is reduced at the same time average temperature in the room grows compared to variant 1-1. But 5 Pa pressure difference in variant 2-2 critical levels down the temperature and increases necessary heat amount up to 2 times in comparison with variant 2-1.

ISBN 9984 – 779 – 06 – 8

3. 3D modelling

3D modelling, which is more numerical capacious for calculus than 2D modelling, allows to realize more exact model and accurately disclose and analyse the heat exchange processes in a real room. In a spatial modelling it is possible to visualize some effect that is not possible in 2D models – e.g. air inflow distribution through crannies in the window-frame is noticeably spatial. The outside pressure value is set to 1 Pa in this modelling variant (3-1) and on ventilation it is set to 0 Pa, thereby total pressure difference ΔP is 1Pa, what agrees with real natural conditions with slow breeze outdoors. Because of outdoors overpressure the air flows in through 5mm tight opening and the its velocity reaches 1,5 m/s. The velocity decreases farther from wall and is less than 10 cm/s in the middle of the room – isosurface with absolute velocity value of 0,55 m/s is visualized in Fig. 8a.

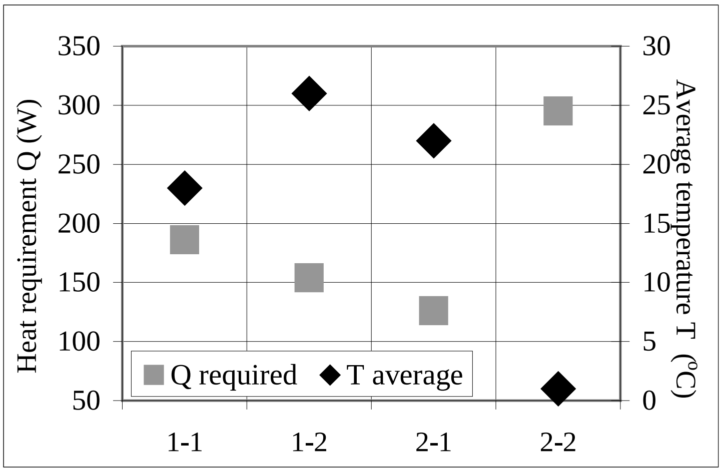


Fig. 7. **Characteristic average temperature and velocity in the middle of a room**

The window-sill greatly blocks hot airflow from heater, thereby air temperature near window's surface with heat transfer coefficient U=2,5 W/m^{2}K is noticeably lower than surface temperature of wall with U=0,35 W/m^{2}K. The temperature near air inflow area is considerably lower – isosurface with temperature of 7°C demonstrates that lowest temperatures exist in lower corners of window where greatest air velocities (Fig. 8b) are present. Relatively dense air after inflowing through opening continues to move down along edges of the window-sill.

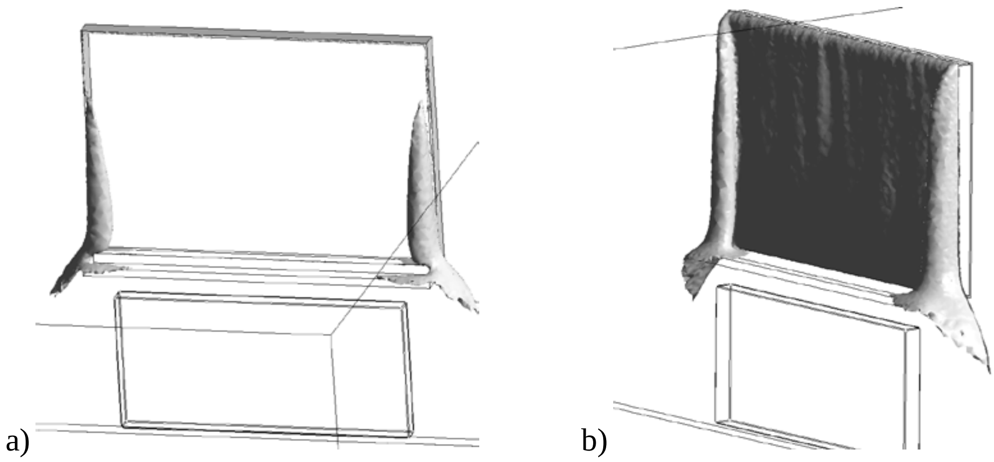


Fig. 8. **Isosurfaces of v=0,55 m/s (a) and T=7°C (b) for modelling variant 3-1**

The air exchange intensity near the upper part of window is noticeably lower – this is due to impact of two processes. One of them is aforesaid pressure difference that promotes outdoor's air inflow. Other process is determined by convective airflows along window surfaces:

- indoors warm air becomes cold near window with great heat conductivity and moves down along its surface, in that way it generates traction for cold outdoors air inflow trough crannies in the lower part of window-frame;
- at the same time outdoors air becomes warm near outer window surface and moves up, what helps to create additional traction for air outflow in the upper part of the window.

ISBN 9984 – 779 – 06 – 8

If there is not an extra pressure difference then typical vertical temperature distribution develops in a window, as well as air outflow appears in the upper part of openings and inflow appear in the lowest section. Aforementioned situation may change if there is no window-sill present which helps to prevent direct airflow from the heater.

Conclusions

The 2D and 3D calculations of airflows and temperature distribution in a living room show the influence of rearrangement of structural elements of a room on the character of airflow velocities and its directions in this room. As shown, it also influences the temperature field distribution, because of the heat exchange variation conditions near the building structures.
Openings in the room's walls lead to convective heat losses, which through pressure difference radically change the physical fields' distribution in the room. In this case additional convective heat losses arise, which are usually greater than those by heat conduction. The distribution of heat losses for rooms is confirmed by measurements of such parameters as airflow velocities and temperatures in different places of the room.
The above-mentioned modelling method enables to choose (in the design stage) appropriate structural elements adequately - either of the building or its separated rooms – that have the desired values of thermo-technical parameters. The model of a separated room shows the influence of various kinds of factors on the resulting distributions of thermo-physical parameters in the room that are directly related to the conditions of thermal comfort. Since the model allows, at the same time, the heat consumption to be reduced, its use may help to reduce energy production and the related pollution.

Acknowledgements

The authors would like to acknowledge *PAIC Ltd.* for offered modelling software
This paper is supported by *the European Social Fund*

References

1. Jakovičs A., Jēkabsons N., Mühlbauer A., Trümmann H. Bestimmung des effektiven Wärmedurchgangs-koeffizienten von Bauelementen unter praxisnahen Bedingungen. Elektrowärme International A2, 1997.
2. Latvian building normative LBN 002-01 „Ēku norobežojošo konstrukciju siltumtehnika", 2002.
3. Мухачов Г., Щукин В. Термодинамика и теплопередача. Москва. Высшая школа, 1991.
4. Седов Л.И. Механика сплошной среды. Том I. Москва, 1976.
5. Frost W., Moulden T.H. Handbook of Turbulence. Fundamentals and applications. Vol.1. New York, 1997.
6. Gendelis S., Jakovičs A. Numerical modelling of airflow and temperature distribution in heated rooms. Latvian Journal of physics and technical sciences. 2003, N 3.

ISBN 9984 – 779 – 06 – 8

THE PROBLEM OF MINIMIZATION OF AN UNEVEN FUNCTION OF SEVERAL VARIABLES IN THE NORM l_1 AND l_∞ BY MEANS OF NEURAL NETWORKS

VAIRĀKU ARGUMENTU FUNKCIJAS MINIMIZĀCIJA l_1 UN l_∞ NORMĀS AR NEIRONU TĪKLU PALĪDZĪBU

JÓZEF GIL

University of Zielona Góra, Department of Civil and Environmental Engineering
65-246 Zielona Góra, Poland
Phone: + 4868 3282416, *fax*: + 4868 3247292, *e-mail*:J.Gil@ib.zgora.pl

Abstract. *The paper presents the problem of the minimization of an uneven function of several variables $F: R^m \to R^n$. In general, the minimization of an uneven function is difficult in terms of numerical application, especially when there is no information about the character of the unevenness of the function or any precise data about the distribution of observation errors. This paper presents two algorithms for the minimization of an uneven function by means of neural networks: solutions to an overdetermined system of linear equations according to the criteria of the norm l_1 and according to the criteria of the norm l_∞ (the Chebyshev norm) with the use of a square and exact penalty function. The results of particular solutions have been compared with the solution via the method of the least squares. The equalization tasks have been performed with minimum restrictions of extents of freedom.*

Keywords: *minimization of an uneven function in the norm l_1 and l_∞.*

Introduction

In a wide class of technical and scientific problems, especially in terms of the equalization of geodesic observations, the most frequent procedure for the estimation of the components of the parameters vector of linear models (Gauss-Markov models) is the method of the least squares. The use of the average-square solution to systems of linear equations with a specific redundancy, optimum in terms of the norm l_2 is closely connected to the assumption that observation errors are subject to the Gauss distribution.

Although, the average-square solution often effectively leads to the solution in other norms [3], research into robust statistics proves [5] that for the distribution of errors subject to uniform distribution, the most suitable criterion for minimization is the residuum norm $\|\boldsymbol{v}\|_\infty$ called the Chebyshev norm, and for the Cauchy distribution the optimum minimization criterion is used in the form $\|\boldsymbol{v}\|_1$. Moreover, the norm $\|\boldsymbol{v}\|_1$ is preferred when there is not enough information about the distribution of errors.

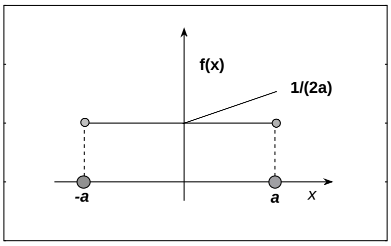


Fig. 1. **The density of a uniform distribution**

A uniform distribution (fig. 1), within the range of $[-a, a]$ is called distribution density.

ISBN 9984 – 779 – 06 – 8

$$f(x)=\frac{1}{2a} \qquad \text{for } |x| \le a \qquad (1)$$

and

$$f(x)=0 \qquad \text{for } |x|>a \qquad (2)$$

The desity of probability for the Cauchy distribution centered at the origin of the system has the form

$$f(x)=\frac{1}{\pi}\frac{t}{t^2+x^2}, \qquad (-\propto < x < +\propto) \qquad (3)$$

where $t>0$ is the scale parameter. The diagram of the density of the Cauchy distribution (fig. 2) resembles the diagram of a normal distribution, but it approximates the x axis very slowly.

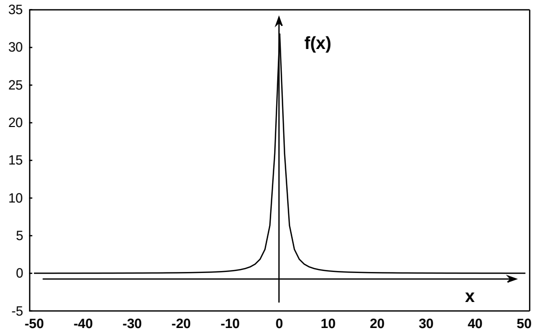


Fig. 2. **The density of the Cauchy distribution**

Because of the fact that it is difficult to determine the distribution density of the probability of the random vector which burdens the observation vector, the alternatives to the method of the minimization of the sum of the squares of corrections to the observation are the method of the minimization of the sum of modules (the minimization of the norm $//\boldsymbol{v}//_1$) and the method of minimax (the minimization of the Chebyshev norm $//\boldsymbol{v}//_\propto$). Up till now the abovementioned methods have been used mainly in procedures for the estimation of parameters of non-differentiable functions.

The purpose of this paper is to show the possibilities of determining the estimator $\hat{\boldsymbol{x}}$ of the vector of parameters $\boldsymbol{x}$ and the residuum $\boldsymbol{v}=\boldsymbol{A}\hat{\boldsymbol{x}}-\boldsymbol{l}$ of the linear model $\boldsymbol{Ax}\cong\boldsymbol{l}$ by means of neural networks according to the criterion in the form of the minimization of the norm $//\boldsymbol{v}//_1$ and the norm $//\boldsymbol{v}//_\propto$.

Formulation of the problem

First, let us cosider the general problem of solving an overdetermined system of linear equations $\boldsymbol{Ax}=\boldsymbol{l}+\boldsymbol{v}$ where $\boldsymbol{A}$ is the linear representation assigning the observation vector $\boldsymbol{l}\in R^m$ $(m\ge n)$ to the parameter vector $\boldsymbol{x}\in R^n$ according to the norm criterion $//\boldsymbol{v}//_{\boldsymbol{k}}$, defined in the form of an objective function in the form [2]

$$F_k(x)=1/k\sum_{i=1}^{m}/v_i(\boldsymbol{x})/^k \qquad \text{for } (1\le k<\propto), \quad (4)$$

$$\text{and } v_i(\boldsymbol{x})=\sum_{i=1}^{n}a_{ij}x_j-l_i \quad (i=1,2,...,m).$$

The solution to the problem of the minimization of the function $F_k(\boldsymbol{x})$ boils down to the implementation of a set of differential equation

$$\frac{dx_j}{dt}=-\mu_j\frac{\partial F_k(\boldsymbol{x})}{\partial x_j} \qquad (5)$$

ISBN 9984 – 779 – 06 – 8

where $\mu_j > 0 \;\; (j = 1,2,...,n)$ is the learning coefficient.

The process of the minimization of the function $F_k(\boldsymbol{x})$ is a stationary process, where the change of the direction of the function gradient vector $F_k(\boldsymbol{x})$

$$\nabla F_k(x) = \left[\frac{\partial F_k(\boldsymbol{x})}{\partial x_1}, \frac{\partial F_k(\boldsymbol{x})}{\partial x_2}, ..., \frac{\partial F_k(\boldsymbol{x})}{\partial x_n} \right] \tag{6}$$

is dynamic in character, and the components of the vector gradient are activation functions in the form

$$g[v_i(\boldsymbol{x})] = |v_i(\boldsymbol{x})|^{k-1} \; sgn[v_i(\boldsymbol{x})], \tag{7}$$

and

$$\mathrm{sgn}[v_i(\boldsymbol{x})] = \begin{cases} 1 & for \;\; v_i(\boldsymbol{x}) > 0 \\ -1 & for \;\; v_i(\boldsymbol{x}) < 0 \end{cases} \tag{8}$$

The procedure for the minimization of the function $F(\boldsymbol{x})$ according to the criterion in the form of the norm $\|\boldsymbol{v}\|_1$ and according to the criterion in the form of the norm $\|\boldsymbol{v}\|_\infty$ is a little different. According to the criterion of the norm $\|\boldsymbol{v}\|_1$, the system of differential equations (5) for $k = 1$ (cf. formula (8)) is

$$\frac{dx_j}{dt} = -\mu_j \sum_{i=1}^{m} a_{ij} \; sgn[v_i(\boldsymbol{x})] \quad (i = 1,2,...,m) \tag{9}$$

where the activation function is the sign function.

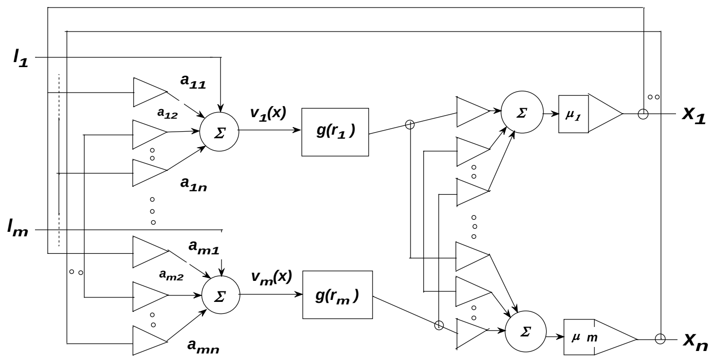


Fig. 3. **The block diagram of signal flow in a neural network for the solution to the task of minimization according to the criterion of the norm** $\|\boldsymbol{v}\|_k \; (1 \le k < \infty)$

The process of the estimation of parameters in the form of the block diagram of the signal flow, corresponding to the system of differential equations (9), has been illustrated in fig. 3.

Hence, it can be seen that the coordinates of the input vector are the coordinates of the column vectors of the matrix $\boldsymbol{A}$ and the coordinates of the vector of free terms $\boldsymbol{I}$. The correction vector $\boldsymbol{v}$ is calculated on the basis of the approximate values of the coordinates of the parameter vector $\boldsymbol{x}$, then the value of the signum activation function $\boldsymbol{v}(\boldsymbol{x})$, whose sign corresponds to the direction of the correction of the function $F_k(\boldsymbol{x})$ at the point $\boldsymbol{x}$ is also calculated. The following steps are in compliance with the method of the greatest descent, bearing in mind the scalar learning coefficient μ_j (the step coefficient) ($j = 1,2,...n$).

ISBN 9984 – 779 – 06 – 8

The norm $\|v\|_{\infty}$ - the Chebyshev norm as the criterion for the minimization of the maximum absolute error

We set the task of such a choice of the coordinates $x_j \; (j = 1,2,...,n)$ of the parameter vector $\boldsymbol{x}$, that the functional

$$V = \max_{1 \le i \le m} [|v_i(\boldsymbol{x})|] \qquad v_i(\boldsymbol{x}) = \sum_{j=1}^{n} a_{ij} x_j - l_i \tag{10}$$

which is the representation of each of the coordinates of the vector $\boldsymbol{x}$ separately, should reach the minimum value. The problem of optimization will be formulated by the introduction of the additional variable δ, and the original problem will be transformed to the problem modified by the minimization of the variable δ, including the constraint

$$|v_i(\boldsymbol{x})| - \delta \le 0 \tag{11}$$

Thus, the solution to the problem of minimization according to the diagram in fig. 3, boils down to finding the least

$$\delta^{\bullet} = F_{\infty}(\boldsymbol{x}^{\bullet}) \ge 0 \tag{12}$$

so that the following condition is fulfilled

$$|v_i(\boldsymbol{x})| \le \delta^{\bullet} \tag{13}$$

In order to minimize the value δ we will use, according to [7], the method of the square and exact penalty function [4], used in non-differentiable minimization. For the square penalty function, the energetic function (objective function) is:

$$F(\boldsymbol{x},\delta) = \alpha\delta + \frac{\beta}{2}\sum_{i=1}^{m}\{[\delta + v_i(\boldsymbol{x})]_-^2 + [\delta - v_i(\boldsymbol{x})]_-^2\} \tag{14}$$

where

$$[w]_- = \min\{0,w\} \tag{15}$$

The penalty coefficients $\alpha > 0, \beta > 0$ specify the participation of the penalty component.
If we mark as

$$C_{i1} = \delta + v_i(\boldsymbol{x}) \tag{16}$$

$$C_{i2} = \delta - v_i(\boldsymbol{x}) \tag{17}$$

and the following steps will depend on the gradient strategy as the activation function $f(C_{i1,i2})$, which assumes only two binary values 0 and 1, then according to the condition (15) we can write

$$f(C_{i1,i2}) = 0 \;\text{ if }\; \delta + v_i(\boldsymbol{x}) \ge 0 \;\text{ or }\; \delta - v_i(\boldsymbol{x}) \ge 0 \tag{18}$$

$$f(C_{i1,i2}) = 1 \;\text{ if }\; \delta + v_i(\boldsymbol{x}) < 0 \;\text{ or }\; \delta - v_i(\boldsymbol{x}) < 0 \tag{19}$$

The problem of the minimization of the value δ boils down solving the system of the two differential equations (after the initial values of the coordinates of the vector $\boldsymbol{x}$, the coefficient δ and the penalty coefficients α and β have been adopted).

$$\frac{d\delta}{dt} = -\eta\{\frac{\alpha}{\beta} + \sum_{i=1}^{m}[(\delta + v_i(\boldsymbol{x}))f(C_{i1}) + (\delta - v_i(\boldsymbol{x}))f(C_{i2})]\} \tag{20}$$

ISBN 9984 – 779 – 06 – 8

$$\frac{dx_j}{dt} = -\eta_j \sum_{i=1}^{m} \{a_{ij}[(\delta + v_i(\boldsymbol{x}))f(C_{i1}) - (\delta - v_i(\boldsymbol{x}))f(C_{i2})]\} \qquad (21)$$

When the exact penalty function [4] is used, the energetic function is defined as

$$F(\boldsymbol{x},\delta) = \alpha\delta - \beta\sum_{i=1}^{m}\{[\delta + v_i(\boldsymbol{x})]_- + [\delta - v_i(\boldsymbol{x})]_-\} \qquad (22)$$

The parameter δ and the coordinates x_j $(j = 1,2,...,n)$ of the parameter vector $\boldsymbol{x}$ are obtained from the solution to the set of differential equations

$$\frac{d\delta}{dt} = -\eta\left[\frac{\alpha}{\beta} - \sum_{i=1}^{m}[f(C_{i1}) + f(C_{i2})]\right] \qquad (23)$$

$$\frac{dx_j}{dt} = -\eta_j \sum_{i=1}^{m} a_{ij}[f(C_{i2}) - f(C_{i1})] \qquad (24)$$

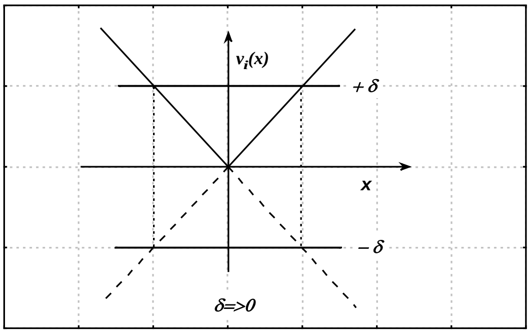


Fig. 4. **The graphical representation of the solution to the task of the minimization of the function** $F(x,\delta)$

The forms of the differential equations (20), (21), (23) and (24) result from the partial derivatives calculated and equated to zero of the energetic functions (14) and (22) with relation to the coefficient δ and the components x_i $(i = 1,2,...,n)$ of the parameter vector $\boldsymbol{x}$. The solution to the task of the minimization of the energetic functions (14) i (22) in compliance to the equation (11) has been presented in fig. 4.

The analysis of the algorithms under discussion used for the estimation of parameters of a vertical geodesic network

The abovementioned methods of estimation do not precisely determine the choice of a method of calculations. In the paper [9] the author clearly remarks that the method of the least squares is used with the assumption that particular observations are in an independent normal distribution. Also K.F. Gauss had his doubts about the optimality of this method and suggested an alternative procedure according to the rule of the least modules [6]. The verification of the linear model optimised via the method of the least squares requires a test concerning the normality of the distribution of the observation vector $\boldsymbol{l}$ with an application of the adequate way of classification of the random vector coordinates described in the paper [1].

In practice the minimization methods under discussion have been used for the assessment of the displacement of a building founded on expansive soil (clay). The overdetermined system of linear equations $\boldsymbol{Ax} = \boldsymbol{l} + \boldsymbol{v}$ put into a configuration of 17 lines $(m = 17)$ and 11 columns $(n = 11)$ has been solved in four variants:

- in the norm $\|\boldsymbol{v}\|_2$ (the standard deviation $m_0 = 0,28\ mm$),

ISBN 9984 – 779 – 06 – 8

- in the norm $//v//_1$ (the coefficient of accuracy for the solution $m_1 = 0{,}36\ mm$),
- in the norm $//v//_\infty$ with the use of a square penalty function (the accuracy coefficient for the solution $m_2 = 0{,}29\,mm$),
- in the norm $//v//_\infty$ with the use of an exact penalty function (the accuracy coefficient for the solution $m_3 = 0{,}33\ mm$).

In all the four cases the accuracy indices for the solution reached almost identical values, but the values of parameters estimated indicated certain differences. The best approximation to the average square solution proved to be the solution in the norm l_∞ with the use of a square penalty function (fig. 5) because of the values of the accuracy indices for the minimization and because of the value of the correlation coefficient r of the residuum vectors, which turned out to be equal $r_{v//x//2-v//x//\infty} = 0{,}96$.

The displacements specified via the solution to the task in the norm l_1 are different in value from the displacements in the norms l_2 and l_∞. The reasons for this discrepancy can be found in the density of probability of the random variable $\boldsymbol{1}$ different from the density of probability of the Cauchy distribution.

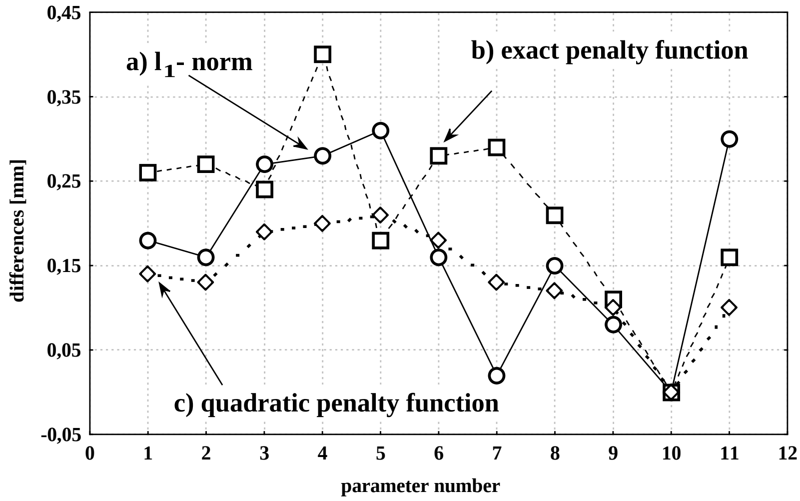


Fig. 5. **The diagram of the differences between the displacement values obtained from equalization in the norm l_1 and l_∞ and the results of equalization in the norm l_2**

Conclusions

The problem of the minimization of absolute residuum values is the counterpart to linear programming, similarly the ordinary method of the least squares can be regarded as a particular case of square programming. The most important difference in the approach to the method of minimization in the norm l_1 and the norm l_2 results from the form of energetic functions. The results of the minimization of an energetic function in the norm l_1 are usually similar to the results of the minimization of even functions [2]. The average values of parameters are obtained from the solution to the task via the method of the least squares, and the parameters resulting from the solution in the norm l_1 or in the norm l_∞ assume median values with the assumption that the matrix $\boldsymbol{A}$ is a full rank. For this reason the square of the norm l_1 will always be greater in value than the square of the norm l_2.

Optimization according to the criterion of the norm l_∞ which consists in the minimization of the maximum values of a function, is suitable for observations without disturbances such as impulses i.e. observations being in uniform distribution. The norm l_∞ becomes considerably

ISBN 9984 – 779 – 06 – 8

important in the process of the approximation of a uniform function, specified within a certain range or a discrete set of points, by means of the Chebyshev polynomials. The above example and the opinions on this subject presented in publications prove that uniform approximations are close to approximations via methods of the least squares [8].

References

1. Brillouin L., Nauka a teoria informacji, PWN, Warszawa 1969.
2. Cichocki A., Unbehauen R., Neural Networks for Solving Systems of Linear Equations – Part II:minimax and Least Absolute Value Problems, IEEE Transactions on Circuits and Systems, Vol. 39, No.9, 1992.
3. Dahlquist G., Björck Ä., Metody numeryczne, PWN, Warszawa 1983.
4. Fletcher R., Practical Methods of Optimization. New York: Wiley-Interscience, 1986.
5. Huber P.,J., Robust Statistics, New York:Wiley, 1981.
6. Kadaj R., Modele, metody i algorytmy obliczeniowe sieci kinematycznych w geodezyjnych pomiarach przemieszczeń i odkształceń obiektów, monografia, Wydawnictwo AR im. H. Kołłątaja w Krakowie, Kraków 1998.
7. Kennedy M.P., Chua L.O., Neural networks for nonlinear programming, IEEE Trans. Circuits Syst., vol. CAS-34, 1987.
8. Korn Granino,A., Korn Teresa, M., Matematyka dla pracowników naukowych i inżynierów, cz. II, PWN, Warszawa 1983.
9. Nowak E., Badanie przemieszczeń drogą statystycznej weryfikacji poprawności modelu i obserwacji, Mat. Sympozjum „Informatyka w Geodezji", Warszawa 1982.

ISBN 9984 – 779 – 06 – 8

INSTABILITY MODELING OF FINANCIAL PYRAMIDS
FINANŠU PIRAMĪDU NESTABILITĀTES MODELĒŠANA

STASYS GIRDZIJAUSKAS, VERA MOSKALIOVA

Vilnius University, Kaunas Faculty of Humanities, Department of Informatics,
Muitinės g. 8, LT-3000 Kaunas, *Phone*: + 370 8 37 44280
e-mail: stasys.girdzijauskas@vukhf.lt *e-mail*: vera.moskaliova@vukhf.lt

Abstract. *The financial structures that make use of money flow for "easy money" or cheating purpose are called financial pyramids. Recently financial pyramids intensively penetrates IT area. It is rather suitable way of the fraud. Money flow modeling and activity analysis of such financial systems allows identifying financial pyramids and taking necessary means of precautions. In the other hand even investing companies that function normally when market conditions changes (e.g. interest rates) eventually might become financial pyramid. Modeling of financial pyramids allows identifying signs of such instability.*

Keywords: *financial investments, financial pyramids, limited resources, money flow modelling.*

Introduction

Financial structures that use money flows for cheating purpose usually are called financial pyramids or financial bubble. As well snow bowl, chain letters, games, matrix, multilevel trade systems usually are called financial pyramids (FP). Recently financial pyramids intensively penetrates IT area. We can see many different FP in the internet websites. Money flow modeling and research of these systems, allows identifying signs of such instability.

There are several approaches towards mathematical description of FP in Literature.

Not giving a definition of a bubble the authors [1] mentioned that financial bubbles are "movements in the price, apparently unjustified by information available at the time, taking the form of a rapid grow followed by a burst or at least a sharp decline". In the paper the effectiveness of the market is assumed and a quite strong assumption is made: all market participants have one and the same information after "announcement" of prices.

Others authors [2] the game approach is used. A financial bubble is being modeled as stochastic incomplete information game between the Ponzi firm and population of individuals. It is supposed that the Ponzi firm knows all its movies and movies of the population, but individuals know only their own movies and of several their acquaintances.

S.V.Dubovsky [3, 4, 5] introduced a model of a financial bubble, in which different cases of the growth of the outstanding total face-value of the bubble securities in circulation or total value of current sales are given as scenarios, which are monotone growing functions of time.

The goal of our research is to analyze FP models, to introduce the mathematical models for its recognition. This problem is very distantly researched. **The object** of the work is existing FP, its methods and models. The paper is prepared using comparable analysis, mathematical analysis of scientific literature and summing-up methods.

The authors describe FP of investment companies. Such companies often organize only the capturing of money and promise high interest rates. At first the company pays these interest rates, and at the end the loss of money follows.

The simplified model of financial pyramid

Money flows are complicated, and to generalize them into united model is rather complicate. First we analyze a simple case of FP money flow [6]. Lets assume, that the Organizer of FP collets money. He promises 20% of interest rate per month (792 percentages interest rate per year). An investment can not be repossessed for 5 month. At first clients of FP put equal sums of money a. Lets find when will be collected the biggest sum of money and when it will not be enough of this sum to pay the percentages. S_n presents the Sum of money, which Organizer will collect after n months. Let's do mathematical model of such activity and build a pyramid.

ISBN 9984 – 779 – 06 – 8

Further are presented S_n values after one, two, three and etc. months, till money theoretical be enough for the percentage payment. The example presents for how long it will be enough of accumulated money for percentage payment:

$S_1 = a$

$S_2 = a + 0{,}8a = 1{,}8a$

$S_3 = a + 0{,}8a + 0{,}6a = 2{,}4a$

$S_4 = a + 0{,}8a + 0{,}6a + 0{,}4a = 2{,}8a$

$S_5 = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a = 3a$

$S_6 = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a + 0 = 3a$

$S_7 = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a + 0 - 0{,}2a = 2{,}8a$

$S_8 = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a + 0 - 0{,}2a - 0{,}4a = 2{,}4a$

$S_9 = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a + 0 - 0{,}2a - 0{,}4a - 0{,}6a = 1{,}8a$

$S_{10} = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a + 0 - 0{,}2a - 0{,}4a - 0{,}6a - 0{,}8a = 1{,}0a$

$S_{11} = a + 0{,}8a + 0{,}6a + 0{,}4a + 0{,}2a + 0 - 0{,}2a - 0{,}4a - 0{,}6a - 0{,}8a - a = 0$

An example shows that paying 20% per month the Organizer will run out of money per 11 month. This will not happen as all the money will be spent for paying interest. The maximum sum he can reach on the 5th and 6th periods. But later on the sum is declining and becomes equal to 0.

Accumulative money value dependence from time and returned percentage rate.

In this example we are investigating the members of money flow, which have a fixed size. Now lets as each month β percentages (calculated by hundredth) from initial contribution are paid to depositors. Then in n month cumulative sum will be:

$S_n = a + (1-\beta)a + (1-2\beta)a + ... + (1-(n-1)\beta)a$.

In the right of equality is arithmetic progression. Lets find the sum of firsts n members of progression and get S_n value.

$$S_n = \frac{a\,n}{2}\left(2 + \beta(1-n)\right) \qquad (1)$$

Here S_n is a Cumulative Sum of money which the Organizer gets after n periods (months), a – sum of money contributed in each period (month) start, β – active percentage (hundredth) calculated from initial (principal) Sum.

With reference to formula (1) we found the cumulated capital dependence on accumulation time, (in month), when β rate of percentages paid to clients are different.

This is obvious that when the paid percentage rate is growing then time of accumulation period is declining.

Theoretically FP can exist till it has accumulated money (until S_n >0). After solving the equation $S_n = \frac{a\,n}{2}\left(2 + \beta(1-n)\right) > 0$ (when n >0), we get that FP could exist for the following time period: $n \le \frac{2}{\beta} + 1$. If we would assume that β=0.2 we would get that n<=11. That lets us to confirm our calculations and results of the figure1.

ISBN 9984 – 779 – 06 – 8

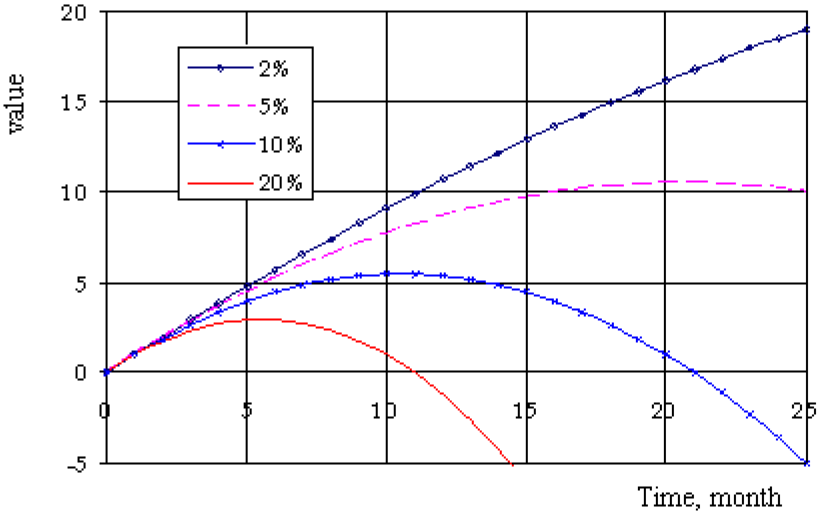


Fig. 1. **The dependence of FP accumulated capital from the time, with different interest rates**

In the calculations accumulation of money was a discrete process. More natural and more adequate process which represents real situations would be steady accumulation. **Let variable** ***n*** **let's be continuous**. We note that formula (1) is equation of parabola. After making a transformation of this equation we got $S_n = \frac{a(2+\beta)}{2} n - \frac{a\beta}{2} n^2$.

The branches of the parabola are go down. The maximum of parabola coincide with its summit. Based on known formula of parabolas summit abscissa calculation we find the biggest value of function (1) which is equal to the variable *n*.

$$n = \frac{1}{\beta} + \frac{1}{2}$$

It this is the time when FP has accumulated the largest amount of money. For example, when β=0.2 the largest sum of money will be accumulated after 5,5 month.

The same result we would get while analyzing the functions (1) extremums using fluxion.

FP with variable money flow members

Now let's analyze the case when contributed money sums are not fixed [7]. After the firsts largess interest payments the amount of contributions begins to change: to grow or decline.

The grow accumulation. Let's discuss the case of grow accumulation. We can say that number of contributions grow in geometric progression. At first lets assume that q>1. Then on the first month the contributed sum will be a, that is $S_1 = a$,

On the second month - $S_2 = a + a(1-\beta)q$

On the third $S_3 = a + a(1-\beta)q + a(1-2\beta)q^2$

At the end on month *n* the accumulated value is

$$S_n = a + a(1-\beta)q + a(1-2\beta)q^2 + ... + a(1-(n-1)\beta)q^{n-1}$$

That could be written as $S_n = a\frac{q^n - 1}{q-1} - a \cdot \beta \sum_{i=1}^{n-1} i \cdot q^i$ (2)

If q=1 (sums of contribution are fixed sizes) we would get formula (1) $S_n = a\left(n - \beta \sum_{i=1}^{n-1} i\right)$

After analyzing the equation (2) (like on equation (1)), one more time we can see the instability of FP.

The results of equation (2) are presented in the figure 2. There is shown the case when interest of 20% from principal value is paid for each period (month), and one contributed sums are fixed size (q=1). When contribution is growing then maximum sum is accumulated in the same time

ISBN 9984 – 779 – 06 – 8

period. The value of sum grows too. However lifetime of FP is going down, because accumulated sums are parcel out to defray rather high interest rates.

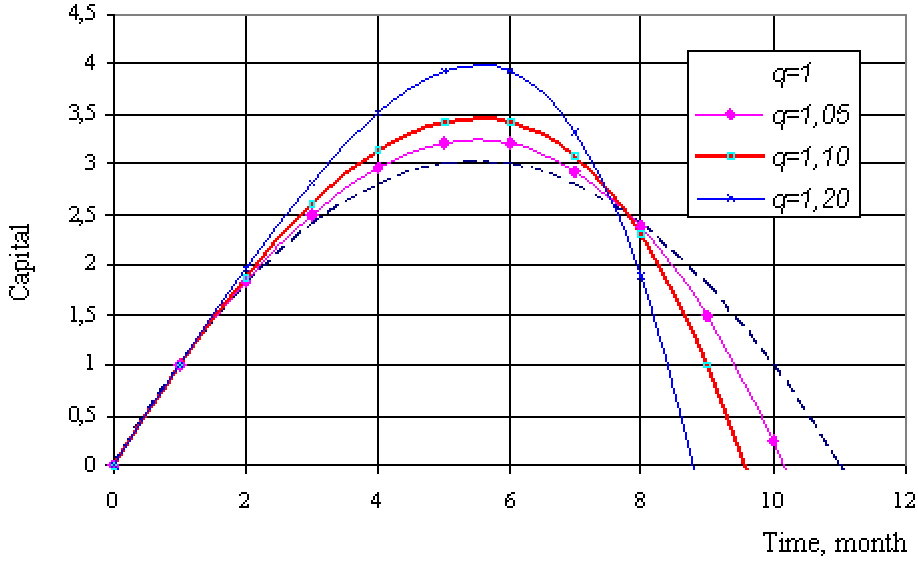


Fig. 2. **The dependence of FP accumulated capital from the time, when interest rate 20% (the grow of accumulation)**

FP lifetime has two phases (stages):
1. in the first stage accumulated capital is growing;
2. in the second one – declining.

If q=1 then the grow phase and the decline phase are symmetric: terms of both phases are equal. But if q>1 then the second phase becomes shorter than the first one.
Here we have got sudden conclusion: the bigger is the accumulated sum, the faster is it's overspend. FP which grows more quick, exists shorter than others, which principal grow is more slow. When the denominator of geometric progression grow, then grows the skew of phases: the second phase decline and conversely.
The declining accumulation. Based on the analysis of accumulation cases, we can make an assumption that decrease of denominator of progression lets exist FP for longer time. Lets denominator of progression be q<1. In the figure 3 is illustrated the dependence of accumulated capital to the cumulated time, when the denominator of progression increase from 1 to 0.7. Here the same as in earlier cases basic value of interest rate is 20 percentages (β = 20 %) per month. All contributions are fixed sizes (q=1). We saw that FP which has basic parameters exits for the shortest time. When denominator of progression decline we saw the second phase of FP lifetime sudden becomes longer. That means that such FP can exists very long time. Its lifetime in the instance could be equal to investment companies lifetime period.

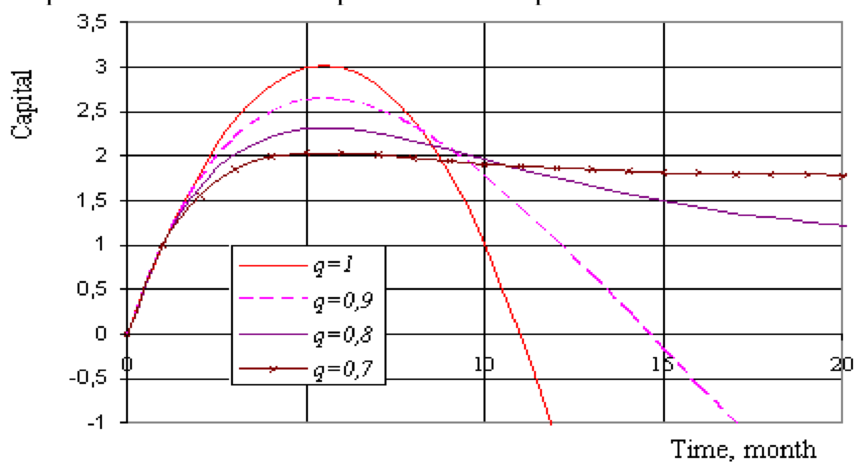


Fig. 3. **The dependence of FP accumulated capital from the time, when interest rate 20% (the decline of accumulation)**

ISBN 9984 – 779 – 06 – 8

In all these cases we analyzed money flows and not value of time. Because FP simply doesn't make any investment. Now let's implicate the time factor.
Lets FP work like investing company which is **investing the capital with interest rate of month *i***. Here $r = 1+i$ is coefficient of capital grow. Then (accumulated value) of **future value** of FP we can describe like:

$$S_n = a \cdot r^n + a(1-\beta)q \cdot r^{n-1} + a(1-2\beta)q^2 \cdot r^{n-2} + \ldots + a(1-(n-1)\beta)q^{n-1} \cdot r + a(1-n\beta)q^n \qquad (3)$$

Here S_n – future value of accumulated sum of money, n- cumulated number of periods, a –sum of money contributed at each period beginning, β – active percentage calculated from principal Sum (in this case could be dividend rate), q- coefficient of contribute size variation (grow, decline), r- coefficient of invest contribution grow size with interest rate i ($r = 1 + i$).
In this expression determinant value has proportion of coefficients q and r. It is not hard to see that if $q=r$ then equation (3) becomes equation (1) with further multiplier (factor) r^n. Then accumulated sum we can write like:

$$S_n = a\sum_{m=0}^{n}(1-m\beta)\cdot q^m r^{n-m} . \qquad (4)$$

Here m is serial number of money flow member.
We analyze accumulating model (5) and find dependences of accumulated value to cumulated time, when other FP parameters are different. Lets take fixed cumulated time equal to 50 periods (n=50), the interest rate 10 percentages and fixed amount of contribute equal to one (a = 1).

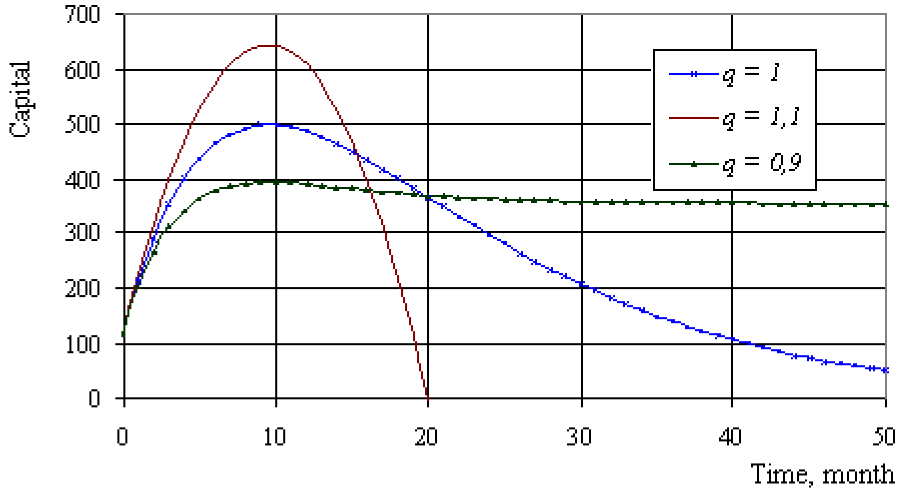


Fig. 4. **The dependence of future value of accumulated capital from the time, when *a=1; r=1.1; n=50; β=10%***

In the figure 4 we can see the dependence of future value of accumulated capital from time of the cumulate when number of contributions is different. We note the shortest lifetime of FP is at the period when number of contributions (q) is largest and is equal to coefficient of grow of amount of contribution r ($q = r = 1.1$). In the case when number of contributions is fixed (q=1), the amount of accumulated capital is slowly declining, because β value is rather high (β =0.1). In the third case FP becomes stable, when the number of contributions constantly declines (q =0.9). We can maintain that FP becomes (usual, normal) investing company. Such company has quite stable money.
There are image dependences of future value of accumulated capital from different number of contributions. It is presented in the figure 5. In this case it is taken higher coefficient of profitability. It is equal 20 percentages. Obviously that grow of profitability rise the stability of FP. In this case only when coefficient q=1.1 FP is instable. But lifetime is signally elongated.

ISBN 9984 – 779 – 06 – 8

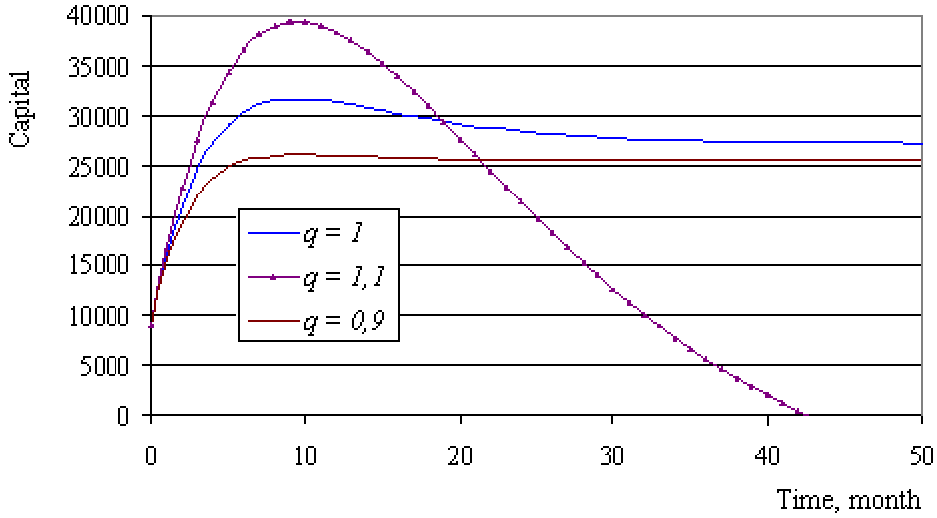


Fig. 5. **The dependence of future value of accumulated capital from the time, when *a=1; r=1.2; n=50; β=10%***

When profitability grows FP becomes completely stable. We can see it in figure 6.

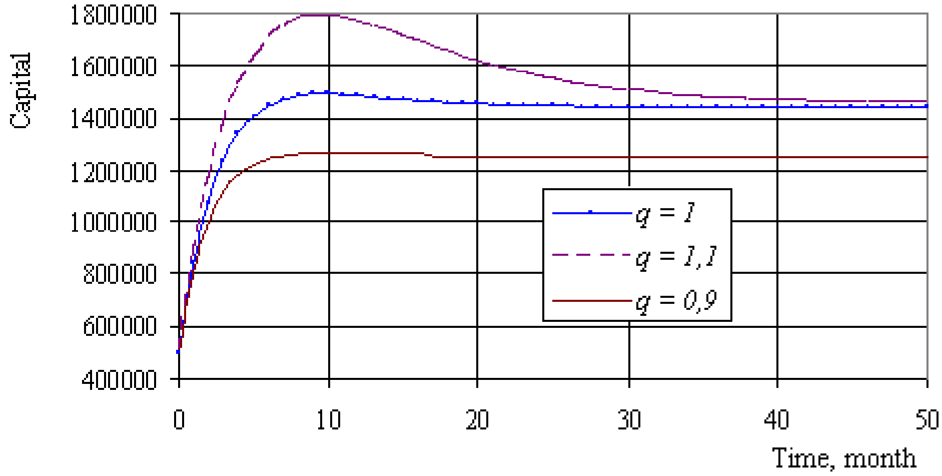


Fig.6. **The dependence of future value of accumulated capital from the time, when *a=1; r=1.3; n=50; β=10%***

Here in all cases we saw stability of FP. It works stable and looses features which are characteristic to FP. So it could be as normal investing company. We must mark that when number of contributions declines then stability of system grows.

Conclusions

Financial structure that use money flows for cheating purpose are called financial pyramids (FP). Information technologies let to make theoretical analysis of FP using mathematical models. Money flow modelling and research of these systems allow identify signs of such instability. We can make the following conclusions:

1. Accumulated Capital in the FP is made of 2 phases. The first is growing of capital, other declining of capital.
2. Accumulated Capital in the FP which members of money flows are fixed has equal term phases.
3. Accumulated capital in the FP which members of money flows are not fixed the second phase is variable. This phase is longer when intensity of accumulation declines and conversely.
4. When the coefficient of profitability of contribution grows and number of contribution like as interest rate declines then FP works normally like investing company.
5. Mathematical models of FP it is possible to restructure into investment models and to examine them.

ISBN 9984 – 779 – 06 – 8

References

1. Blanchard O.-J., Watson M. Bubles, rational expectations and financial markets in P.Wachtel Crises in economic and financial structure. – Lexington (MA), 1982.
2. Белянин А.В, Исупова О.Г. Финансовые пирамиды в переходной эконоие с точки зрения теории игр//Российская программа экономических исследований. Научный доклад №2000/10 (www.eerc.ru, http://195.28.33.75/)
3. Дубовский С.В. Прогнозирование инфляции и обменного курса рубля в Российской нестационарнойэкономике. – М.: Издательство УРСС.-2001
4. Дубовский С.В. Обменый курс рубля как результат денежной эмиссии, внешней торговли и блуждающих финансовых потоков //Экономика и математичесские методы, 2002, том 38, №2, с. 84-96.
5. Димитриади Г.Г. Модели финансовых пирамид: детерминироанный подход.
6. Бухвалов А., Бухвалов А., Идельсон А. Финансовые вычисления для профессионалов. СПб.: БХВ-Петербург, 2001, 320 с.
7. Girdzijauskas S. Finansinių piramidžių nestabilumo modeliavimas: VU Kauno humanitarinio fakulteto konferencijos „Informacinės technologijos verslui – 2003“ pranešimų medžiaga. Kaunas: Technologija, 2003, p. 33-38.

ISBN 9984 – 779 – 06 – 8

EXTRACTING RULES FROM TRAINED RBF NEURAL NETWORKS
LIKUMU IEGŪŠANA NO APMĀCĪTIEM RBF NEIRONU TĪKLIEM

PETER GRABUSTS

Rezekne Higher Educational Institution
Atbrivoshanas al. 90, Rezekne LV-4600, Latvia
Phone: + 371 46 23798, *e-mail*: peter@ru.lv

Abstract. *This paper describes a method of rule extraction from trained artificial neural networks. The statement of the problem is given. The aim of rule extraction procedure and suitable neural networks for rule extraction are outlined. The RULEX rule extraction algorithm is discussed that is based on the radial basis function (RBF) neural network. The extracted rules can help discover and analyze the rule set hidden in data sets. The paper contains an implementation example, which is shown through standalone IRIS data set.*

Keywords: *neural networks, rule extraction, RBF networks, RULEX algorithm.*

Introduction

Nowadays a considerable effort is made to „write" and „read" symbolic information into and from artificial neural networks (ANN) [1, 2]. The motivation is multifold. ANNs have shown a very good ability to represent „empirical knowledge", as the one contained in a set of examples, but the information is expressed in a „sub-symbolic" form - in the structure, weights and biases of a trained ANN, not directly readable for the human user. So, an ANN behaves nearly like a „black box", providing no explanation to justify its decisions taken in various instances. This forbids the usage of ANNs in „safety-critical" domains, which include the economic and financial applications, and makes it difficult to verify and debug software that includes ANN components. On the other hand, the extraction of the knowledge contained in an ANN allows the „portability" of the information to other systems, in both symbolic (AI) and sub-symbolic (ANN) forms.

A direct way of converting neural to symbolic knowledge is through rule extraction. This process provides a limited form of an explanation facility of how a neural network may classify any given input pattern. Rule extraction is a process that discovers the hyper plane positions of the input-to-hidden units and the hidden-to-output units of a neural network. These positions are then formulated as IF..THEN rules with the most important input unit labels acting as the rule antecedents. The discovery of the hyper plane positions can be found by a number of techniques that analyze the weights and biases of the neural network. Rule extraction can be carried out using a variety of neural network types such as multi-layer perceptions, Kohonen networks, radial basis functions (RBF) and recurrent networks.

Rule extraction from RBF neural networks

The nature of RBF networks [3] makes them a suitable solution for rule extraction process. It is possible to extract a series of IF. THEN rules that are able to state simply and accurately the knowledge contained in the neural network. The RBF network consists of the feed forward architecture with an input layer, a hidden layer of RBF "pattern" units and an output layer of linear units. The input layer simply transfers the input vector to the hidden units, which form a localized response to the input pattern. Learning is normally undertaken as a two-stage process. The first stage consists of an unsupervised process in which the RBF centers (hidden units) are positioned and the optimum field widths are determined in relation to the training samples. The second stage of learning involves the calculation of the hidden unit to output unit weights and is achieved quite easily through a simple matrix transformation. The radial basis functions in the hidden layer are implemented by kernel functions, which operate over a localized area of input

ISBN 9984 – 779 – 06 – 8

space. The effective range of the kernels is determined by the values allocated to the center and width of the radial basis function. The Gaussian function has a response characteristic determined by equation [3]:

$$Z_j(x) = \exp\left(-\frac{\| x - \mu \|^2}{\delta_j^2}\right)$$

The response of the output unit is calculated as

$$y = \sum_{j=i}^{J} W_{ij} Z_j(x)$$

where: W - weight matrix, Z - hidden units activations, x - input vectors, μ- parameter vector, σ- width of receptive field.

Rule extraction may be viewed in one of two ways. First, it can be seen as a technique for determining how the neural network performs any given input to output mapping. Second, the rule extraction process may often produce rules that are more accurate than the original neural network. The local nature of each RBF hidden unit enables a simple translation into a single rule:

IF Feature_1 is TRUE AND IF Feature_2 is TRUE AND IF Feature_n is TRUE THEN Class_x

where a Feature is composed of upper and lower bounds calculated by the RBF center μ_n positions, RBF width σ and feature steepness S. The value of the steepness was discovered empirically to be about 0.6 and is related to the value of the width parameter. The values of μ and σ are determined by the RBF training algorithm [3]. The upper and lower bounds are calculated as follows:

$$X_{lower} = \mu_i - \sigma_i + S \quad \text{and} \quad X_{upper} = \mu_i + \sigma_i - S$$

The rule extraction algorithm RULEX [4] can be seen below in Fig. 1:

Input:	Hidden weights μ (center positions) Gaussian radius spread σ Steepness S
Output:	One rule per hidden unit

Procedure:	Train RBF network on data set
	For each hidden unit:
	    For each μ_i
	        $X_{lower} = \mu_i - \sigma_i + S$
	        $X_{upper} = \mu_i + \sigma_i - S$
	Build rule by:
	    antecedent=[X_{lower}, X_{upper}]
	    Join antecedents with AND
	    Add class label
	Write rule

Fig. 1. **Rule extraction algorithm**

Application example of rule extraction technique

The experiment performed was intended as an implementation of the RULEX algorithm that would give an idea of rule extraction possibilities from neural networks. The main aim of the experiment was to extract rules and test their quality. The software program is written in MATLAB. The present paper is a continuation of the study presented in [5].

The experiment employed the well-known Fisher's IRIS data set [6]. As known, it contains three flower classes of 50 elements each: setosa, versicolor and virginica. Every flower has 4 attributes:

- ✓ SL - sepal length;

ISBN 9984 – 779 – 06 – 8

- ✓ SW - sepal width;
- ✓ PL - petal length;
- ✓ PW - petal width.

Table 1 shows data fragments of each class.

Table 1.

IRIS data fragment

Setosa				Versicolor				Virginica			
SL	SW	PL	PW	SL	SW	PL	PW	SL	SW	PL	PW
5.1	3.5	1.4	0.2	7.0	3.2	4.7	1.4	6.3	3.3	6.0	2.5
4.9	3.0	1.4	0.2	6.4	3.2	4.5	1.5	5.8	2.7	5.1	1.9
4.7	3.2	1.3	0.2	6.9	3.1	4.9	1.5	7.1	3.0	5.9	2.1
4.6	3.1	1.5	0.2	5.5	2.3	4.0	1.3	6.3	2.9	5.6	1.8
....	....	....	....	....	....	....	....	....	....	....	....

Using the GhostMiner statistical package, data normalisation was performed and element distribution by class as well as different statistical indexes were obtained (see Fig. 2 and 3).

	sepal length	sepal width	petal length	petal width
Minimum	0	0	0	0
Average	14.56	8.76	15.9467	8.55333
Maximum	34	22	42	21
Variance	90.8789	52.3447	160.762	45.4434
Std	9.53304	7.23496	12.6792	6.74118
Missing val.	0	0	0	0

Fig. 2. **Statistical indexes of the normalised Fisher's IRIS database**

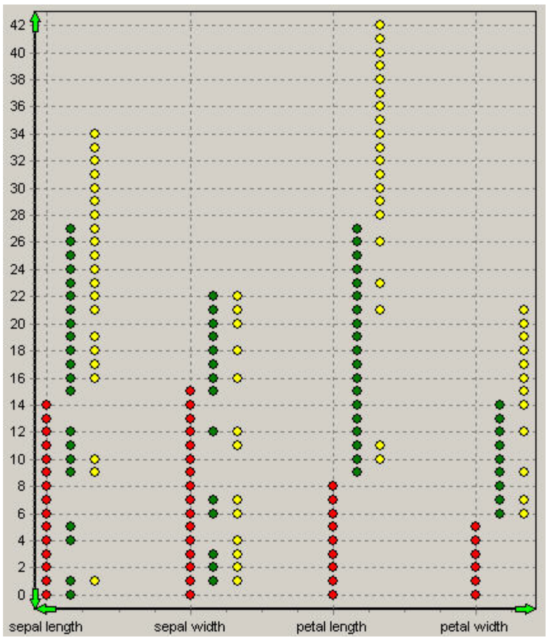


Fig. 3. **Distribution of elements by class**

For data visualisation, 2D projections can be used which show the distribution of particular parameters with regard to each other. Fig. 4.a illustrates the distribution of *petal length* with regard to *sepal length*, whereas Fig. 4.b depicts the distribution of *petal width* with regard to *sepal width*.

ISBN 9984 – 779 – 06 – 8

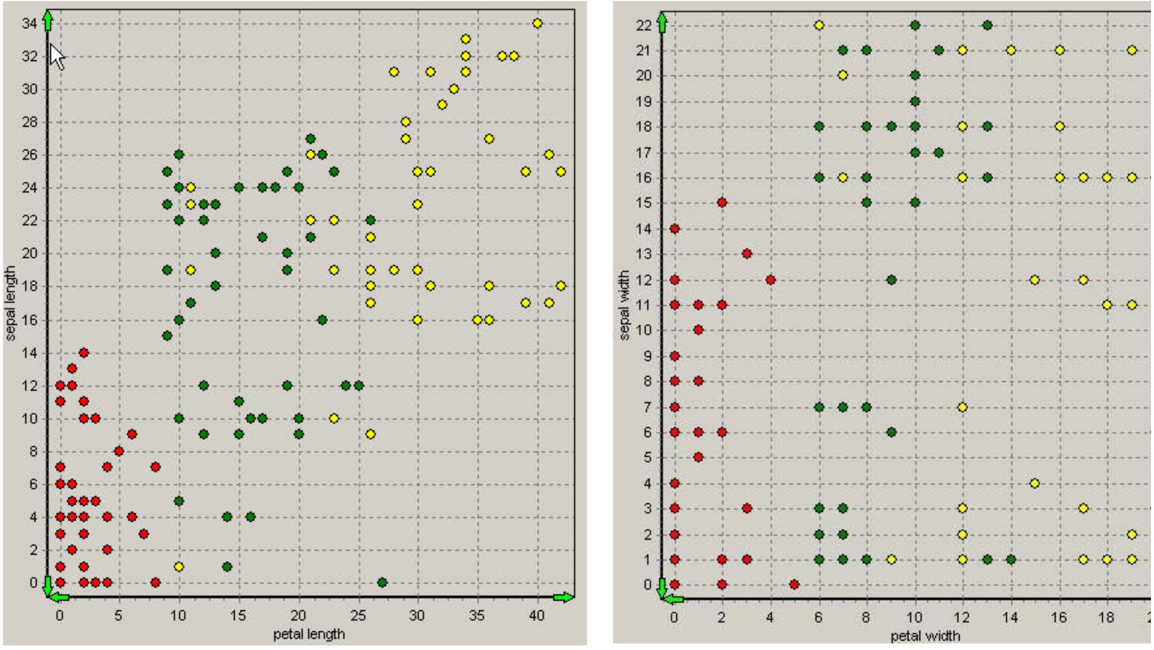


Fig. 4. **2D distributions of particular parameters: pl-sl (a) and pw-sw (b)**

The tasks of the experiment were as follows:

1. To accomplish network training by the RULEX algorithm at different training sets, namely:
   – Training set A - first 25 elements of every class;
   – Training set B - arbitrary 20 elements of every class;
   – Training set C - all 50 elements of every class.
2. To examine the effect of parameter S on the quality of extracted rules.

In case A, first 25 elements of every class were used as a training set. For all training sets, the values of parameter S were found experimentally. At each training stage, class centers and radius values were calculated according to the RULEX algorithm. Based on those values, for each class of training elements, X_{lower} and X_{upper} were calculated as well as the antecedent parts characterising the corresponding class. Then testing over the whole IRIS data set was made so as to determine to which extent the found rules correctly described elements of each class. For each class, the count of elements satisfying the rules was found as well as the percentage of elements correctly describing the rules. For convenience, IRIS variables SL, SW, PL and PW were denoted, respectively, as X1, X2, X3 and X4. Table 2 shows the results of the experiment, whereas Table 3 represents the rules extracted at different S values.

Table 2.

Results of training set A (first 25 elements of every class)

Correct	Values of parameter S													
	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.6
I	50	49	49	49	48	47	44	40	32	19	12	5	0	0
II	50	50	50	49	49	48	45	44	40	36	28	20	10	0
III	50	50	50	50	49	49	49	48	47	44	43	42	38	21
%	100	99.3	99.3	98.7	97.3	96	92	88	79.3	66	55.3	44.7	32	14

ISBN 9984 – 779 – 06 – 8

Table 3.

Training set A: characteristics of the extracted rules

	Parameter S=-0.9	Parameter S=0
Values of centers and radii	Class 1 = 5.03 3.48 1.46 0.25 Class 2 = 6.01 2.78 4.31 1.34 Class 3 = 6.58 2.93 5.64 2.04 Values of radii = 0.33 0.64 1.09	Class 1 = 5.03 3.48 1.46 0.25 Class 2 = 6.01 2.78 4.31 1.34 Class 3 = 6.58 2.93 5.64 2.04 Values of radii = 0.33 0.64 1.09
Percentage of rules correctly describing elements of classes	100	66
Rule of Class 1	IF (X1>= 3.80 AND < 6.26) AND IF (X2>= 2.25 AND < 4.71) AND IF (X3>= 0.23 AND < 2.69) AND IF (X4>= -0.98 AND < 1.48) THEN SETOSA	IF (X1>= 4.70 AND < 5.36) AND IF (X2>= 3.15 AND < 3.81) AND IF (X3>= 1.13 AND < 1.79) AND IF (X4>= -0.08 AND < 0.58) THEN SETOSA
Rule of Class 2	IF (X1>= 4.47 AND < 7.55) AND IF (X2>= 1.24 AND < 4.31) AND IF (X3>= 2.77 AND < 5.85) AND IF (X4>= -0.19 AND < 2.88) THEN VERSICOLOR	IF (X1>= 5.37 AND < 6.65) AND IF (X2>= 2.14 AND < 3.41) AND IF (X3>= 3.67 AND < 4.95) AND IF (X4>= 0.71 AND < 1.98) THEN VERSICOLOR
Rule of Class 3	IF (X1>= 4.58 AND < 8.57) AND IF (X2>= 0.94 AND < 4.92) AND IF (X3>= 3.65 AND < 7.63) AND IF (X4>= 0.05 AND < 4.04) THEN VIRGINICA	IF (X1>= 5.48 AND < 7.67) AND IF (X2>= 1.84 AND < 4.02) AND IF (X3>= 4.55 AND < 6.73) AND IF (X4>= 0.95 AND < 3.14) THEN VIRGINICA

In case B, 20 elements, arbitrarily selected from every class, were employed as a training set. Table 4 demonstrates the results of the experiment, but Table 5 shows the rules extracted at different S values.

Table 4.

Results of training set B (arbitrary 20 elements of every class)

Correct	Values of parameter S													
	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.6
I	49	49	48	48	45	40	39	27	14	9	2	0	0	0
II	50	49	49	48	45	44	40	36	28	20	10	3	0	0
III	49	49	48	47	45	43	43	42	39	35	29	23	16	0
%	98.7	98	96.7	95.3	90	84.7	81.3	70	54	42.7	27.3	17.3	10.7	0

Table 5.

Training set B: characteristics of the extracted rules

	Parameter S=-0.9	Parameter S=0
Values of centers and radii	Class 1= 5.04 3.45 1.49 0.25 Class 2 = 5.99 2.77 4.32 1.35 Class 3 = 6.54 2.95 5.44 1.94 Values of radii = 0.19 0.43 0.73	Class 1 = 5.04 3.45 1.49 0.25 Class 2 = 5.99 2.77 4.32 1.35 Class 3 = 6.54 2.95 5.44 1.94 Values of radii= 0.19 0.43 0.73
Rules correctly describe elements of classes (%)	98.67	42.67
Rule of Class 1	IF (X1>= 3.95 AND < 6.13) AND IF (X2>= 2.36 AND < 4.54) AND IF (X3>= 0.40 AND < 2.59) AND IF (X4>= -0.84 AND < 1.34) THEN SETOSA	IF (X1>= 4.85 AND < 5.23) AND IF (X2>= 3.26 AND < 3.64) AND IF (X3>= 1.30 AND < 1.69) AND IF (X4>= 0.06 AND < 0.44) THEN SETOSA

ISBN 9984 – 779 – 06 – 8

Rule of Class 2	IF (X1>= 4.66 AND < 7.32) AND IF (X2>= 1.44 AND < 4.10) AND IF (X3>= 2.99 AND < 5.65) AND IF (X4>= 0.01 AND < 2.68) THEN VERSICOLOR	IF (X1>= 5.56 AND < 6.42) AND IF (X2>= 2.34 AND < 3.20) AND IF (X3>= 3.89 AND < 4.75) AND IF (X4>= 0.91 AND < 1.78) THEN VERSICOLOR
Rule of Class 3	IF (X1>= 4.91 AND < 8.17) AND IF (X2>= 1.33 AND < 4.58) AND IF (X3>= 3.81 AND < 7.06) AND IF (X4>= 0.31 AND < 3.57) THEN VIRGINICA	IF (X1>= 5.81 AND < 7.27) AND IF (X2>= 2.23 AND < 3.68) AND IF (X3>= 4.71 AND < 6.16) AND IF (X4>= 1.21 AND < 2.67) THEN VIRGINICA

In case C, all 50 elements of every class served as a training set. Table 6 shows the results of the experiment, but Table 7 represents the rules extracted at different values of parameter S.

Table 6.

Results of training set C (all 50 elements of every class)

Correct	Values of parameter S													
	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.6
I	50	49	49	48	48	45	40	40	27	15	10	4	0	0
II	50	50	50	49	49	47	44	42	37	32	25	16	9	0
III	50	49	49	49	49	47	47	44	42	41	36	32	26	6
%	100	98.7	98.7	97.3	97.3	92.7	87.3	84	70.7	58.7	47.3	34.7	23.3	4

Table 7.

Training set C: characteristics of the extracted rules

	Parameter S=-0.9	Parameter S=0
Values of centers and radii	Class 1 = 5.01 3.42 1.46 0.24 Class 2 = 5.94 2.77 4.26 1.33 Class 3 = 6.59 2.97 5.55 2.03 Values of radii = 0.30 0.61 0.87	Class 1 = 5.01 3.42 1.46 0.24 Class 2 = 5.94 2.77 4.26 1.33 Class 3 = 6.59 2.97 5.55 2.03 Values of radii = 0.30 0.61 0.87
Rules correctly describe elements of classes (%)	100	58.7
Rule of Class 1	IF (X1>= 3.80 AND < 6.21) AND IF (X2>= 2.21 AND < 4.62) AND IF (X3>= 0.26 AND < 2.67) AND IF (X4>= -0.96 AND < 1.45) THEN SETOSA	IF (X1>= 4.70 AND < 5.31) AND IF (X2>= 3.11 AND < 3.72) AND IF (X3>= 1.16 AND < 1.77) AND IF (X4>= -0.06 AND < 0.55) THEN SETOSA
Rule of Class 2	IF (X1>= 4.42 AND < 7.45) AND IF (X2>= 1.26 AND < 4.28) AND IF (X3>= 2.75 AND < 5.77) AND IF (X4>= -0.19 AND < 2.84) THEN VERSICOLOR	IF (X1>= 5.32 AND < 6.55) AND IF (X2>= 2.16 AND < 3.38) AND IF (X3>= 3.65 AND < 4.87) AND IF (X4>= 0.71 AND < 1.94) THEN VERSICOLOR
Rule of Class 3	IF (X1>= 4.82 AND < 8.36) AND IF (X2>= 1.20 AND < 4.74) AND IF (X3>= 3.78 AND < 7.32) AND IF (X4>= 0.26 AND < 3.80) THEN VIRGINICA	IF (X1>= 5.72 AND < 7.46) AND IF (X2>= 2.10 AND < 3.84) AND IF (X3>= 4.68 AND < 6.42) AND IF (X4>= 1.16 AND < 2.90) THEN VIRGINICA

The data obtained prove that parameter S plays an essential role in the application of the RULEX algorithm: the greater the negative value of S is, the more the lower boundary of rule performance range, X_{lower}, decreases at the same time raising the upper boundary, X_{upper}, of the range. That causes the enlargement of the cluster describing antecedent part and thus increases

ISBN 9984 – 779 – 06 – 8

the value of the area in which the extracted rule is fulfilled. For training sets A, B, and C, the dependence of the total count of elements, correctly describing rules, on parameter S is shown in Table 8 and represented as a graph in Fig. 5.

Table 8.

The dependence of the total count (%) of rule satisfying elements on S

%	Values of parameter S													
	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.6
A	100	99.3	99.3	98.7	97.3	96	92	88	79.3	66	55.3	44.7	32	14
B	98.7	98	96.7	95.3	90	84.7	81.3	70	54	42.7	27.3	17.3	10.7	0
C	100	98.7	98.7	97.3	97.3	92.7	87.3	84	70.7	58.7	47.3	34.7	23.3	4

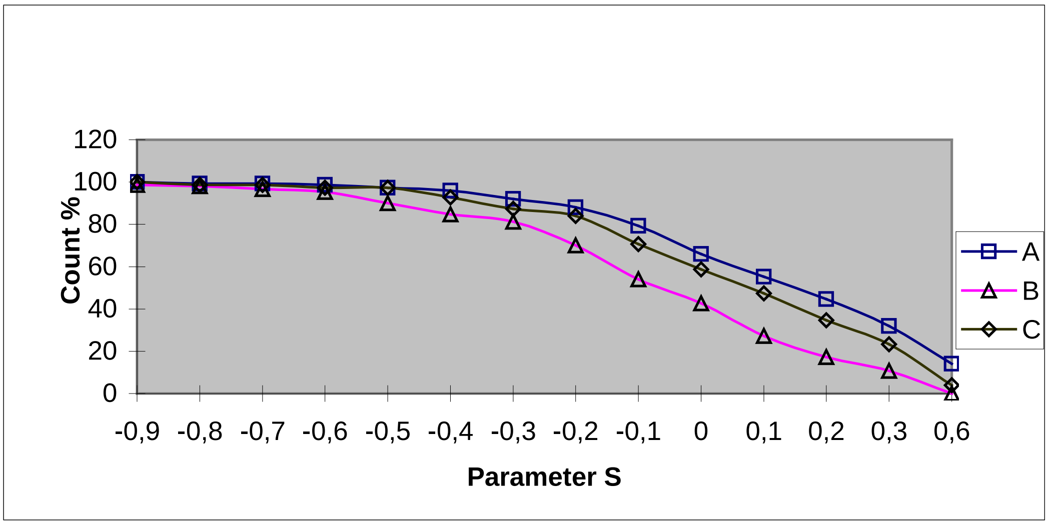


Fig. 5. **Dependence of the count (%) of elements correctly describing rules on parameter S**

Conclusions

The aim of this study was to continue the experiments described in [5]. In this paper a rule-extraction algorithm is shown which is based on the radial basis function (RBF) neural network classifier. After training the RBF classifier, the rules will be extracted through analyzing the parameters of the classifier. One hidden unit corresponds to one rule. Before extracting rules, the weights connecting the hidden units with output units are simplified. Then the interval for each input in the condition part of every rule is adjusted with a view to obtaining high rule accuracy by iteration steps. This rule extraction technique is shown through IRIS data set experimental results.

The extracted rules can help discover and analyse the hidden knowledge in data sets further.

References

1. Andrews, R., Diederich, J., Tickle, A. A survey and critique of techniques for extracting rules from trained artificial neural networks. Knowledge-Based Systems, 8(6), 1995, p.373-389.
2. Crawen, M., Shavlik, J. Using sampling and queries to extract rules from trained neural networks. Machine Learning: Proceedings of the Eleventh International Conference, 1994.
3. Hush, D.R., Horne, B.G. Progress in Supervised Neural Networks. What's new since Lippmann? IEEE Signal Processing Magazine, vol.10, No 1, January 1993.
4. Andrews, R., Gewa, S. RULEX and CEBP networks as the basis for a rule refinement system. In: J. Hallam et al, editor, Hybrid Problems, Hybrid Solutions. IOS Press, 1995.
5. Grabusts P. Neural networks methods of knowledge extraction. Proceedings of the International Conference "Scientific Achievements for Wellbeing and Development of Society", March 4-5, Rezekne, Rezekne Higher Educational Institution, 2004, p. 99-106.
6. Fisher R.A. The use of multiple measurements in taxonomic problems. Ann. Eugenics, 7(2), 1936, p.179-188.

ISBN 9984 – 779 – 06 – 8

SIMPLE METHODS OF ENGINEERING CALCULATIONS FOR SOLVING TRANSFER PROBLEMS OF MULTI – SUBSTANCES IN HORIZONTAL LAYER

VIENKĀRŠU ALGORITMU IZSTRĀDE DAUDZKOMPONENTU MATERIĀLU PĀRNESES PROBLĒMAI HORIZONTĀLĀ SLĀNĪ

Harijs Kalis, Ilmārs Kangro [1]

Institute of Mathematics Latvian Academy of Sciences and University of Latvia
Akadēmijas laukums 1, LV – 1524, Rīga, Latvija, *e-mail*: KALIS@LANET.LV
[1] Rēzekne Higher Educational Institution, Department of Engineering Science
Atbrīvošanas aleja 90, LV – 4601, Rēzekne, Latvija, *e-mail*: kangro@ru.lv

Abstract. *We consider the simple algorithms in the modelling of the transfer problem of different substances (concentration, heat, moisture, and e. c.) in plate. The approximations of corresponding initial – boundary value problem of the system of the partial differential equations (PDE) is based on the finite volume method. This procedure allows one to reduce the 2-D transfer problem described by a PDE to initial value problem for a system of ordinary differential equations (ODE) of the first or second order. In the stationary case the exact finite – difference vector scheme is obtained.*

Keywords: *2-D heat transfer problem, finite – volume method, finite – difference scheme, diffusion of heat and moisture.*

Introduction

By means of the differential equations of parabolic type (for example, the equations of heat conductivity $\partial(K\partial u/\partial x)/\partial x + F(x,t) = c\rho\partial u/\partial x)$ and equations of Poison type $u_{xx} + u_{yy} = f(x,y),\quad (x,y)\in D$ considering them with boundary and initial conditions become possible the mathematical modelling of many theoretical and practical problems. Their solutions serve not only as theoretical base for the further researches, but also are decisions of many actual practical problems.

For example, it is possible to estimate the heat-shielding properties of protections of the equipment at influence of a fire, to calculate of dynamics of dangerous factors of a fire in a room [9]. The calculation of heat transfer in a ground layer and in an atmosphere [10] is possible. It is possible to find out the algorithm for describing the temperature changes depending on time for surfaces on fibbers glasses at its heating without radiation [3] and with radiation [4,5], the algorithm for calculation of a temperature mode in a wall of a building with linings taking into account an opportunity of there heating [6,7].

Here it is very important to find simple algorithms for engineering - technical calculations, which are characterized by the sufficient accuracy of calculations, by the simplicity of calculations (with an opportunity of use of mathematical systems of a high level, for example, Mathematica, Maple, Matlab, etc.), by the universality of algorithm (the decision not only the given problem, but also an opportunity of its application for the decision of wider class of adjacent questions).

One of ways of the decision of the named problem is the reducing of a differential problem to system of the ordinary differential equations using thus, for example, a method of final volumes [2].

Continuing beforehand mentioned subjects we shall consider the forming of simple algorithms for modelling of the transfer problem of different substances (concentration, heat, moisture, and e. c.) in plate.

ISBN 9984 – 779 – 06 – 8

Materials and methods

Mathematical model

Let's consider transfer problem of m substances $(m \geq 2)$ in the plate $\Omega = \{0 \leq x \leq l, -\infty < y < +\infty, -\infty < z < +\infty\}$ with thickness l. We shall consider the initial – boundary value problem of system m PDE -s for vector – function (vector – column) $u = u(x,t) = \{u^{(1)}(x,t), u^{(2)}(x,t), ..., u^{(m)}(x,t)\}^T$ in the following form

$$G\frac{\partial u}{\partial t} = L\frac{\partial^2 u}{\partial x^2} - Q(x,t), \tag{1.1}$$

where G is quadratic – matrix $m \times m$ with constant elements $g^{(i,j)}$ $(\det(G) \neq 0)$, L is quadratic, positive definite matrix $m \times m$ with constant elements $l^{(i,j)} > 0$, Q is vector – column $m \times 1$ with elements $q^{(i,j)}(x,t), i, j = \overline{1,m}$. The boundary conditions on the surfaces $x = 0, x = l$ are

$$L\frac{\partial u(0,t)}{\partial x} = \alpha_0(u(0,t) - T_0),\ L\frac{\partial u(l,t)}{\partial x} = \alpha_l(T_l - u(l,t)), \tag{1.2}$$

where α_0, α_l are the positive definite matrix (transfer matrix) with constant elements $\alpha_0^{(i,j)}, \alpha_l^{(i,j)}$, T_0, T_l are known vector – functions with constant elements $T_0^{(j)}, T_l^{(j)}, j = \overline{1,m}$.

For the initial conditions for $t = 0$ we give

$$u(x,0) = \varphi(x), \tag{1.3}$$

where $\varphi(x)$ is vector – column with elements $\varphi^{(j)}(x), j = \overrightarrow{1,m}$.

If the elements of matrix α_0, α_l are equal infinity, then we have the first kind boundary conditions in the form

$$u(0,t) = T_0,\ u(l,t) = T_l \tag{1.4}$$

The vector transfer equation (1.1) can be presented in the following form

$$L\frac{\partial^2 u}{\partial x^2} = F, \tag{1.5}$$

where the vector column $F = G\dot{u} + Q$, $\dot{u} \equiv \frac{\partial u}{\partial t}$. If $\dot{u} = 0$ and $Q = Q(x)$, then we have the stationary vector boundary – value problem (1.2), (1.5).

The exact vector 3 – points finite difference scheme in the stationary case

We use the method of finite volumes [2-2] for approximation of the differential problem (1.1) – (1.4). We consider $N+1$ grid points in the x - direction $0 < x_0 < x_1 < ... < x_N = l$ with steps $h_k = x_k - x_{k-1}, k = \overline{1,N}$. The exact vector finite – difference scheme for given vector – function F can be obtained in similar [2, 5] form

$$\begin{cases} Lh_1^{-1}(u_1 - u_0) - \alpha_0(u_0 - T_0) = \tilde{R}_0^+ \\ Lh_{k+1}^{-1}(u_{k+1} - u_k) - Lh_k^{-1}(u_k - u_{k-1}) = \tilde{R}_k,\ k = \overline{1, N-1}, \\ \alpha_l(T_l - u_N) - Lh_N^{-1}(u_N - u_{N-1}) = \tilde{R}_N^- \end{cases} \tag{2.1}$$

where $u_k = u(x_k,t) \equiv u_k(t)$, $\tilde{R}_k = \tilde{R}_k^+ + \tilde{R}_k^-, k = \overline{1,N-1}$, $\tilde{R}_k^+ = GR_k^+ + I_k^+$, $\tilde{R}_k^- = GR_k^- + I_k^-$,

$$R_k^- = \frac{1}{h_k}\int_{x_{k-1}}^{x_k}(x - x_{k-1})\dot{u}_k(x,t)dx, \qquad R_k^+ = \frac{1}{h_{k+1}}\int_{x_k}^{x_{k+1}}(x_{k+1} - x)\dot{u}_{k+1}(x,t)dx,$$

$$I_k^- = \frac{1}{h_k}\int_{x_{k-1}}^{x_k}(x - x_{k-1})Q(x,t)dx,\ I_k^+ = \frac{1}{h_{k+1}}\int_{x_k}^{x_{k+1}}(x_{k+1} - x)Q(x,t)dx$$

are the vectors – column of m order.

ISBN 9984 – 779 – 06 – 8

If Q is the constant vector, then integrals are in form $I_k^- = 0.5h_k Q$, $I_k^+ = 0.5h_{k+1}Q$.
In the non-stationary case $(\dot{u} \neq 0, Q = Q(x,t))$ we must do integrals $R_k^{\pm}$ approximately with corresponding quadrate formulas. Now we shall discuss only 3 grid points $x_0 = 0$ $x_1 = h_1$, $x_2 = l = h_1 + h_2$ $(N = 2)$.
The 3 - grid points problem and approximation of integrals
The vector finite – difference scheme ($\alpha_0 = \propto$ - the elements of matrix α_0 are equal to infinity or in the first boundary condition (1.2) $u(0,t) = T_0$) is in the form

$$\begin{cases} Lh_2^{-1}(u_2 - u_1) - Lh_1^{-1}(u_1 - T_0) = G(R_1^+ + R_1^-) + I_1 \\ \alpha_l(T_l - u_2) - Lh_2^{-1}(u_2 - u_1) = GR_2^- + I_2^- \end{cases} \tag{3.1}$$

where $I_1 = I_1^- + I_1^+$, $R_1^+ = \dfrac{1}{h_2}\int\limits_{h_1}^{l}(l - x)\dot{u}(x,t)dx = h_2 J_1$, $R_2^- = \dfrac{1}{h_2}\int\limits_{h_1}^{l}(x - h_1)\dot{u}(x,t)dx = h_2 J_2$,

$$J_1 = \int\limits_0^1 (1 - \tilde{x})V_2(\tilde{x})d\tilde{x} \ , \qquad J_2 = \int\limits_0^1 \tilde{x}V_2(\tilde{x})d\tilde{x} \ , \qquad \tilde{x} = (x - h_1)/h_2, \qquad V_2(\tilde{x}) = \dot{u}(h_1 + \tilde{x}h_2, t),$$

$$R_1^- = \frac{1}{h_1}\int\limits_0^{h_1} x\dot{u}(x,t)dx = h_1 J_3 \ , \ J_3 = \int\limits_0^1 \tilde{x}V_1(\tilde{x})d\tilde{x} \ , \ \tilde{x} = x/h_1, \ V_1(\tilde{x}) = \dot{u}(\tilde{x}h_1, t).$$

In the non-stationary case $(\dot{u}_k \neq 0)$, using initial – value problem for system of ODE one must do integrals R_1^+, R_1^-, R_2^- approximately with quadrature formulas contained the derivatives of the first and second order in following way:

$$J_k = A_1^{(k)}V_2(0) + A_2^{(k)}V_2(1) + A_3^{(k)}V_2'(1) + B_1^{(k)}V_2''(0) + B_2^{k}V_2''(1) + r_k, \ k = 1,2 \tag{3.2}$$

$$J_3 = A_1^{(3)}V_1(0) + A_2^{(3)}V_1(1) + B_1^{(3)}V_1''(0) + B_2^{(3)}V_1''(1) + r_3 \tag{3.3}$$

where $r_k = \dfrac{h_2^5}{5!}\partial^5\dot{u}(\xi_k,t)/\partial x^5 C_k, \xi_k \in [h_1, l], k = 1,2$, $r_3 = \dfrac{h_1^4}{4!}\partial^4\dot{u}(\xi_k,t)/\partial x^4 C_3, \xi_3 \in [0, h_1]$,
are the vectors – error terms, $A_j^{(k)}, B_j^{(k)}, C_k \ (j,k = 1,2,3)$ are the indefinite coefficients.
The coordinates of vectors $J_k, k = 1,2,3$, $V_1(0)$, $V_2(0)$, $V_1(1)$, $V_2(1)$, $V_2'(1)$, $V_1''(0)$, $V_1''(1)$, $V_2''(0)$, $V_2''(1)$ are independent of the coefficients of quadrature formulas and we can determine the coefficients using the scalar power functions $V_1(\tilde{x}) = \tilde{x}^i, i = \overline{0,4}$, $V_2(\tilde{x}) = \tilde{x}^i, i = \overline{0,4}$. We get the system of linear algebraic equations for $A_j^{(k)}$, $B_j^{(k)}$ in the form

$$1/(i+1)(i+2) = A_1^{(1)}0^i + A_2^{(1)} + iA_3^{(1)} + i(i-1)\left(B_1^{(1)}0^{i-2} + B_2^{(1)}\right); \tag{3.4}$$

$$1/i + 2 = A_1^{(2)}0^i + A_2^{(2)} + iA_3^{(2)} + i(i-1)\left(B_1^{(2)}0^{i-2} + B_2^{(2)}\right); \tag{3.5}$$

$$1/(i+2) = A_1^{(3)}0^i + A_2^{(3)} + i(i-1)\left(B_1^{(3)}0^{i-2} + B_2^{(3)}\right); \tag{3.6}$$

where $0^j = 1, \ j \leq 0$.
The solutions of these systems are
$A_1^{(1)} = 7/30$, $A_2^{(1)} = 4/15$, $A_3^{(1)} = -(1/10)$ $B_1^{(1)} = -(1/180)$, $B_2^{(1)} = -(1/72)$, $A_1^{(2)} = 1/15$, $A_2^{(2)} = 13/30$, $A_3^{(2)} = -(1/10)$, $B_1^{(2)} = -(1/360)$ $B_2^{(2)} = 1/90$, $A_1^{(3)} = 1/6$, $A_2^{(3)} = 1/3$, $B_1^{(3)} = -(7/360)$, $B_2^{(3)} = -(1/45)$.
Constants C_k in the residual $r_k \ (k = \overline{1,3})$ are determined from (3.2), (3.3) if $V_1(\tilde{x}) = \tilde{x}^4$, $V_2(\tilde{x}) = \tilde{x}^5$:
$C_1 = -(13/630)$, $C_2 = -(4/315)$, $C_3 = 1/10$.

ISBN 9984 – 779 – 06 – 8

Results and discussion

By means of the considered algorithm it is possible to receive the following results:

1. In the case of $\alpha_0 \neq \infty$ we can in the formula (3.3) add the term $A_3^{(3)}V_1'(0)$ and in the formula (3.6) the term $iA_3^{(3)}0^{i-1}$; then $A_1^{(3)} = 4/15$, $A_2^{(3)} = 7/30$, $A_3^{(3)} = 1/10$, $B_1^{(3)} = 1/72$, $B_2^{(3)} = -(1/180)$, $C_3 = 13/630$, $r_3 = O(h_1^5)$;

2. If the formula (3.2), (3.3) contains the derivative of the first order $\left(B_1^{(k)} = B_2^{(k)} = 0\right)$, then $A_1^{(1)} = A_2^{(1)} = 1/4$, $A_3^{(1)} = -(1/12)$, $C_1 = 1/20$; $r_1 = O(h_2^3)$, $A_1^{(2)} = 1/12$, $A_2^{(2)} = 5/12$, $A_3^{(2)} = -(1/12)$, $r_2 = O(h_2^3)$, $A_1^{(3)} = 1/6$, $A_2^{(3)} = 1/3$, $C_3 = -(1/12)$, $r_3 = O(h_1^2)$.

3. If the integrals J_1 are approximated without the derivatives $\left(A_3^{(1)} = B_1^{(1)} = B_2^{(1)} = 0\right)$, then from (3.4) we obtain [7, 8]

$A_1^{(1)} = 1/3$, $A_2^{(1)} = 1/6$, $C_1 = -(1/12)$; $r_1 = O(h_2^2)$

4. If the integrals J_3 (similar J_2) are approximated without the derivatives of second order and $\alpha_0 \neq \infty$ (in the formula (3.3) we have term $A_3^{(3)}V_1'(0)$) then from (3.6) we obtain

$A_1^{(3)} = A_2^{(3)} = 1/4$, $A_3^{(3)} = 1/12$, $C_3 = -(1/20)$; $r_3 = O(h_1^3)$;

5. In the case of $\alpha_0 \neq \infty$ we have by (3.1) adding from (2.1) vector difference equations

$$Lh_1^{-1}(u_1 - u_0) - \alpha_0(u_0 - T_0) = GR_0^+ + I_0^+,$$

where $R_0^+ = \dfrac{1}{h_1}\int_0^{h_1}(h_1 - x)\dot{u}(x,t)dx = h_1 J_0$, $J_0 = \int_0^1 (1-\tilde{x})V_1(\tilde{x})d\tilde{x}$ - and in the first equations (3.1) replace vector T_0 by u_0. Then

$$J_0 = A_1^{(0)}V_1(0) + A_2^{(0)}V_1(1) + A_3^{(0)}V_1'(0) + B_1^{(0)}V_1''(0) + B_2^{(0)}V_1''(1) + r_0 \ ,$$

where $r_0 = \dfrac{h_1^5}{5!}\partial^5\dot{u}(\xi_0,t)/\partial x^5 C_0,\ \xi_0 \in [0,h_1]$

In this case we have the equations for $A^{(0)}, B^{(0)}$ in the form

$$1/(i+1)(i+2) = A_1^{(0)}0^i + A_2^{(0)} + iA_3^{(0)}0^{i-1} + i(i-1)\left(B_1^{(0)}0^{i-2} + B_2^{(0)}\right),\ i = \overline{0,4},$$

where $A_1^{(0)} = 13/30$, $A_2^{(0)} = 1/15$, $A_3^{(0)} = 1/10$ $B_1^{(0)} = 1/90$, $B_2^{(0)} = -(1/360)$.

If $V_1(\tilde{x}) = \tilde{x}^5$, then $C_0 = 4/315$.

Using the vector difference equation (3.1) and the right – side integral approximation (3.2), (3.3) with the neglected error terms $r_k, k = 1,2,3$, the approximate numerical solutions – vectors $u_1(t), u_2(t)$ at every time moment $t > 0$ can be found by solving the following vector system of ODE – s of second order $(\dot{u}_0 = \ddot{u}_0 = 0, \alpha_0 = \infty)$:

$$\begin{aligned} &Gh_2\left(A_1^{(1)}\dot{u}_1 + A_2^{(1)}\dot{u}_2 - h_2A_3^{(1)}L^{-1}\alpha_l\dot{u}_2 + h_2^2B_1^{(1)}L^{-1}\left(\dot{Q}(h_1,t) + 6\ddot{u}_1\right) + h_2^2B_2^{(1)}L^{-1}\left(\dot{Q}(l,t) + 6\ddot{u}_2\right)\right) + \\ &6h_1\left(A_2^{(3)}\dot{u}_1 + h_1^2B_1^{(3)}L^{-1}\dot{Q}(0,t) + h_1^2B_2^{(3)}L^{-1}\left(\dot{Q}(h_1,t) + 6\ddot{u}_1\right)\right) + I_1 = L\left(h_2^{-1}(u_2 - u_1) - h_1^{-1}(u_1 - T_0)\right) \end{aligned} \quad (3.7)$$

$$\begin{aligned} &Gh_2\left(A_1^{(2)}\dot{u}_1 + A_2^{(2)}\dot{u}_2 - h_2A_3^{(2)}L^{-1}\alpha_l\dot{u}_2 + h_2^2B_1^{(2)}L^{-1}\left(\dot{Q}(h_1,t) + 6\ddot{u}_1\right) + h_2^2B_2^{(2)}L^{-1}\left(\dot{Q}(l,t) + 6\ddot{u}_2\right)\right) + \\ &+ I_2^- = \alpha_l(T_l - u_2) - Lh_2^{-1}(u_2 - u_1) \end{aligned} \quad (3.8)$$

The initial conditions are

$$u_1(0) = \varphi(h_1),\ u_2(0) = \varphi(l),\ \dot{u}_1(0) = G^{-1}\left(L\varphi''(h_1) - Q(h_1,0)\right),$$
$$\dot{u}_2(0) = G^{-1}\left(L\varphi''(l) - Q(l,0)\right) \quad (3.9)$$

Here one should take in account that from (1.1 - 1.4) follows: $V_1(0) = \dot{u}_0$, $V_1(1) = \dot{u}_1$, $V_2(0) = \dot{u}_1$, $V_2(1) = \dot{u}_2$, $V_1'(0) = h_1\partial\dot{u}(0,t)/\partial x = h_1\partial u'(0,t)/\partial t = h_1L^{-1}\alpha_0\dot{u}_0$,

$V_2'(1) = h_2\partial u'(l,t)/\partial t = -h_2L^{-1}\alpha_l\dot{u}_2$, $V_1''(0) = h_1^2\partial^2\dot{u}(0,t)/\partial x^2 = h_1^2L^{-1}\left(G\ddot{u}_0 + \dot{Q}(0,t)\right)$

ISBN 9984 – 779 – 06 – 8

$V_1''(1) = h_1^2 L^{-1}\left(G\ddot{u}_1 + \dot{Q}(h_1,t)\right)$, $V_2''(0) = h_2^2 \partial^2 \dot{u}(h_1,t)/\partial x^2 = h_2^2 L^{-1}\left(G\ddot{u}_1 + \dot{Q}(h_1,t)\right)$,
$V_2''(1) = h_2^2 L^{-1}\left(G\ddot{u}_2 + \dot{Q}(h_1,t)\right)$, where $u' = \partial u/\partial x$.

The uniform grid in the 3 – points problem

If $h_1 = h_2 = h$, then we can approximate both integrals $R_1 = R_1^+ + R_1^-$ and R_2^- in equations (3.1), in the form

$R_1/h = J_1 = \int_0^1 \tilde{x} V(\tilde{x}) d\tilde{x} + \int_1^2 (2-\tilde{x}) V(\tilde{x}) d\tilde{x}$, $\quad R_2^-/h = J_2 = \int_1^2 (\tilde{x}-1) V(\tilde{x}) d\tilde{x}$, $\quad \tilde{x} = x/h$, where $V(\tilde{x}) = \dot{u}(\tilde{x}h,t)$,

$$J_k = A_1^{(k)}V(0) + A_2^{(k)}V(1) + A_3^{(k)}V(2) + A_4^{(k)}V'(2) + B_1^{(k)}V''(0) + B_2^{(k)}V''(1) + B_3^{(k)}V''(2) + r_k, \quad (4.1)$$

$r_k = (h^7/7!)\partial^7 \dot{u}(\xi_k,t)/\partial x^7 C_k$, $\xi_k \in [0,l]$, $k = 1,2$.

Using the power functions $V(\tilde{x}) = \tilde{x}^i$, $i = \overline{0,6}$ in the expression (4.1) we obtain the solutions of two systems of 7 linear algebraic equations [8] in the form

$A_1^{(1)} = A_3^{(1)} = 11/252$, $A_2^{(1)} = 115/126$, $A_4^{(1)} = 0$, $B_1^{(1)} = B_3^{(1)} = -(13/15120)$
$B_2^{(1)} = 313/7560$, $A_1^{(2)} = 5/204$, $A_2^{(2)} = 13/252$, $A_3^{(2)} = 221/504$, $A_4^{(2)} = -(2/21)$,
$B_1^{(2)} = -(19/30240)$, $B_2^{(2)} = -(37/30240)$, $B_3^{(2)} = 269/30240$, $C_1 = 0$, $C_2 = -(16/315)$.

Therefore $r_1 = (h^8/8!)\partial^8 \dot{u}(\xi_1,t)/\partial x^8 C_1$ and $C_1 = 59/1890$.

Here from $V(0) = \dot{u}_0$, $V(1) = \dot{u}_1$, $V(1) = \dot{u}_2$, $V'(2) = -hL^{-1} - \alpha_l \dot{u}_2$, $V''(0) = h^2 L^{-1}\left(G\ddot{u}_0 + \dot{Q}_0\right)$, $V''(1) = h^2 L^{-1}\left(G\ddot{u}_1 + \dot{Q}_1\right)$, $V''(2) = h^2 L^{-1}\left(G\ddot{u}_2 + \dot{Q}_2\right)$ follows the system of ODE – s in the form

$$Gh^2\left(A_1^{(1)}\dot{u}_0 + A_2^{(1)}\dot{u}_1 + A_3^{(1)}\dot{u}_2 + h^2 L^{-1}\left(B_1^{(1)}\left(G\ddot{u}_0 + \dot{Q}_0\right) + B_2^{(1)}\left(G\ddot{u}_1 + \dot{Q}_1\right) + B_3^{(1)}\left(G\ddot{u}_2 + \dot{Q}_2\right)\right)\right) + hI_1 = L\left(u_2 - 2u_1 + T_0\right) \quad (4.2)$$

$$Gh^2\left(A_1^{(2)}\dot{u}_0 + A_2^{(2)}\dot{u}_1 + A_3^{(2)}\dot{u}_3 - hA_4^{(2)}L^{-1}\alpha_l \dot{u}_2 + h^2 L^{-1}\begin{pmatrix} B_1^{(2)}\left(G\ddot{u}_0 + \dot{Q}_0\right) + B_2^{(2)}\left(G\ddot{u}_1 + \dot{Q}_1\right) + \\ B_3^{(2)}\left(G\ddot{u}_2 + \dot{Q}_2\right)\end{pmatrix}\right) + hI_2^{-1} = h\alpha_l\left(T_l - u_2\right) - L\left(u_2 - u_1\right) \quad (4.3)$$

The following initial conditions are in the form (3.9).

If $\alpha_0 = \alpha_l = \infty$, $u_2 = T_l$, $Q = const$, then $\dot{u}_0 = \dot{u}_2 = 0$, then $\ddot{u}_0 = \ddot{u}_2 = 0$, $\dot{Q} = 0$ and from (4.2) follows the ODE of second order

$$Gh^2 A_2^{(1)}\dot{u}_1 + h^4 B_2^{(1)} G L^{-1} G \ddot{u}_1 + h^2 Q = L\left(T_l - 2u_1 + T_0\right) \quad (4.4)$$

If in the formula (4.1) are only the values $V(0), V(1)$ used, then we have the system of ODE –s of first order

$$h^2\left((2/3)G\dot{u}_1 + Q\right) = L\left(T_l - 2u_1 + T_0\right). \quad (4.5)$$

If in the formula (4.1) are the values $V(0), V(1), V(2)$ used, then we have the following system of ODE –s of first order with error term $O(h^4)$ [7, 8]

$$h^2\left((5/6)G\dot{u}_1 + Q\right) = L\left(T_l - 2u_1 + T_0\right). \quad (4.6)$$

Application example1

Let us consider the case $Q = 0$, $T_0 = T_l = 0$, $\varphi(x) = \left(\sin(\pi x), \sin(\pi x)\right)^T$, $l = 1$, $h = 0.5$, $L = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$, $G = \begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix}$, then the exact solution of PDE problem (1.1), (1.3), (1.4) is

$$u(x,t) = \left(e^{-\pi^2 t}\sin(\pi x), e^{-\pi^2 t}\left(1 + \pi^2 t\right)\sin(\pi x)\right)^T \text{ or } u_1 = u(h,t) = \left(e^{-\pi^2 t}, e^{-\pi^2 t}\left(1 + \pi^2 t\right)\right)^T. \quad (4.7)$$

From the first order ODE – s (error $O(h^2)$) follows the initial – value problem $G\dot{u}_1 = -12u_1$, $u_1(0) = (1,1)^T$ with the solutions $u_1 = \left(e^{-12t}, e^{-12t}\left(1 + 9.6t\right)\right)^T$. (4.8)

ISBN 9984 – 779 – 06 – 8

Therefore in the (4.7) the value π^2 is replaced with 12.
From the ODE – s (4.6) (error $O(h^4)$) follows the equations $G\dot{u}_1 = -9.6u_1$ and the solution is

$$u_1 = \left(e^{-9.6t}, e^{-9.6t}(1+9.6t)\right)^T, \tag{4.9}$$

therefore in the (4.7) the value π^2 is replaced with 9.6.
From the second order ODE – s (4.4) (error $O(h^8)$) follows the initial – value problem

$$\begin{cases} b_1 G^2 \ddot{u}_1 + a_1 G\dot{u}_1 + u_1 = 0 \\ u_1(0) = (1,1)^T,\ \dot{u}_1(0) = -G^{-1}\left(\pi^2, \pi^2\right)^T = \left(-\pi^2, 0\right)^T \end{cases}, \tag{4.10}$$

where $G^2 = \begin{pmatrix} 1 & 0 \\ 2 & 1 \end{pmatrix}$, $G^{-1} = \begin{pmatrix} 1 & 0 \\ -1 & 1 \end{pmatrix}$, $a_1 = h^2 A_2^{(1)}/2$, $b_1 = h^4 B_2^{(1)}/2$, $A_2^{(1)} = 115/8.126$, $B_2^{(1)} = 313/32.7560$, $b_1 = 1/32$, $a_1 = 1/8$.
Let denote $u_1^{(1)} \equiv y$, $u_1^{(2)} \equiv z$, then we have the initial – value system of two ODE – s of second order

$$\begin{cases} b_1\ddot{y} + a_1\dot{y} + y = 0,\ y(0) = 1,\ \dot{y}(0) = -\pi^2 \\ b_1\ddot{z} + a_1\dot{z} + z = -2b_1\ddot{y} - a_1\dot{y},\ z(0) = 1,\ \dot{z}(0) = 0 \end{cases}.$$

The solution is

$$\begin{cases} y(t) = D_1 \exp(\mu_1 t) + D_2 \exp(\mu_2 t) \\ z(t) = D_1(1-\mu_1 t)\exp(\mu_1 t) + D_2(1-\mu_2 t)\exp(\mu_1 t) \end{cases}, \tag{4.11}$$

where $\mu_{1,2} = -a_1/(2b_1) \pm \sqrt{(a_1/2b_1)^2 - 1/b_1}$, $\mu_1 = -9.87$, $\mu_1 = -78.3$,
$D_1 = \left(\mu_2 + \pi^2\right)/\left(\mu_2 - \mu_1\right)$, $D_2 = -\left(\pi^2 + \mu_1\right)/\left(\mu_2 - \mu_1\right)$.
Using the approximation $u''(h,t) \approx \Lambda u_1 = -h^{-2}2u_1(t)$ (the method of lines with error $O(h^2)$) we get first order ODE – s $G\dot{u}_1 = -8u_1$ and the solution is

$$u_1 = \left(e^{-8t}, e^{-8t}(1+8t)\right)^T, \tag{4.12}$$

therefore in the exact solution (4.7) the value π^2 is replaced with 8.
Using the approximation $u''(h,t) \approx \Lambda u_1 - \left(h^2/12\right)\partial^4 u(h,t)/\partial x^4 = \Lambda u_1 - \left(h^2/12\right)\left(L^{-1}G\right)^2 \ddot{u}_1$ (the method of lines with error $O(h^4)$), we have the problem (4.10) with $b_1 = \left(h^4/24\right) = 1/384$, $a_1 = \left(h^2/2\right) = 1/8$, and the solution is in the form (4.11).
The results of calculation obtained by MAPLE are seen in the Table 1 and Table 2, where u_*, v_* - exact values of $u_1^{(1)}, u_1^{(2)}$ from (4.7); u_{p2}, v_{p2} - values with approximation $O\left(h^2\right)$ from (4.8); u_{p4} v_{p4} - values with approximation $O\left(h^4\right)$ from (4.9); u_{p8} v_{p8} - values with $O\left(h^8\right)$ from (4.11); u_{t2}, v_{t2} - values with $O\left(h^2\right)$ from (4.12) (method of lines); u_{t4}, v_{t4} - values with $O\left(h^4\right)$ from (4.11) (method of lines).

Table 1

The values of $u(0.5,t)$ in order of time

t	u_*	v_*	u_{p8}	v_{p8}	u_{p4}	v_{p4}
0.1	.372708	.740556	.372696	.740546	.383	.750
0.2	.138911	.413111	.138902	.413092	.147	.482
0.3	.051773	.205068	.051768	.205052	.056	.218
0.4	.019296	.095475	.019294	.095464	.021	.104
0.5	.007192	.042682	.007191	.042676	.008	.048

ISBN 9984 – 779 – 06 – 8

Table 2

The values of $u(0.5,t)$ in order of time

t	u_{p2}	v_{p2}	u_{t2}	v_{t2}	u_{t4}	v_{t4}
0.1	.301	.663	.449	.809	.366	.737
0.2	.091	.308	.202	.525	.133	.402
0.3	.027	.126	.091	.308	.048	.195
0.4	.008	.048	.041	.171	.017	.088
0.5	.002	.017	.018	.092	.006	.038

Application example2

In [1] by modelling textile package are considered the equations for diffusion of heat and moisture in the following form

$$\begin{cases} a_1\partial C/\partial t - b_1\partial T/\partial t = c_1\partial^2 C/\partial x^2 \\ -b_2\partial C/\partial t + a_2\partial T/\partial t = c_2\partial^2 T/\partial x^2 \end{cases}, \tag{4.13}$$

where $a_1 = 1+\gamma\sigma$, $a_2 = 1+\varepsilon\varpi$, $b_1 = \gamma\varpi$, $b_2 = \varepsilon\sigma$, $c_1 = gD_A$, $c_2 = K/(c\rho)$, $\gamma = (1-v)/v\rho_S$, $\varepsilon = q/c$, $M = const + \sigma C - \varpi T$ - the amount of moisture absorbed by unit mass of fibre, T - the temperature, C - concentration of water vapour in the air space, σ, ϖ - constants, D_A - diffusion coefficient for moisture on air, v - fraction of the total volume of the package is occupied by air and 1 – v by fibre of density ρ_S, g - factor of fibres orientation, c - the specific heat of the fibres, K - the heat conductivity of the package, ρ - the density of the package, q - the heat evolved when the water vapour is absorbed by the fibres.

The system of two PDE – s (4.13) is in form (1.1), where

$Q = 0$, $u = (C,T)^T$ - vector – column, $G = \begin{pmatrix} a_1 & -b_1 \\ -b_2 & a_2 \end{pmatrix}$, $L = \begin{pmatrix} c_1 & 0 \\ 0 & c_2 \end{pmatrix}$, $c_1 > 0$, $c_2 > 0$,

$\det(G) = a_1a_2 - b_1b_2 = (1+\gamma\sigma)(1+\varepsilon\varpi) - \gamma\varpi\varepsilon\sigma = 1+\gamma\sigma+\varepsilon\varpi > 0$.

The boundary conditions in the element of textile package are in the form $(x = l)$

$$\begin{cases} L\dfrac{\partial u(l,t)}{\partial x} = -\alpha_l\left(-u(l,t)+U_l\right) \\ u(0,t) = U_0 \end{cases}, \tag{4.14}$$

where $U_0 = (C_0,T_0)^T$, $U_l = (C_l,T_l)^T$ are given vectors – column, α_l - diagonal – matrix $\begin{pmatrix} \alpha_{lC} & 0 \\ 0 & \alpha_{lT} \end{pmatrix}$, where α_{lC}, α_{lT} - corresponding transfer coefficients.

The 3 – point finite – difference scheme is (3.1) and following system of ODE – s is in form (3.7), where $L^{-1} = \begin{pmatrix} c_1^{-1} & 0 \\ 0 & c_2^{-1} \end{pmatrix}$.

The vector $\varphi(x) = (C_*(x),T_*(x))^T$ is the initial distributions of C and T in the package by $t = 0$.

ISBN 9984 – 779 – 06 – 8

Conclusions

The aim of this paper was to continue and improve the methods described in [2-2-5-8]. The approximations of initial – boundary value problem of the system of the partial differential equations (PDE) to initial value problem for a system of ordinary differential equations (ODE) of the first or second order is considered. The described method is based on the finite – volume method. It is possible to solve transfer problems of $m > 2$ different substances (concentration, heat, moisture, and e. c.) in plate due to the obtained finite – difference vector scheme. The computations were processed by mathematical system MAPLE. The accuracy of obtained method was verified in the example 1 (due to the exact solution of PDE (4.7)). The most precise results are achieved from (4.11) with the error $O(h^8)$: 3 –4 signs of accuracy (Table 1) and from (4.11) (method of lines) with the error $O(h^4)$: 1- 2 signs of accuracy (Table 2).

Taking advantages of computer technique and appropriate mathematical approach now it is possible to deal with such theoretical and practical problems, solutions of them in the past was impossible (example 2).

References

1. Crank, J. The mathematics of diffusion, Oxford, Clarendon Press, 1956, p. 303 – 325.
2. Kalis, H. Effective finite-difference scheme for solving some heat transfer problems with convection in multilayer media. International Journal of Heat and Mass Transfer 43 2000, p.4467-4474.
3. Kalis, H., Kangro, I. The methods of engineering calculation heat transfer process through one layer for numerical modelling. Proc. Of the Int. conf.: ''Integration problems of the Baltic sea region countries on their way to the European Union'', March 2-3, 2000, Rēzekne, 2000, p.44-50.
4. Kalis, H., Kangro, I. Simulation of the heat transport problems with radiation in plate. In.: Proc. Of the Int. conf.: "Environment, technology, resources'', Rezekne, June 19-21, 2001, p.273-279.
5. Kalis, H., Kangro, I. Simple algorithm's for the calculation of heat transport problem in plate. In.:R. Čiegis (ed.) MATHEMATICAL MODELLING AND ANALYSIS, Vol.6 Nr.1, Vilnius, 2001, p.85-96.
6. Kalis, H., Kangro, I. Design procedure of distribution of temperatures in the three-layer environment. In.: Proc. Of the Int. conf.: ''Traditions and innovations in sustainable development of society'', Rezekne, February 28-March 2, 2002, p.176-186.
7. Kalis, H., Kangro, I. Simple methods of engineering calculation for solving heat transfer problems. In.: R. Čiegis (ed.) MATHEMATICAL MODELLING AND ANALYSIS, Vol.8 Nr.1, Vilnius, 2003, p.33-42.
8. Kalis, H., Kangro I. Promotion of accuracy engineering – technical calculations of heat transfer in two layer environment. In.: Proc. of the Int. conf.: ''Scientific Achievements for Wellbeing and Development of Society – Enabling Environment for Society Wellbeing'', Rēzekne, March 4-5, 2004, Rēzeknes Augstskola, p.91-98.
9. Васильев П. П. Безопасность жизнедеятельности. М.: ЮНИТИ, 2003, с.120-129.
10. Семенченко Б.А. Физическая метеорология. М.: Аспект Пресс, 2002, с.156-196.

ISBN 9984 – 779 – 06 – 8

THE EFFECTIVENESS OF THE LEARNING ALGORITHM OF RADIAL BASIS NETWORKS WITH RELATION TO THE TRANSFER FUNCTIONS APPLIED ON THE EXAMPLE OF MAPPING OF THE LIE LAND OF ZIELONA GORA CITY

APMĀCĪBAS ALGORITMA EFEKTIVITĀTE PILSĒTAS VIDES PLĀNOŠANAS UZDEVUMA GADĪJUMĀ

MARIA MRÓWCZYŃSKA

University of Zielona Góra, Institute of Building Engineering
65-516 Zielona Góra, ul. Z. Szafrana 2, Poland
Phone: + 48 683282636, *e-mail*: m.mrowczynska@ib.uz.zgora.pl

Abstract. *The article presents problems connected to the use of radial basis networks for the approximation of the ground surface. The main goal of this paper is to research into the precision of topographic profile representation with relation to the transfer functions applied. The paper contains a description of the structure of a radial basis network and a description of networks learning by means of the hybrid method with the use of the notion of the Green matrix pseudoinverse. Special attention was given to the problem of a choice of transfer functions: the Gauss function, the exponential function, the Hardy function, the spliced function of the third and fourth degree as well as bicentral functions with an independent slope and rotation. the result of this article is an example of the operation of a network with relation the transfer functions under discussion.*

Key words: *radial basis networks, transfer functions, topographic profile representation.*

Introduction

From the mathematical point of view multilayer sigmoidal neural networks play the part of the approximation of stochastic functions with several variables, which represent the set of input variables $\boldsymbol{x} \in R^N$ onto the set of output variables $\boldsymbol{y} \in R^M$ [3]. The representation of the input set onto the output set is effected by adjusting an approximation function of several variables to the values assigned i.e. stretching over the learning set of a multidimensional hyperplane, which best adapts to the vector assigned.

Basis networks, in which a hidden neuron realizes a function changing around a chosen center $\boldsymbol{c}$, are networks with radial basis functions $\varphi = \left(\|\boldsymbol{x} - \boldsymbol{c}\|\right)$. The role of the hidden neuron boils down to the radial representation of the space around one point assigned or a group of such points as a cluster.

The simplest radial network (fig. 1) operates on the basis of multidimensional interpolation, which consists in adopting p hidden neurons of the radial type and specifying a representation function *F(x)* for which the conditions of interpolation are satisfied.

$$F\left(\boldsymbol{x}_i\right) = d_i \tag{1}$$

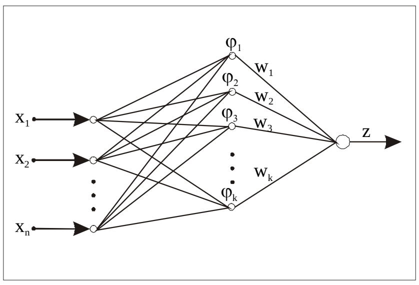


Fig. 1. **The general radial network form**

ISBN 9984 – 779 – 06 – 8

The generalization properties of a network are degraded when the number of radial functions is the same as the number of learning data. In this course of action i.e. with the assumption that the number of centres equals the number of coordinates of the input vector $(c_i = x_i, \;\; i = 1, \ldots, p)$, the model adapts to the learning data, because the number of extents of freedom for the system (the number of equations – the number of unknown quantities)

$$\begin{bmatrix} \varphi_{11} & \varphi_{12} & \cdots & \varphi_{1K} \\ \varphi_{21} & \varphi_{22} & \cdots & \varphi_{2K} \\ \cdots & \cdots & \cdots & \cdots \\ \varphi_{p1} & \varphi_{p2} & \cdots & \varphi_{pK} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \cdots \\ w_K \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \\ \cdots \\ d_p \end{bmatrix} \tag{2}$$

is zero. From the above, the generalization quantities of a network are obtained when the condition $K < p$ is fulfilled, where K is the number of centres c_i $(i = 1, 2, \ldots, K)$, and p is the number of learning standards $(\boldsymbol{x}, \boldsymbol{d})$. The vector $\boldsymbol{x}$ is an input vector, and the vector $\boldsymbol{d}$ is an assigned vector.

Materials and methods

It has been proved [3] that the adoption of a sufficient number of hidden neurons representing radial functions $\varphi(\boldsymbol{x})$ makes it possible to solve the task by means of only two network layers: the hidden layer realizing the function transfer vector $\varphi(\boldsymbol{x})$ of the i^{th} neuron and the output layer with one neuron, whose signal is the function of a linear weighted adder.

The architecture of radial networks is analogous in structure to the structure of a multiplayer neural network with one hidden layer and a linear output neuron. The argument of a radial function is the distance between the input signal x_i and the centre c_i, and the role of hidden neurons is played by radial basis functions.

The most frequently used radial function is the Gauss function. With the assumption that its centre is in point c_i the function has the form (reduced):

$$\varphi(\boldsymbol{x}) = \varphi(\|\boldsymbol{x} - c\|) = \exp(-\frac{\|\boldsymbol{x} - c_i\|^2}{2\delta_i^2}) \tag{3}$$

where δ_i is the parameter which determines the width of the function. Apart from the Gauss function a radial exponential function is used [3,5]

$$\varphi(\|\boldsymbol{x} - c\|) = \frac{1}{\sqrt{\|\boldsymbol{x} - c\|^2 + \sigma^2}} \tag{4}$$

and a radial linear function

$$\varphi(\|\boldsymbol{x} - c\|) = \|\boldsymbol{x} - c\|^{2n+1} \;\; (n = 1, 2, \ldots). \tag{5}$$

The diagrams of the abovementioned functions have been presented in figures 2a – 2c.

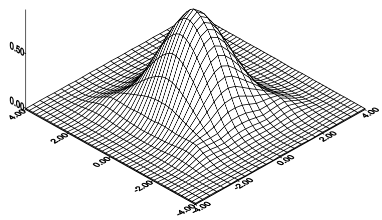


Fig. 2-a. **The Gauss function (3)**

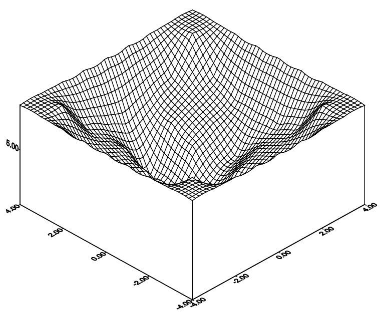


Fig. 2-b. **The exponential function (4)**

ISBN 9984 – 779 – 06 – 8

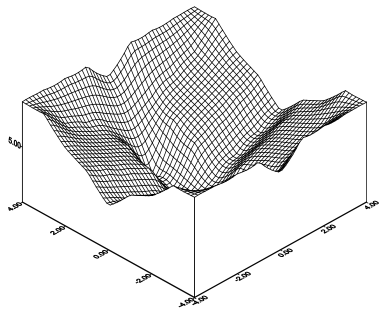


Fig. 2-c. **The linear function (5)**

Fig. 2. **Diagrams of radial basis functions**

Apart from the abovementioned radial basis functions, in particular cases other function definitions are used [1], such as for example a spliced function of the second degree

$$\varphi(\|x-c\|) = (\sigma\|x-c\|)^2 \ln(\sigma\|x-c\|) \tag{6}$$

a circular spliced function of the third degree

$$\varphi(\|x-c\|) = \frac{1}{4\sigma^2}\begin{cases} \sigma^3 + 3\sigma^2(\sigma-r) + 3\sigma(\sigma-r)^2 + 3(\sigma-r)^3 & \text{for } r \le \sigma \\ (2\sigma-r)^3 & \text{for } \sigma < r \le 2\sigma \\ 0 & \text{for } 2\sigma < r \end{cases} \tag{7}$$

and a circular spliced function of the fourth degree

$$\varphi(\|x-c\|) = \frac{1}{2\sigma^2}\begin{cases} -2r^2 + 3\sigma^2 & \text{for } r \le \sigma \\ (2\sigma-r)^2 & \text{for } \sigma < r \le 2\sigma \\ 0 & \text{for } 2\sigma < r \end{cases} \tag{8}$$

where $r = \|x-c\|^2$. Diagrams of the functions (6), (7), (8) have been presented in figures 3a – 3c.

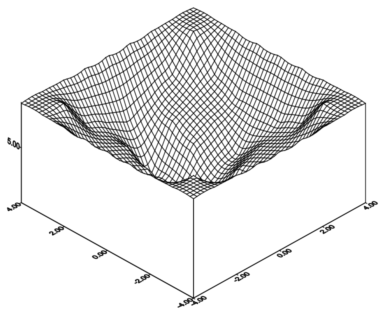


Fig. 3-a. **The spliced function (6)**

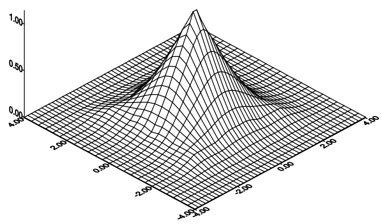


Fig. 3-b **The spliced function of the third degree (7)**

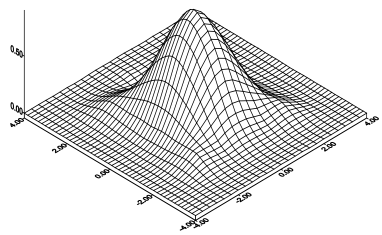


Fig. 3-c. **The spliced function of the fourth degree (8)**

Fig. 3. **Diagrams of radial basis functions**

ISBN 9984 – 779 – 06 – 8

Another group of functions used in the learning process of radial networks are bicentral functions [1], which result from a combination of two sigmoidal functions. The simplest bicentral function is defined as the product of two sigmoidal functions in the form

$$Bi(\boldsymbol{x},\boldsymbol{c},\boldsymbol{b},\boldsymbol{s})=\sum_{i=1}^{n}\delta(\exp(s_i)\times(x_i-c_i+\exp(b_i)))(1-\delta(\exp(s_i)\times(x_i-c_i-\exp(b_i)))) \tag{9}$$

where:

$\delta(x)=\dfrac{1}{(1+\exp(-x))}$,

$\boldsymbol{c}$ – centre,

$\boldsymbol{b}=\dfrac{\max(x_i)-\min(x_i)}{2}$ - broadening,

$\boldsymbol{s}$ – slope.

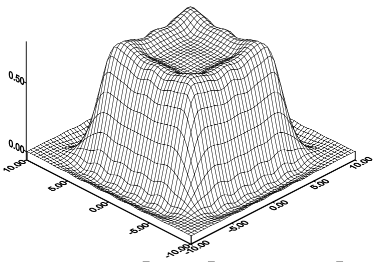


Fig. 4-a. $\boldsymbol{b}=[5 \quad 5]$ **and** $\boldsymbol{s}=[3 \quad 3]$

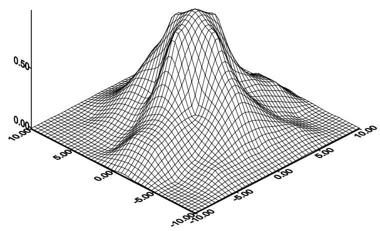


Fig. 4-b. $\boldsymbol{b}=[5 \quad 5]$ **and** $\boldsymbol{s}=[1 \quad 1]$

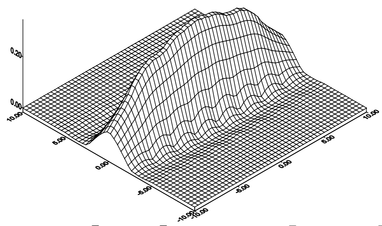


Fig. 4-c. $\boldsymbol{b}=[5 \quad 2]$ **and** $\boldsymbol{s}=[0.3 \quad 3]$

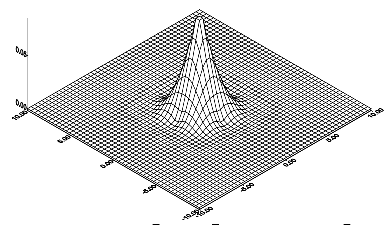


Fig. 4-d. $\boldsymbol{b}=[1 \quad 1]$ **and** $\boldsymbol{s}=[0.5 \quad 0.5]$

Fig 4. **Examples of bicentral functions for the broadening value b and the slope of the transfer functions**

The form of the bicentral function $B_i(\boldsymbol{x},\boldsymbol{c},\boldsymbol{b},\boldsymbol{s})$ can be changed by changing the position of the centre point $\boldsymbol{c}$, changing the broadening $\boldsymbol{b}$ and specifying the slope $\boldsymbol{s}$**.** Examples of bicentral functions with relation to the values assumed $\boldsymbol{b}$ and $\boldsymbol{s}$ have been presented in fig. 4a – 4d. The broadening $\boldsymbol{b}$ and the slope $\boldsymbol{s}$ as independent parameters make it possible to represent more complicated surface contours than do the Gauss functions [1]. An increase in the accuracy representation by means of bicentral functions is also possible because of the use of two centres $c_i+\exp(b_i)$ as well as $c_i-\exp(b_i)$, which is different in the case of radial base functions localised around one centre $\|x-c\|$. Another way of changing the form of a bicentral function is the use of two independent slopes s_i and s_i', which increases the adaptation flexibility of the functions estimated. The adoption of two independent slopes s_i and s_i' leads to the definition of a bicentral transfer function as:

$$Bi2s(\boldsymbol{x},\boldsymbol{c},\boldsymbol{b},\boldsymbol{s})=\sum_{i=1}^{n}\delta(\exp(s_i)\times(x_i-c_i+\exp(b_i)))(1-\delta(\exp(s_i')\times(x_i-c_i-\exp(b_i)))) \tag{10}$$

ISBN 9984 – 779 – 06 – 8

One of the learning algorithms for neural networks with radial basis functions is the hybrid algorithm, where learning consists in choosing a suitable number of parameters of radial functions $\varphi(\|\boldsymbol{x}-\boldsymbol{c}\|)$ and weights w_j so that the goal function is minimized to the form

$$E=\sum_{i=1}^{p}\left[\sum_{j=1}^{K} w_j \varphi\left(\|\boldsymbol{x}_i-\boldsymbol{c}_j\|-d_i\right)\right]^2 \tag{11}$$

With the assumption that the parameters of radial functions are known the minimization of the goal function boils down to solving a set of linear equations with relation to the weight vector $\boldsymbol{w}$ in the form

$$\mathbf{G}\boldsymbol{w}=\boldsymbol{d} \tag{12}$$

where $\mathbf{G}$ is a matrix containing the values of radial basis functions called the Green matrix in the form:

$$\mathbf{G}=\begin{bmatrix} \varphi_{11}=\left(\|\boldsymbol{x_1}-\boldsymbol{c_1}\|\right) & \varphi_{12}=\left(\|\boldsymbol{x_1}-\boldsymbol{c_2}\|\right) & \cdots & \varphi_{1K}=\left(\|\boldsymbol{x_1}-\boldsymbol{c_K}\|\right) \\ \varphi_{21}=\left(\|\boldsymbol{x_2}-\boldsymbol{c_1}\|\right) & \varphi_{22}=\left(\|\boldsymbol{x_2}-\boldsymbol{c_2}\|\right) & \cdots & \varphi_{2K}=\left(\|\boldsymbol{x_2}-\boldsymbol{c_K}\|\right) \\ \cdots & \cdots & \cdots & \cdots \\ \varphi_{p1}=\left(\|\boldsymbol{x_p}-\boldsymbol{c_1}\|\right) & \varphi=_{p2}\left(\|\boldsymbol{x_p}-\boldsymbol{c_2}\|\right) & \cdots & \varphi_{pK}=\left(\|\boldsymbol{x_p}-\boldsymbol{c_K}\|\right) \end{bmatrix}$$

The first stage of the hybrid algorithm is the specification of the weight vector w by means of the notion of the pseudoinverse $\mathbf{G}^+$ of the matrix $\mathbf{G}$ as

$$\boldsymbol{w}=\mathbf{G}^+\boldsymbol{d} \tag{13}$$

One of the ways of specifying the pseudoinverse $\mathbf{G}^+$ of the matrix $\mathbf{G}$ is the Gram-Schmidt method of ortogonalization, where the matrix $\mathbf{G}$ is decomposed into the matrices $\mathbf{Q}$ and $\mathbf{R}$ [2]. The matrix $\mathbf{Q}$ is a matrix with ortonormal columns with the dimensions $p\times K$, and the matrix $\mathbf{R}$ is an upper triangular matrix with the dimensions $K\times K$. According to this method the pseudoinverse is specified from the relation

$$\mathbf{G}^+=\boldsymbol{R}^{-1}\boldsymbol{Q}^T \tag{14}$$

In the second stage, with frozen values of input weights, centres and widths of radial basis functions are adapted with the use of gradient optimization methods, most frequently the method of the greatest fall. For the goal function defined by the formula (11) the adaptation of centres c and widths of basis functions σ is achieved according to the formulas

$$c_{ij}(n+1)=c_{ij}(n)-\eta\frac{\partial E}{\partial c_{ij}} \tag{15}$$

$$\sigma_{ij}(n+1)=\sigma_{ij}(n)-\eta\frac{\partial E}{\partial \sigma_{ij}} \tag{16}$$

where n – present interaction, $(n+1)$– subsequent interaction, η - learning coefficient.

Results and discussion

Radial basis functions including the transfer functions mentioned in this article have been used for describing topographic profile. The learning set consisted of 2000 points (*x, y, z*), generated as dispersed points, whose heights were within the limit of 80÷210 m. The assessment of the quality of neural networks with radial basis functions with relation to the transfer functions used has been expressed by means of the learning error – *RMSE* (*Root Mean Squared error*) and presented in fig. 5.

ISBN 9984 – 779 – 06 – 8

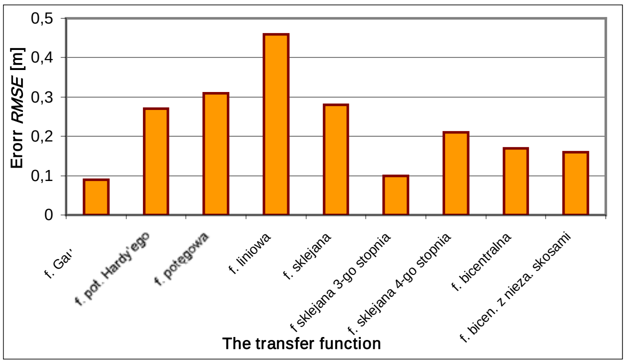


Fig. 5. **The learning results of a redial network with relation to the transfer function used**

The best learning result of a radial network was achieved when the Gauss function (1) was used as a transfer function, for which the learning error was *RMSE*=0.09m (fig. 6), and the greatest error *RMSE*=0.46m (fig. 7) occurred when a radial linear function was used (3). Learning was effected by means of the hybrid method in a learning set, which consisted of 2000 points and 500 test points, the number of neurons in the hidden layer was 20 [4].

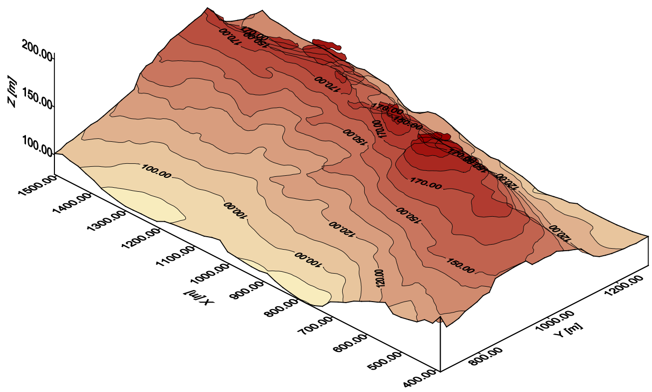


Fig. 6. **A representation of the terrain surface by means of the Gauss function**

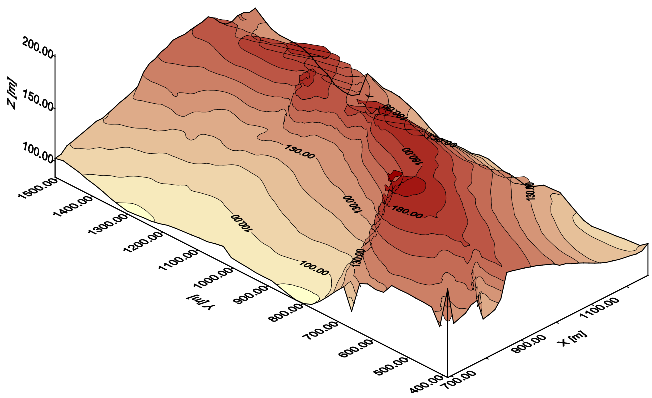


Fig. 7. **A representation of the terrain surface by means of a linear function**

ISBN 9984 – 779 – 06 – 8

Conclusions

While solving tasks by means of radial basis networks the basic problems are the right choice of initial parameters and as well as the most suitable transfer function for a particular problem. The use of a random choice of these parameters increases the probability of stopping the process of learning at a local minimum. Therefore, it is better to choose initial parameters by means of procedures based on information in the learning set, and parameters of radial functions obtained in this way are adopted as initial values. An advantage of radial networks is a simple learning algorithm and precise network architecture, which is a condition for the starting point to be closer to the optimum solution in comparison to the algorithm used in sigmoidal networks. Moreover, the hybrid approach to the specification of parameters of radial functions and the weight vector simplifies and quickens convergence to the solution of the task of approximation.

References

1. Jankowski N., Ontogeniczne sieci neuronowe. O sieciach zmieniających swoją strukturę. Akademicka Oficyna Wydawnicza EXIT, Warsaw 2003.
2. Kiełbasiński A., Schwetlick H., Numeryczna algebra liniowa. Wydawnictwo Naukowo – Techniczne, Warsaw 1992.
3. Osowski S., Sieci neuronowe w ujęciu algorytmicznym. Wydawnictwo Naukowo – Techniczne, Warsaw 1996.
4. Mrówczyńska M., The influence of normalisation of an input vector on the effect of numerical procedure with the use of the backprpagation error method. VI Międzynarodowa Konferencja Doktorantów. Brno 2004.
5. Żurada J., Barski M., Jędruch W., Sztuczne sieci neuronowe. Podstawy teorii i zastosowania, Wydawmnictwo naukowe PWN, Warsaw 1996.

ISBN 9984 – 779 – 06 – 8

DEVELOPMENT OF INTELLIGENT DECISION MAKING MODEL FOR STOCK MARKETS
INTELIĢENTA LĒMUMU PIEŅEMŠANAS MODEĻA IZSTRĀDE AKCIJU TIRGUS VAJADZĪBĀM

JOVITA NENORTAITE, RIMVYDAS SIMUTIS

Vilnius University Kaunas Faculty of Humanities Muitines 8, 44280
Kaunas, Lithuania, *Phone*: + 370 37 422566,
e-mail: jovita.nenortaite@vukhf.lt, rimvydas.simutis@vukhf.lt

Abstract. *This paper is focused on the development of intelligent decision making model which is based on the application of artificial neural networks (ANN) and swarm intelligence technologies. The proposed model is used to generate one-step forward investment decisions. The ANN are used to make the analysis of historical stock returns and to calculate one day forward possible profit, which could be get while following the model proposed decisions, concerning the purchase of the stocks. Subsequently the Particle Swarm Optimization (PSO) algorithm is applied in order to select the „global best" ANNs for the future investment decisions and to adapt the weights of other networks towards the weights of the best network. The experimental investigations were made considering different number of neural networks, moving time intervals and commission fees. The experimental results presented in the paper show that the application of our proposed methodology lets to achieve better results than the average of the market.*

Keywords: *Stock Markets, Artificial Intelligence, Artificial Neural Networks, Swarm Intelligence.*

Introduction

The continuing improvements of computer technologies, telecommunication services' grow make a big influence on the globalization of stock markets and more efficient its information processing tools are required. The complexity and „noisiness" of stock markets cause difficulties in making real time analysis of it and forecasting its changes in the future. Before, in stock markets the importance of decisions making was given to the stock market experts, as experts are able to provide rule and experience based solutions for well-defined systems. The situation is changing as the complexity of stock markets is growing. It was proved that having complex systems a collection of individuals often solves a problem better than an individual - even an expert [1]. Individuals acting within „a swarm" interact with each other in order to solve a global objective in a more efficient manner than a single individual could [4].

Recently, working with stock markets' prediction the bigger importance is given to the artificial intelligence tools then to the statistical once. It was proved by scientists, that the application of ANNs can give promising results in the stock markets prediction. The main objective of this paper is to develop the decision making model, based on the application of artificial intelligence tools: ANNs and swarm intelligence technologies (PSO).

The PSO is closely related to evolutionary computation and artificial life (A-life) in general [3]. The same as evolutionary programming it is highly dependent on stochastic processes. The optimizer which is used in the PSO algorithm, while making adjustment towards „local" and „global" best particles, is conceptually similar to the crossover operation used by genetic algorithms [5, 6]. As well PSO includes fitness function, which measures the closeness of the corresponding solution to the optimum. The same function is included in other paradigms of evolutionary computation. The main difference of PSO concept from the evolutionary computing is that PSO is the only evolutionary algorithm that does not incorporate survival of the fittest, which features the removal of some candidate population member [10].

The problem of stock markets forecasting was analyzed by many researchers in the past. Considerable efforts have been put into investigation of stock markets changes and creating its forecasting systems. But there are not so many examples of Swarm Intelligence applications. The swarm intelligence approach seems to be relatively new in the field of Computer Science. However, the published examples of swarm intelligence applications seem to be promising and

ISBN 9984 – 779 – 06 – 8

give good results. In paper [7] there is proposed the forecasting methodology for the daily exchange rates of Japanese Yen against the US Dollar and of the US Dollar to the British Pound. The proposed forecasting methodology includes clustering technology, ANNs and evolutionary computing. In contrast to this paper we focus on the formation of recommendations while making investment decision in stocks' markets. As well we are working with a large data set that lets us to propose more stable investment decision system. In paper [2] the authors are focusing on adapting PSO to dynamic environments. This paper is more focused on the modifications of PSO algorithm, while our goal is to introduce the investment decision making methodology where PSO will be only one constituent of it.

First of all in the paper there is introduced the proposed decision making model. After, the presentation of experimental investigations is made and the main conclusions of the work are presented.

Proposed decision making model

The analysis and forecast of stock markets is stickler, because of its complexity and noisiness. Various economics activities and psychological factors affect the rise and fall of daily stock returns [8]. There is not enough to use conventional techniques to conduct the stock markets predictions, as its changes are influenced by stochastic human factors, non-linear, multivariable and temporal nature of stock price transitions. The use of artificial intelligence had made a big influence on the forecasting and investment decision making technologies and it was proved that the efficient results can be obtained. In this paper we are proposing a decision making model, which could be applied for stock trading processes. The scenario of proposed decision making model is presented in *Fig.1.*

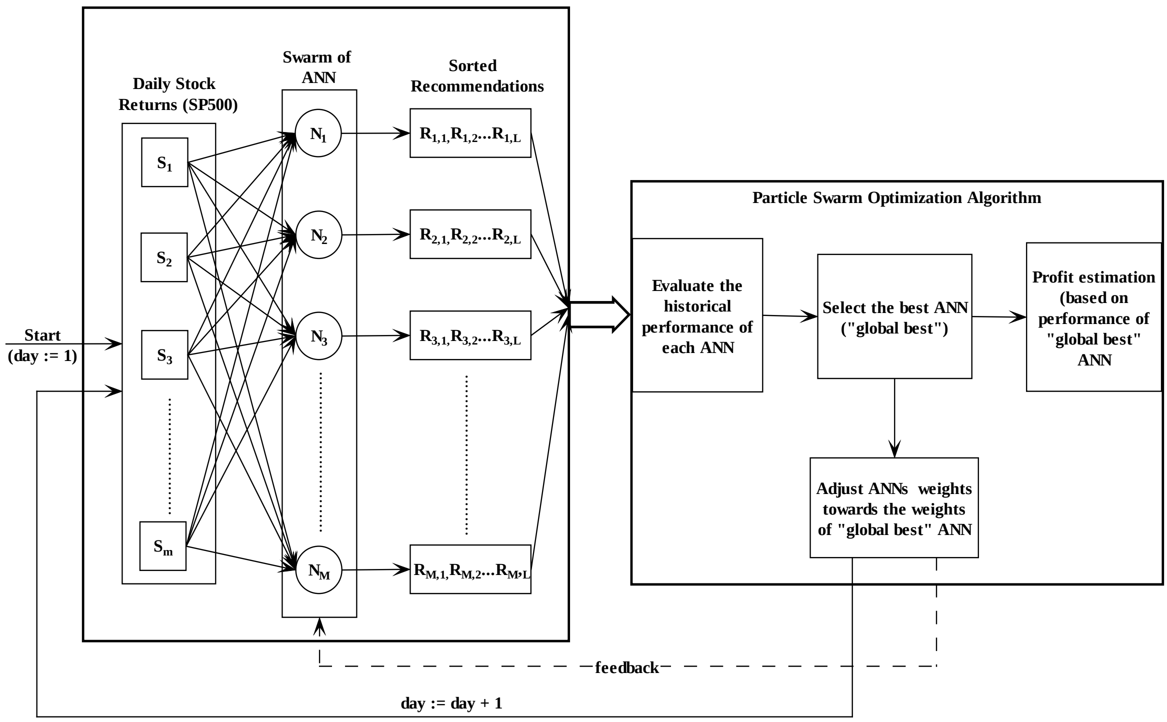


Fig. 1. **Scenario of decision making model**

The introduced decision making scenario (Fig. 1) presents a realization of the model, which is made every day and its result is one day forward decision (buy, sell and hold). The scenario could be described in several stages:

1. At first, the data set of 350 stocks (from S&P500 group) is formed. This data set includes the information about daily stock returns for the time period of 12 years (01/Oct/91-01/Oct/03).

ISBN 9984 – 779 – 06 – 8

2. The data set is passed to the ANNs. The net result is a linear combination of each of the weighted input vectors.

$$x = \sum w_j p_j \tag{1}$$

Here w_j represents the weights, and p_j - the changes of stocks price.

The ANNs' weights are initialized randomly at the beginning of the procedure according to the formula:

$$w = rand(n,k) - 0.5 \tag{2}$$

Where *n* is randomly initializes weights of ANNs and *k* corresponds with the number of used ANNs. The random numbers are kept relatively small.

3. Further, for each day, and each stock the recommendations are calculated using different number of ANNs. The net result is passed to the hyperbolic tangent function and the recommendations for the stocks' trading are calculated according to the below presented formula:

$$R = \frac{2}{1+e^{-x}} - 1 \tag{3}$$

The recommendations (*R*) represent the relative rank of investment attraction to each stock in the interval *[-1,1]*. The values *-1, 0* and *+1* represent recommendations: sell, hold and buy respectively.

4. After the recommendations are calculated, all the stocks are sorted (according to these recommendations) in the descending order.
5. From the sorted list of stocks, three stocks with the highest recommendation are selected.
6. Further, the decision concerning the stock returns is made, according to the chosen stocks' returns and applying sliding windows.
7. Before the next iteration of the model the training of ANN is made. For the training of ANN there is applied PSO algorithm (see Fig.1). The training of all ANNs is made through the adjustment of ANNs weights towards the weights of "global best" ANN on a current day.

For experimental investigations we were considering two different kinds of ANN (see Fig. 2 and Fig. 3): single layer ANN (linear case) and two layers ANN (non-linear case).

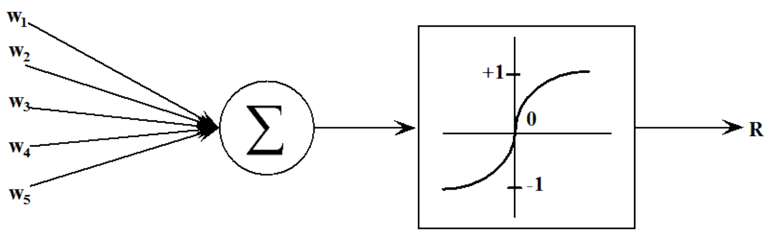


Fig. 2. **Single layer ANN**

While applying single layer ANN we are checking what results can be achieved while having the simplest cased of the decision making model. The non-linear case of ANN lets to check if the more advanced case of decision making model is correlated with the improvements of the results.

ISBN 9984 – 779 – 06 – 8

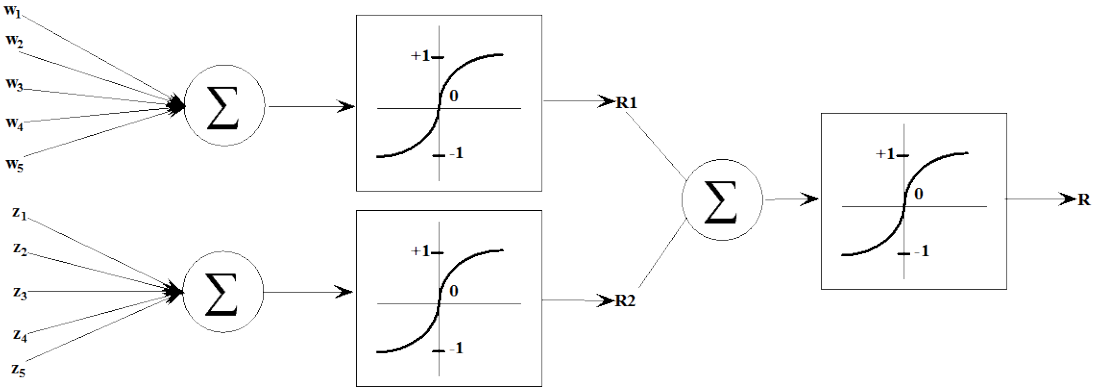


Fig. 3. **Two layers ANN**

As it was mentioned before, the expected return is calculated using the idea of sliding window. An example of sliding windows is presented in Fig.4.

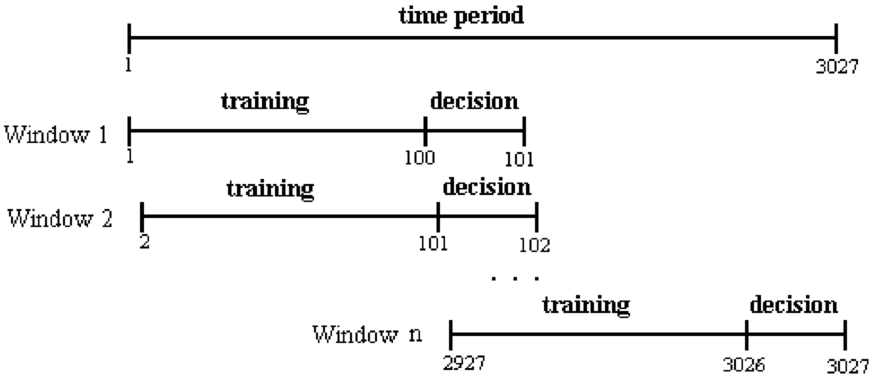


Fig. 4. **Sliding window**

As it can be seen from the Fig. 4, the sliding window is divided into two parts: training and decision making. In the training part there are selected the particles with the best performance (the highest total profit for the selected sliding window) and the „worst" particles are trained towards the behavior or these selected „global best" particles. It is important to mention, that the data, which was used for the calculation of recommendations it is not further used for the training of ANNs (it becomes out sample data).

Experimental investigation

The realization of the proposed decision making model was made using MATLAB software package. The experimental investigations were divided into three parts:

1. The first part was focused on the selection of sliding window size and number of ANNs (the detailed experimental investigation is presented in article [11])
2. The second part of experimental investigations focuses on the analysis of learning rate (see article [11]).
3. The third part was dedicated for the evaluation of decision making model (linear and non-linear cases).

All the experimental investigation were run according to the above presented scenario (see Fig. 1) and were focused on the estimation of possible returns, which could be got while applying our proposed decision making model. In all the cases the expected returns were calculated considering transaction fees that are unavoidable in the stock markets. The analysis of the commission fees of different e-brokers showed that the commission fee in real trading process is usually between 0.15 % - 0.3 %. For example, such transition fees are provided by the company of Interactive Brokers [9]. Having bigger selling and buying volumes this fee could be even

ISBN 9984 – 779 – 06 – 8

smaller - 0.1 %. Based on that for the further investigations we are considering the commission fee which is equal to 0.15 %. We are making an assumption that each day we are paying 0.15 % of commission fee for buying new stocks. The value got on the last investigated trading day is considered as the profit. The profit is calculated as a sum of stock returns (%):

$$P_{end} = \sum_{t=2}^{P_{end}} P_{t+1} \tag{4}$$

Where:

$$P_{t+1} = \frac{K_{t+1} - K_t}{K_t} * 100\% \tag{5}$$

Here P_{t+1} represents the profit at time period *t+1*. If at the moment *t* there were bought stocks for the price K_t, when the price of these stocks after some time period (year, month etc.) will be K_{t+1} and the profit (%) will be equal to the value of P_{t+1}.

In all experimental investigation the training of ANNs was made through the adjustment of ANNs weights towards the weights of ``global best'' ANN. For the adjustment of the weights there was chosen the learning rate of 0.05. Such value was selected based on the experimental results which are presented in the article [11]. As well it is important to mention, that for all experimental investigation, the sliding window of 100 days was used. The results of experimental investigations are presented in Fig. 5.

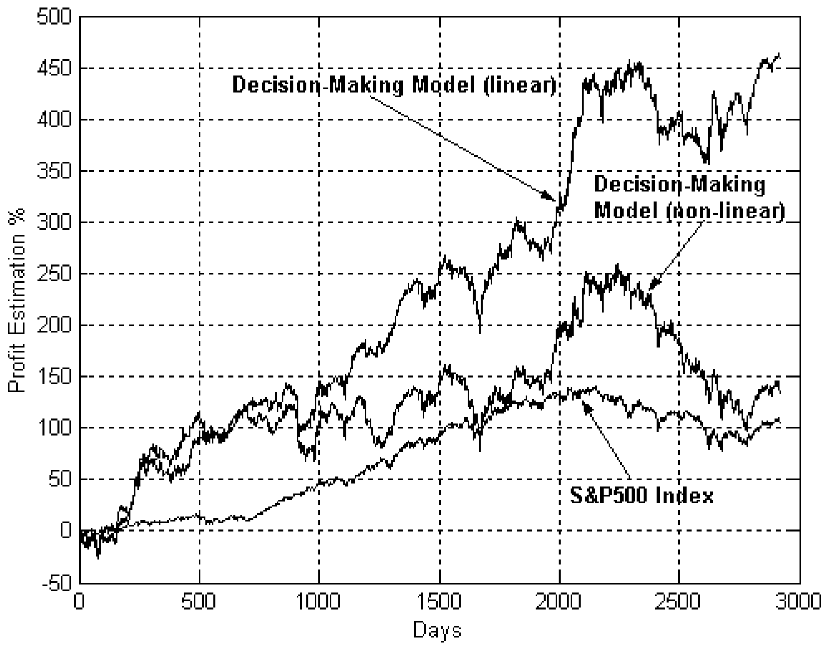


Fig. 5. **Comparison of the results**

In Fig. 5 there is presented the comparison of the results while having three cases: conservative investment approach (investments are done into S&P500 index by buying and holding it for all time period), and decision making model (linear case) application and decision making model (non-linear case) application. The presented results in the Fig. 5 show, that the application of PSO algorithm and training of ANNs towards the performance of the ``global best'' ANN give quite good results. Compare to the conservative approach the proposed decision making model lets to achieve almost 5 times better results (having the linear case of the model). The reason of that is that every day the investment decisions are made using the ``global best'' particle and at the same time all other particles are slightly moved towards it. Such training of ANNs ensures

ISBN 9984 – 779 – 06 – 8

the movement towards the best decision. In the case of non-linear decision making model the results are not so good. That lets us to make an assumption, that in complex systems the more advanced decision making model not necessarily give better results. Non-linear case of decision making model is too complex and its different realizations can have big variations (see Fig. 6).

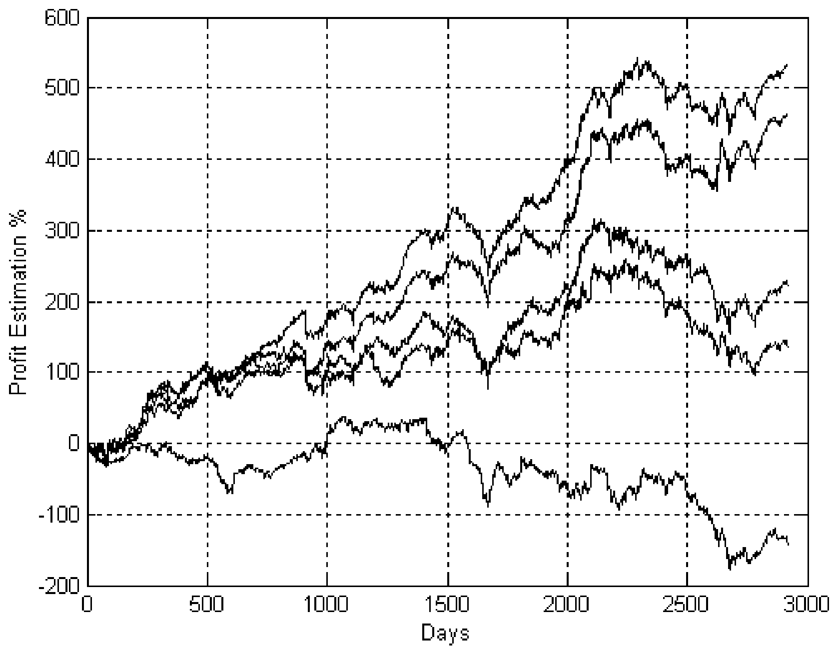


Fig. 6. **Non-linear decision making model (5 realizations)**

As it can be seen from Fig. 6, different realizations of non-linear decision making model give quite contradictory results. That let us to come to the conclusion, that non-linear decision making model is too complex for decision making in very noisy systems. The big variations of its different realizations show, that the non-linear decision making model is not stable and it can not ensure good results in decision making in stock markets.

Conclusions

In this paper we proposed the decision making model based on the application of ANN and PSO algorithm. The model was applied in order to make one-step forward profit estimation considering historical data of stocks returns fluctuations. The evaluation of the model showed that:

1. The linear decision making model can give quite good results (4-5 times better than in the case of conservative investment into S&P500 index).
2. The non-linear decision making model is not stable and it is too complex for decision making in noisy systems.

In the future we intend to make more detailed analysis of the proposed decision making model.

References

1. K. Bartholdson, J. M. Mauboussin, Thoughts on Organizing for Investing Success. Credit Suisse First Boston Equity Research, 2002
2. A. Carlisle, G. Dozier, Adapting Particle Swarm Optimization to Dynamic Environments. 2000 ICAI Proceedings, Las Vegas, 2000, 429-434
3. A. D. Engelbrecht, Computational Intelligence (An Introduction). John Wiley & Sons, London, 2002
4. N. R. Franks, Army of Ants: A Collective Intelligence. American Scientist, 1989
5. J. Kennedy, W. M. Spears, Matching Algorithms to Problems: An Experimental Test of the Particle Swarm and Some Genetic Algorithms on the Multimodal Problem Generator.

2. http://www.aic.nrl.navy.mil/%7Espears/papers/wcci98.pdf, Current as of December 15th, 2003
3. A. S. Khalil, An Investigation into Optimization Strategies of Genetic Algorithms and Swarm Intelligence. Artificial Life, 2001

ISBN 9984 – 779 – 06 – 8

4. N. G. Pavlidis, D. Tasoulis, M. N. Vrahatis, Financial Forecasting Through Unsupervised Clustering and Evolutionary Trained Neural Networks. Financial Forecasting Through Unsupervised Clustering and Evolutionary Trained Neural Networks, 2003
5. P. T. Pham, Neural Networks for Identification, Prediction and Control. Springer-Verlag, New York, 1995
6. Interactive Brokers. http://www.interactivebrokers.com , February 2004
7. R. C. Eberhart, Yuhui Shi, Comparison between genetic Algorithms and Particle Swarm Optimization, Evolutionary programming, 1998, 611-616
8. J. Nenortaite, R. Simutis, Workshop on Computational Methods in Finance and Insurance, Stocks' Trading System Based on the Particle Swarm Optimization Algorithm, Springer-Verlag LNCS 3039, 2004, 843-850

ISBN 9984 – 779 – 06 – 8

THE INFLUENCE OF INFORMATION TECHNOLOGIES ON THE HUMAN FACTOR WITHIN AN ORGNANIZATION

INFORMĀCIJAS TEHNOLOĢIJU IETEKME UZ CILVĒCISKO FAKTORU ORGANIZĀCIJĀ

INGRIDA SARKIUNAITE

Kaunas Faculty of Humanities, Vilnius University Muitines 8,
Kaunas LT-42280, Lithuania
Phone: + 370 37 422344, +370 422566, *e-mail*: ingrida.sarkiunaite@vukhf.lt

Abstract.. *The article discusses a number of important changes of influence of information technologies on human factor within the organization. The focus of the article is on human factor and IT using problem. According to the theoretical and empirical material of IT influence on human factor, aspects of information technology are analyzed.*

Keywords: *information technologies, organization, management, human factor.*

Introduction

New scientific knowledge, informatization, and the high level of assimilation of information resources are becoming the basis for the existence of highly effective and competitive organisations. An analysis of research related to the information technologies' (IT) influence on the human factor, demonstrated that IT, while making the transformation of organization resources, make the transformation of employee's behaviour inside the organization as well.

During the recent years, the majority of organizations in the whole world, and especially in countries with transition economics, place increasing importance on the formation of the methods of work that would allow for activity in the context of new economical conditions created by a rapid process of globalization, business automatization, and the use of information technologies. A number of companies choose virtual environment for their business [15, 10], where they form not only qualitatively new relationships with the external environment, but also organize conventional working relationships. Thus the influence of the human factor in symbiosis with information technologies creates a creative factor in the organization. Therefore the priority of development and maintenance of competitiveness in modern organizations is the search for a new approach to the complex of the main factors of an organization (capital, personnel, management structure, and finances), this approach being based on information technologies.

Today we can see an increasingly prominent tendency when direct communication between people in both personal and working relations is replaced by communication mediated by information technologies, from mobile phones to computer networks. This tendency has a certain effect on the human factor, their development, and maybe even existence, at least in the traditional sense. Therefore organizations that want to remain viable and not to lose the human factor now face a real challenge related to the achievement of these goals. This was also confirmed by empirical studies. One of the important consequences of the usage of information technologies is the disappearance of traditional boundaries between work, recreation, learning, information, and activity [16]. The Internet and other information technologies are seen by many authors as "revolutionary" and are compared to the industrial revolution of the 18^{th} – the 19^{th} centuries. On the individual level this revolution is associated with the social effect of information technologies, including new forms of relationship between people and maintaining social contacts [12].

The problem of influence of information technologies on human factor, and its management under is not sufficiently disclosed, and there are not enough systemic studies in this field.

ISBN 9984 – 779 – 06 – 8

The object of the article - the influence of information technologies on the human factor.
The goal of the article is to analyze the tendencies of influence of usage IT on human factor.
The methods of the study. The analysis of the theoretical premises of IT influence on human factor was performed when employing general scientific research methods: *analysis of scientific literature, synthesis, abstraction, induction, and deduction.*
The empirical study was performed using the quantitative research method – *questionnaire-based inquiry* and *quantitative analysis of the obtained findings (methods of mathematical and statistical data processing with the help of SPSS software package).*

Technology and people at work

There are many factors to which the organization must respond. One of the most important is that technology, for as technology increases, organization finds itself bombarded with change [5]. The relation ship of technology to people at work is known as socio technical system, and modern managers are finding that they must give increased attention to this technical-human interface.
Information technologies have an effect on people at work for two reasons. First, IT is causing a change in people values, which they bring to the workplace with them. Second, information technologies is leading to changes in the work environment, from the machines people use in creating output and making decisions to the way in which their offices and workstations are designed. R.M.Hodgetts [5] in analyzing this people-work environment-technology interface, considered five areas:

- changing organizational cultures;

Organizational culture is the environment in which people work. When this environment changes, people must learn to adapt, to learn new jobs, create new skills of employees' interact and communication.

- alienation in the workplace;

Alienation is the one of the most important behavioral implications of information technologies. This concept incorporates (1) powerlessness, (2) meaninglessness, (3) isolation, (4) self-estrangement.

- the fear of replacement by machine;

Employees' fear, that they will be replaced by machines, is another problem created by technology. This fear is typical among people who are not highly skilled or who are performing paperwork functions.

- how employee's feel about there jobs;
- the quality of work life issue.

E.Turban, E.Mclean, J.Wetherbe [19] also assume that the use of IT has brought many changes to organizations. These changes are being felt in areas like structure, authority, power, and job content; employee career ladders and supervision; manager's job. IT affects individuals in various ways:

- job satisfaction;
- dehumanization and psychological impacts;
- information anxiety;
- impacts on health and safety.

To prevent the spread of above mentioned bad IT influence on human factor aspects, R.Hodgetts [5] suggested steps for the managers that can be followed to help with the personal challenge:

- become familiar with jobs people are doing;
- be aware of the negative impact technology can have;
- get employees input regarding how to use technology;
- keep employees apprised of what is going on;
- be hones with employees.

ISBN 9984 – 779 – 06 – 8

Organization structure and IT

A.Majchark, Q.Wang [8], E.Turban, E.Mclean, J.Wetherbe [19] analyzed the concept of networked organizations, where organizational structures are related by computer networks and are supported by information systems. Table 1 shows the major characteristics of the networked organization and compares them with the characteristics of the hierarchical organization.

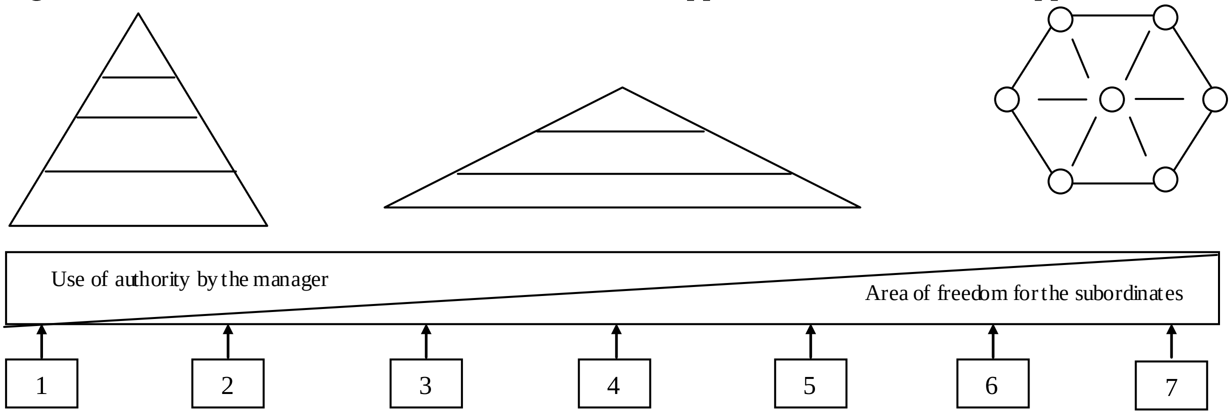
Table 1.

Networked versus hierarchical organization

Classical/Hierarchical organization	Networked organization
Forma	Informal
Highly structured	Loosely structured
Manage	Delegate/lead
Control	Ownership/participation
Direct	Empower
Employees a cost	Employees an asset
Information management – owned	Information shared ownership
Hierarchical organizations	Flatter/manageable organizations
Risk avoidance	Risk management
Individual contributions	Team contributions

The hierarchical and networked approaches to management obviously present significant contrast, and each has its successes and failures. However, today some organizations are turning away from the hierarchical organization toward the networked organization. This trend is being brought about by the evolution from an industrial-based economy to an information-based economy. And in this case, in nowadays most people do knowledge work, in which the intellectual content of the work increases to the point where the subordinate often has more expertise than the "hierarchical" supervisor [19]. Employees in an organizational network are not just "cogs" in a hierarchical machine. Each employee that does knowledge work has special expertise and information.

Figure 1 shows the continuum from the hierarchical approach to the networked approach.



1.	Manager makes decisions and announces or "sell" it.
2.	Manager presents ideas and invites questions.
3.	Manager presents tentative decision subject to change.
4.	Manager presents problem, gets suggestions, makes decision.
5.	Manager defines limits; asks group to make decisions.
6.	Manager permits subordinates to function within limits defined by superior.
7.	Manager allows situational leadership to occur based upon which node of the network is best equipped to solve problem.

Fig. 1. **The roles of managers and subordinates in the different types of organizations (by [19]).**

ISBN 9984 – 779 – 06 – 8

According to W.Niepce, E.Molleman [14], J.A.F.Stoner, R.E.Freeman, D.Gilbert [18], the design and reorganization of organization could help to make successful transformation inside the organization and to make its proper compatibility with surrounding environment. There is highlighted employees "plugging" into the network concept, when the majority of organization management functions are moved to the information systems level and an employee becomes a member of information storage, distribution and processing IS, which is created and integrated in the organization. In such case for him becomes accessible not only information by itself, but as well its processing tools. There is applied the participants principle, when an employee is involved in all the processes in real time – "here and now". At the same time there are applied the classical logistics principals: right information, right processing tools, right complex of relations, for the right employee, on the right time and with the right characteristics that corresponds with the position, competence, responsibilities and humans personal characteristics [1]. Such principal is very good for the formalization of relations – employee is always in the working state and he physically has no time for non work activities.

It is stated, that this transformation changes the work of organization irreversibly – organization is approached not through the separate functional units and its relations, but it is approached as united operating system, with its own information sources, its own users and internecine multi – level relations.

The transfer of employees' communication into IS base lets to make real evaluation of systemic view bases in the organization, when the organization starts to work synchronically and in real time. This causes synergy effect and lets either to save time and expenditure, or to reach better results in the same time and with the same expenditure.

Unfortunately in many cases the employee is suffering – intensive working environment fatigues the person, especially if he is older [20, 11]. Because of this reason, it is important to understand (especially for the managing level) that the part of surplus value, created in synergy principle by the IS structure and its communications links, has to be returned to the employee, especially in the recreation form [2, 3].

After moving organization activity into IS base, in the personnel relations point of view, it can be disaffirmed many vices and syndromes, which are related to human factor – the personnel relations become more formal, the probability of conflicts is decreasing [9]:

- there are the irregularities;
- the discrimination of employees, which appear form the middle level managers, disappears;
- the whole history of employees' actions inside the organization can be seen.

After making theoretical evaluation of information technologies influence on human factor, it was determined, that this action strengthens the need of employees responsibilities, initiative, self action, as well it raises new requirements in the point of view of organization. Information technologies, while making the transformation of organization resources, as well make the transformation of employee's relations inside the organization. The result of such is the transformed output of organization (for example: the higher quality production, services, wellness of the organization, higher quality external relations etc.).

After making an analysis of literature a on information technologies relation to human factor and after making empirical investigations [13, 16, 7, 12, 6, 4, 17], it was determined, that all the investigations are concentrated on the following aspects of people social life: leisure time, singleness, day agenda (working day and weekend), communication, unemployment level. In these investigations there is missing a viewpoint of IT usage appearance in the working activity. While at the same time, in the after work time, IT influence reaches much bigger level and make much bigger influence on the social human activity.

ISBN 9984 – 779 – 06 – 8

IT influence on human factor in Lithuanian organizations

The organization of the research. The employees and managers of Lithuanian organizations related with the use of information technologies were interviewed in the process of the research. The organizations were selected according to the kinds of activity, listed in the catalogue of companies "Visa Lietuva".

The total number of questionnaires sent comprised 700; 663 responses were received; 23 of them were unduly filled in or not filled in at all. Therefore, the data of 640 questionnaires were used in the research. The respondents represented 35 organizations. The questionnaire response rate is 91,4 per cent.

Results of the research

In order to check the assumptions created in the way of theoretical analysis, there was created the following question:

- *How the use of information technologies in the work place conditions the betterment of employees' relations?*

In order to test this question, it was analyzed by using respondents' answers to the following questions:

- *How much time do employees spend using IT?*
- *How many IT do they use for the work?*
- *How employees use the possibility (in percent) to exchange informal information by using IT?*
- *Do employees like to participate in the events organized by an organization?*
- *Do employees care about each other?*
- *Do employees share knowledge received at their workplace with their colleagues?*
- *Are employees satisfied with employees' relations?*
- *Do IT have influence on relations with colleagues?*
- *Do employees* want to work in virtual workplace?

Certain statistically important correlations were determined in Table 2.

Table 2.

Correlation between relations with colleagues and level of using IT

	Relation between the quantity and level of IT usage	**Relation between IT application for informal information exchange and IT usage level**	**Relation between satisfaction with employees' relations and IT usage level**
Attribute (IT usage level)	*Relation strength*	*Relation strength*	*Relation strength*
Number of e-mails sent	0,417**	0,429**	0,339**
Number of Internet using hours	0,323**	0,490**	0,291**
Number of telephone/mobile telephone calls made	0,213**	-	-
Number of messages sent	0,138**	0,354**	-

**p<0,01

The χ^2 (chi-square) criterion was used to investigate the independence of two attributes (Table 3).

ISBN 9984 – 779 – 06 – 8

Table 3.

Independence between attributes

Attribute	"What IT do employees use at their workplace?"	"How employees use the possibility (in percent) to exchange informal information by using IT"	"What is the average number of e-mails you send per day?"	"What is the average number of hours you use Internet per day?"	"What is the average number of hours you speak on telephone/mobile telephone per day?"	"What is the average number of messages you send per day"
Do employees' like to participate in the events organized by an organization?"	p=0,001	p=0,000	p=0,000	p=0,000	p=0,000	p=0,000
Do employees care about each other?	p=0,979	p=0,000	p=0,232	p=0,000	p=0,482	p=0,865
Do employees share knowledge received at their workplace with their colleagues?	p=0,921	p=0,000	p=0,001	p=0,000	p=0,001	p=0,028
Do employees' want to work in virtual workplace?	p=0,007	p=0,218	p=0,031	p=0,027	p=0,427	p=0,687

- independent attributes.

Discussion

The results of investigation show, that higher level of IT usage conditions variety of IT used. Thus, it is possible to admit, that employees' need for interaction with other people realises through various IT tools. Especially it is important for employees, who can contact with colleagues working in other places. On the other hand, it conditions requirement of interaction with other people" face to face", without technical promotion.

The investigation shows, that the most popular are IT intermedia - internet, e-mail and communication tools - mobile telephones. Those tools are usually used by respondents for individual requirements, i.e. e. for informal communication with people. Mostly these informal communication exchange methods are used by 22 - 30 year old respondents, most rarely by 41 - 50 year old respondents and older. Also specific software, data bases, programs and safety-net are used. Interesting fact, that actually 21,7 per cent. of respondents overall do not use IT for their needs. This means, that they do not know how to use IT or prefer communication without technical promotion.

The answers of respondents also proved that higher IT usage level conditions higher intention to participate in the events organized by an organization. Consequently, by using IT employees can exchange informal information more and faster, find out new information, news, make arrangements, and it conditions higher need to meet people "face to face".

Respondents emphasized the importance of employees' attendance. The results of investigation showed, that higher possibilities to exchange formal information by using IT, provided for employees better possibilities of attending their colleagues. And this on its turn conditions the betterment of employees' relations.

This hypothesis is proved by respondents' satisfaction with employees' relations in the aspect of higher usage of IT and the influence of IT on relations with colleagues.

Having started to use IT for doing work, certain changes in the employees' communication sphere, i.e. e. in relations with employees, appeared. 72 per cent. of respondents think, that changes exist and they influence the relations with employees. According to them, it is communicated in more modern ways, which improves communication and information exchange, giving new communication opportunities (video conferences, contact with colleagues working in a geographically different area, do work on-the-job, there is no need for "face o face" communication with managers, etc.), it is possible to suppress reactions, when negative information is received, to exchange with work results faster, to use new mind/idea expression opportunities and encourage informal interaction. On the other hand, people face troubles while

ISBN 9984 – 779 – 06 – 8

conveying their moods or feelings and danger of a too formal communication tone appears, besides, invisible real speaker reaction, too high amount of information, it may also appear competition and antagonism among those who are able to soak up IT and those who are incompetent, too high control possibility, a feeling of insecurity for personal information sending and checking, extra tiredness, staying too long at silly works. Also, subject to IT using style, relations can be more formal and vice versa. 28,1 per cent of respondents pointed, that IT do not make any influence on relations or this influence is very small.

It is emphasized in the answers that working with IT employee does not stand behind computer advance. Also, it is determined by the investigation, that IT usage helps to share knowledge, which is received in the process of work with employees (p=0,055). Consequently, employee having higher possibilities of using IT, creates favourable relations for himself and for otaher employee, because he can more simply and informally perform different kinds of communication functions.

It was determined in the process of investigation, that employees, spending more hours on the Internet, sending more e-mails, do not reject a possibility to work in the virtual workplace (44,2 per cent. - ”pro“, and 40,3 per cent. - ”con“). In conclusion, the influence of IT usage level on employees‘ relations is dynamic, because respondents almost equally estimate possibility to work partially isolated from colleagues and at the same time speak against this form of work

Generalizing the results of the study, the following conclusion can be made: **higher level of the usage of information technologies influences the positive transformation of relations between employees’ and at the same time on employee human factor.**

Conclusions

- The evaluation of the theoretical principles of changes of human factor in the process of transformations of organizations showed that these changes are conditioned by changes in the socio-technical system of the organization. An emphasis is placed on the concept of the employee’s “plugging” into the network, where the majority of the management functions in the organization are transferred to the level of information systems. Thus, the employee of an organization becomes a member of the integrated system of data accumulation, distribution, and processing.
- The theoretical evaluation of information technologies influence on the human factor showed that this influence increases the need for such employee’s features as responsibility, initiative, and independence; in addition to that it raises new requirements for the organization’s attitude to its employee. When influencing the input of the organization, information technologies at the same time transform the relationships between employees within the organization, which, in turn, result in an altered output of the organization (e.g. higher quality production, services, viability and wellness of the organization, higher quality external relationships, etc.).
- The empirical investigation showed, that the higher level of the usage of information technologies influences the positive transformation of relations between employees’ and human factor. This let to make the conclusion, that the higher use level of information technologies conditions the improvement of employees’ relations with each other.

References

1. Armonienė, Andžela. Integruota komunikacija: dinamiškas pasaulis. Vilnius: Vilniaus universiteto komunikacijos fakultetas[interaktyvus]. 2001 [žiūrėta 2003 m. lapkričio 22d.]. Prieiga per internetą: http://www.leidykla.vu.lt/inetleid/info-mok/19/stro.html
2. Ashburner, L. Impact of technological and organizational change. Personnel Review, 1990, Vol. 79, No. 2. p. 16-20.
3. Byrd, T. A.; Ikerd, M. D. Educational needs of information systems personnel and end-users. Public Productivity & Management Review, 1992, Vol. 16. p. 191-204.
4. Gullestrup, Hans. The Challenges facing the international managers in the future. International conference: Globalisation, Internationalisation of Companies and Cross-cultural Management, Comwell Rebild Bakker, Aalborg, Denmark, October 27-29.

ISBN 9984 – 779 – 06 – 8

5. Hodgetts, Richard M. Modern human relations at work. Orlando: The Dryden Press, 1999. p. 493.
6. Katz, J.; Aspend P. Motivations for and barriers to internet usage: results of a national public opinion survey. Internet research-electronic networking applications and policy, 1997, vol. 7, no. 3. p.170.
7. Kraut, R.; Petterson, M.; Lundmark, V.; Kiesler, S.; Mukophadhyay, T.; Scherlis, W. Internet paradox: a social technology that reduces social involvement and psychological well-being? American psychologist, 1998, vol. 53, no. 9. p. 1017-1031.
8. Majchark, A; Wang, Q. Breaking the functional Mind-Set in process organizations, Harward Business Review, September-October, 1996.
9. Martinsons, Maris G.; Chong, Patrick K. The influence of human factors and specialist involvement on information systems success. Human relations, 1999, Vol. 52, No.1. p. 123–152.
10. Merkevičius, Juozas. Organizacijos transformacija informacinėje visuomenėje. Tiltai, 2003, gegužė, Nr. 13, II tomas. p. 323 – 329.
11. Nelson, D. L. Individual adjustment to information-driven technologies: A critical review. MIS Quarterly, 1990, Vol. 14. p. 79-98.
12. Neustadtl, Alan; Robinson, Johm P. Social contact differences between Internet users and nonusers in the general social survey. IT&Society, 2002, Vol. 1, Issue 1. p. 73-102.
13. Nie, Norman H., Hillygus, D. Sunshine. The impact of Internet use on sociability: time-diary findings. IT&Society, 2002, Vol. 1, Issue 1. p. 1-20.
14. Niepce, Willem; Molleman, Eric. Work design issues in lean production from a sociotechnical systems perspective: neo – Taylorism or the next step in sociotechical design?. Human relations, 1998, vol. 51, No. 3. p. 259 – 287.
15. Ott, Marcus; Nastansky, Ludwig. Modeling organizational forms of virtual enterprises. Business computing, 2000.
16. Pronovost, Gilles. The Internet and time displacement: a Canadian perspective. IT&Society, 2002, Vol. 1, Issue 1. p. 44-53.
17. Sarkiunaite, Ingrida; Matiusaityte, Raimundė; Ciutiene, Ruta. Information technologies as the factor of employees‘ relations transformation. *International conference:* Globalisation, Internationalisation of Companies and Cross-cultural Management, Comwell Rebild Bakker, Aalborg, Denmark, 2004, October 27-29.
18. Stoner, James A.F.; Freeman, R. Edward; Gilbert, Danier R. Jr. Vadyba. Kaunas: Poligrafija ir informatika, 1999. 660 p.
19. Turban, Efraim; McLean, Ephraim; Wetherbe, James. Information technology for management: transforming business in the digital economy. New York: John Wiley & Sons, Inc., 2002. 771 p.
20. Willcocks, L.; Mason, D. New technology, human resources and workplace relations. Employee Relations, 1988, Vol. 10, No. 6. p. 3-8.

ISBN 9984 – 779 – 06 – 8

MODELING PARTIAL IGNORANCE IN ARTIFICAL INTELLIGENCE APPLICATIONS
DALĒJĀS NEZINĀŠANAS MODELĒŠANA MĀKSLĪGA INTELEKTA PIELIETOJUMOS

OLEG UZHGA-REBROV

Rezekne Higher Education Institution
Atbrivoshanas al. 90, Rezekne LV – 4600, Latvia,
Phone: + 371 9472205, *e-mail*: rebrovs@tvnet.lv

Abstract. *This study aims to extend and deepen a survey of modern extensions of probability theory represented in [6, 7]. The classical probability theory possesses rather limited possibilities and cannot cope with situations of partial ignorance. Other approaches are required allowing one to solve tasks of that kind. The given paper considers the generalised approach to modelling partial ignorance and its interpretation in the terms of upper and lower probabilities, second order probabilities and belief functions.*

Keywords: *belief functions, focusing, partial ignorance, revision, second order probabilities, upper and lower probabilities.*

Introduction

Artificial intelligence (AI) is commonly treated as different methods of knowledge representation and processing. The present study considers knowledge both as information obtained from objective sources (measurements, observations, and database) and subjective evaluations, judgements and experts' findings. The size and quality of actual knowledge in the context of the specific task solution may vary from complete knowledge to total ignorance [7]. A situation when some knowledge about the subject area is available but it is not complete and/or reliable will be called a situation of partial ignorance. In order to model and process partial knowledge successfully, it is necessary to have a clear idea about the sources and reasons of partial and total ignorance. Those sources and reasons can be divided into three large classes [5].

1. Incompleteness of knowledge represents situations when values of certain variables of the task are unknown. For example, when a database of a group of individuals is being created it might be known that a certain individual is a student, whereas his name might be unknown. In this situation the value of variable Individual's Name is unknown.
2. Imprecision of knowledge relates to the case when values of all or some variables cannot be determined with the required extent of precision. In the above mentioned task of database creation, what is only known regarding the value of variable Age for a specific individual is that he is over 30 years.
3. Uncertainty of knowledge covers the situations when propositions are not certainly true. For the case of database construction, a proposition Individual X is a student - made on the basis of the evidence of the person not sure about that - can serve as an example of uncertain proposition.
4. The concepts of knowledge incompleteness, imprecision and uncertainty have to be strictly distinguished from the concept of uncertainty (randomness) of various processes of the actual world. The external uncertainty exists objectively and does not depend on human consciousness. Uncertainty in AI represents the incompleteness and uncertainty of our knowledge (information) about real world events and processes. For example, assigning chances of random event occurrence might turn to be a troublesome problem for an individual though he/she might clearly imagine the character and structure of those events. Situations are however possible when an individual has no clear ideas about the nature and structure of random events or processes. The uncertainty of that kind - related to the absence of complete and reliable knowledge is examined in this paper.

ISBN 9984 – 779 – 06 – 8

For a long time, probability theory served as the only means for managing uncertainties of the actual world. Probability theory proves to be a very effective mathematical apparatus, however it can be used in the presence of these two conditions:

5. A complete space of random events is specified.
6. To each event a unique number is attached that evaluates its chances and is called probability.

As soon as one of those conditions is broken, probability theory stops being an adequate mathematical apparatus for dealing with uncertainty [3, 6]. Other - more suitable approaches to modelling knowledge incompleteness and uncertainty are becoming necessary. Some of approaches of that kind are discussed in the present paper.

General requirements to the approaches to modelling partial ignorance

In case if the available knowledge about the real world subject area is not reliable and/or certain, our first task is to model such knowledge. Before considering specific approaches to solving that task, let us formulate general requirements that have to be satisfied by any of those approaches. It is evident that the main requirement is an adequate representation of the actual state of things in a form that could help quantify our extent of ignorance. (Qualitative approaches to solving that task exist, for example, nonmonotonic logics, default logics, theory of potential surprise, etc. However, they are not considered in the present paper). In [1, 2] the requirements are represented in the most developed and justified form. Let there be a set of propositions Q about the actual states of the subject area of the actual world. Consider a subset $R(g) \subseteq Q$ of that set. If complete and true knowledge is available, the subset R(g) can be easily divided into two subsets : $\tau(g) = \{gi = T\}$, $\theta(g) = \{gi = F\}$, where symbols T and F denote the truth or falsity of the respective proposition. If our knowledge is not complete, we can distinguish two subsets of propositions $\tau^*(g) \in R(g)$ and $\theta^*(g) \in R(g)$, regarding whose status of truth or falsity we are certainly sure, and a subset of propositions $V(g) = R(g) \setminus (\tau^*(g) \cap \theta^*(g))$, about the truth/falsity status of which we are not certainly sure. Then a subset $\tau^*(g) \cup V(g)$ will contain the propositions which are certainly true (a subset $\tau^*(g)$), and propositions $gi \in V(g)$, which are possibly true. Similarly, a set $\theta^*(g) \cup V(g)$ will contain the propositions which are certainly false (a subset $\theta^*(g)$) and propositions $gi \in V(g)$ which are possibly false.

How to model such a state of partial ignorance? Assume that we are able to construct a function ζ, which attaches the number equal to 1 to all elements from of $\tau^*(g)$; the number equal to 0 to all elements of $\theta^*(g)$ and some number $\alpha \in [0,1]$ to all elements from V(g). Whatever function ζ is, it has to meet the following requirements:

– the value $\zeta(gi \vee gj)$ must be determined by values $\zeta(gi)$ and $\zeta(gj)$ only;
– the value $\zeta(gi \wedge gj)$ must be determined by values $\zeta(gi)$ and $\zeta(gj)$ only;
– the value $\zeta(\neg gi)$ must be determined by $\zeta(gi)$ only.

If some probabilistic function stands for function ζ, $\zeta(gi \vee gj) = \zeta(gi) + \zeta(gj)$, if and only if gi, gj $\in \tau^*(g)$ and gi, gj are probability independent. In general case, function $\zeta(gi \vee gj)$ is not a function of $\zeta(gi)$, $\zeta(gj)$. Similarly, function $\zeta(gi \wedge gj)$ is not a function of $\zeta(gi)$, $\zeta(gj)$. The only requirement the probability function of that kind satisfies is $\zeta(\neg gi) = \zeta 1\ (gi)$. From this it follows that no probabilistic function whatever could model partial ignorance in general case. Two evaluation functions are needed for that. Suitable for that purpose are functions of this kind:

$$SN(g) = \begin{cases} 1, \text{ if } g \in \tau^*(g), \\ 0, \text{ otherwise.} \end{cases}$$

ISBN 9984 – 779 – 06 – 8

$$S\Pi(g) = \begin{cases} 1, \text{ if } g \in \tau^*(g) \cup V(g), \\ 0, \text{ otherwise.} \end{cases}$$

The interpretation of these functions is simple enough and is logically validated. SN(g) = 1 means that g is a certainly true proposition, whereas SΠ(g) = 1 means that g may potentially be a true proposition, though it is not excluded that it might be false. Such an interpretation of SΠ function represents our partial ignorance regarding the truth status of proposition g. Functions SN and SΠ are partially compositional with respect to operations of logical intersection, union and negation:

$SN(gi \wedge gj) = \min (SN(gi), SN(gj))$;

$S\Pi(gi \vee gj) = \max (S\Pi(gi), S\Pi(gj))$;

$SN(g) = 1 - S\Pi(\neg g)$.

Function SN, however, cannot be compositional regarding the disjunction of propositions and function SΠ is not compositionl with regard to the conjunction of propositions.

It is easy to check that $SN(g) = 1 \Rightarrow S\Pi(g) = 1$, and that $g \in V(g)$, if and only if SN(g) = 0 and SΠ(g) = 1. From this it follows that the truth status of proposition g is correctly modelled by a pair of figures:

(SN(g) = 1, SΠ(g) = 1) – g is certainly true;

(SN(g) = 0, SΠ(g) = 0) – g is certainly false;

(SN(g) = 0, SΠ(g) = 1) – the status of g is not known for sure (the state of partial ignorance).

In what follows we will discuss possibilities of function SN and SΠ interpretation in the context of existing approaches to modelling states of partial ignorance.

Interpretation of functions SN and SΠ

Upper and lower probabilities

Upper and lower probabilities are used to model those situations of partial ignorance when ignorance is related to the probabilistic structure. A complete knowledge about the space of random events is available, but due to the absence of reliable information it is only possible to assign a set of probability distributions P = {Pi} in this space. Any distribution $Pi \in P$ can be a true distribution and there is no reason to prefer some $Pi \in P$ with respect to all other distributions in P. The maximum entropy principle for selecting single distribution – recommended by some authors- is not a valid choice criterion in general case. In such a situation, functions SN and SΠ are naturally interpreted as follows:

$S\Pi(P) = \sup P \in P\ P$:

$SN(P) = \inf P \in P\ P$.

Despite the clear and unambiguous interpretation, operating upper and lower probabilities is fairly complicated. A more detailed information on possible techniques of managing probabilities of that kind can be found in [8].

Second order probabilities

Using upper and lower probabilities to model partial ignorance related to the probabilistic structure provides rather limited possibilities to the user. If possible, it would be more suitable to introduce a structure in the set of probabilistic evaluations, which would allow one to represent conclusions regarding the relative plausibility of particular evaluations. Such a structure might be introduced in different ways. One of the techniques is to treat a set of probabilistic evaluations P as a fuzzy set and form the membership function μ(P) in that set which would represent

ISBN 9984 – 779 – 06 – 8

subjective judgements of the individual about the plausibility of particular evaluations. Another way allowing not to exceed probability theory is to form and employ a second-order probability distribution. This distribution is formed in the set of probabilistic evaluations and represents uncertain judgements of the individual about plausibility extent of particular evaluations. The second-order probabilities are frequently called metaprobabilities. Metaprobabilities are not suitable for modelling uncertain judgements in the set of objective probability evaluations. A structure of that kind represents the objective state of things. The only proper tool for removing uncertainty is acquiring additional objective information. Using metaprobabilities proves to be appropriate in the cases when a set (interval) of possible probabilistic evaluations is obtained in a subjective way and the individual has some reasons to consider certain evaluations to be more plausible than others. It should be noted that the application of mathematical expectations of second-order probability distributions does not remove the prior uncertainty and only masks it (see, for example, [4]).

Belief functions

The theory of belief functions - also known as Dempster-Shafer theory - has been developed to model a specific kind of partial ignorance, with which probability theory cannot cope in principle. The conceptual statement of probability theory is represented by a condition that the space of random events is specified completely and uniquely, and that each event is assigned a probabilistic evaluation. In case if probabilities can only be assigned to certain subsets of events from the general space, probability theory cannot be employed in principle to modelling such a specific kind of partial ignorance.

According to the theory of belief functions, to each subset $X \subseteq \Omega$, belief mass $m(X)$ can be assigned that represents the extent of the individual's support of truth X. Then the total amount of support in favour of the truth of subset $A \subseteq \Omega$ is expressed by a belief function as follows:

$bel(A) = \sum \emptyset \neq X \subset A \; m(X)$.

The values of belief functions are interpreted as probabilities in the original Dempster-Shafer theory. Belief functions possess the following features:

$bel(\emptyset) = 0$;

$bel(\Omega) = 1$;

$bel(A1 \cup A2 \cup \ldots \cup An) = \sum i \; bel(Ai) - \sum i{>}j \; bel(Ai \cap Aj) - \ldots - (-1)n \; bel(A1 \cap A2 \cap \ldots \cap An)$.

(Note, that the last expression also holds for the classical probabilities with the change of sign $\geq$ to strict equality $=$).

Plausibility extent of subset A, pl(A), quantifies the maximal quantity of potential support which could be given to A:

$pl(A) = \sum X \cap A \neq \emptyset \; m(X) = bel(\Omega) - bel(\hat{A})$.

Using the general approach to partial ignorance modelling discussed in the previous section, one can correctly state that function bel(A) is interpreted as function SN(A), whereas function pl(A) is interpreted as function SΠ(A).

The theory of belief functions is a widely recognised tool for managing a specific kind of partial ignorance. Ph. Smets has developed his own version of that theory assuming that no probability distribution exists in the space of random events Ω. He has simply examined beliefs at the so-called credal level. He has called his version of belief functions *transferable belief model*. The mathematical apparatus of the transferable belief model at the credal level considerably corresponds to that of Dempster-Shafer theory. The so-called pignistic transformation of beliefs represents the benefit of transferable belief models. As a result of that transformation, belief evaluations at the credal level are transformed into the so-called pignistic probabilities, which could be manipulated using general rules of probability theory. The pignistic probabilites can be successfully applied for decision analysis and choice under risk. It should be noted that the pignistic probabilities in no case can be interpreted as usual probabilities. They represent specific

ISBN 9984 – 779 – 06 – 8

evaluations obtained by artificial transformation of probabilities and show all signs of probabilistic evaluations. As a matter of fact they are not probablities in the commonly accepted sense.

Problems of probabilistic reasoning in situations of partial ignorance

In most common sense, knowledge (complete and incomplete) can be divided into two large groups [1]:

1) based on factual evidence; and
2) generic knowledge.

Factual evidence ensures knowledge about the state of the actual world in the specific situation. This evidence might have different nature and its truth degree can vary within very wide limits. Generic knowledge relates to some subject area as a whole and does not refer to particular situations. Generic knowledge can be represented in the form of a set of plausible rules, different relationships (functional, stochastic etc.), probability distributions and so on. To give an idea of different kinds of knowledge, let us consider the physician's knowledge. His generic knowledge consists in generalised links between the symptoms and the diseases and includes data on the disease frequency (distribution) in the population. Factual evidence for the physician consists in the the symptoms and results of laboratory investigation of the pacient.

Conditioning the existing knowledge on the basis of new data (evidences) is an important step for removing partial ignorance. Two principally different types of conditioning are represented by focusing and revision [1]. The essence of focusing is conditioning generic knowledge by the factual evidence. In the above example with symptoms and deseases, focusing might yield a change of the reference class of diseases, which became possible in the presence of symptoms observable at the pacient. In general probability theory, focusing is accomplished by using Bayes' theorem.

Unlike focusing, revision is either conditioning the generic knowledge by another piece of generic knowledge (G-revision) or conditioning the factual evidence by another piece of factual evidence (F-revision). In the above example with diseases and symptoms, the result of G-revision might consist in modifying the physician's knowledge about disease-symptom links by using new medical knowledge (say, publications in special journals or statistical data). F-revision might consist in the change of the physician's beliefs about a disease, say, by learning the results of laboratory investigation.

In probability theory, both G- revision and F-revision are implemented by means of Bayes' theorem. Thus, the same mathematical apparatus is employed both for focusing and revision in probability theory. The implementation of focusing on the basis of Bayes' theorem seems to be quite justified. A classical task of re-evaluation of probabilities of hypotheses can be considered as a standard focusing task. The recalculation of the posterior probabilities of the hypotheses in the presence of new evidence is successfully accomplished using Bayes' theorem. As regards revision tasks, the use of Bayes' theorem does not seem to be so evident. Let us consider general statement of Bayes' theorem.

$$P(A/B) = P(B \cap A)/P(A).$$

The advocates of standard Bayesian approach assert that as a result of using that rule a change of reference class A does not occur. They treat the posterior distribution P(B/A) as a result of reduction of reference class from the whole space of events up to subset A. That interpretation coincides with the definition of focusing, but not revision, as it is stated frequently.

Now let us discuss approaches to solving tasks of focusing and revision under partial ignorance. In belief function theory, revision is carried out on the basis of Dempster combination rule. That rule actually combines the conjunctive revision of data under partial ignorance with Bayesian normalisation rule [1]. The essence of Dempster rule of conditioning can be expressed as relating the available belief masses mi for focal elements $Ei \in \Omega$ to subsets $Ei \cap A$, where A is a new portion of information, with further re-normalisation of belief masses in those extended subsets.

ISBN 9984 – 779 – 06 – 8

The expected degree of potential support of B provided that A is true, can be calculated as

$S\Pi\ (B/A) = S\Pi\ (A \cap B)\ /\ S\Pi\ (A)$.

That rule can also be set in the general context of upper and lower probabilities as follows:

$$S\Pi\ (B/A) = \sup\ \{P(A \cap B)\ /\ P((A),\ P \leq S\Pi,\ P(A) = S\Pi\ (A)\} \quad (1)$$

The last expression represents the essence of revision under partial representation technique of that kind.

An alternative conditioning rule can be given in this form:

$$S\Pi A(B) = S\Pi\ (A \cap B)\ /\ (S\Pi\ (A \cap B) + SN\ (A \cap \bar{B})). \quad (2)$$

That rule represents focusing. The underlying idea is to calculate possibility of B under the assumption that A is true not making any propositions as to how the set of probabilities will be revised.

In [1] it is shown that function SΠA (B) is generally less informative than function SΠ (A / B) and can even be less informative than the initial function SΠ (A). This result seems to be a paradox. It is, however, easy to explain it. Let a set of probabilities P represent our partial knowledge about the actual value of probability P. Hence SΠA (B) is a degree of potential belief that B is an element (subset) of A, which can be treated as the modification of generic knowledge (focusing). On the other hand, the value of SΠ (A / B) is simply a modification of the initial information, which is a typical revision. SΠA (B) can broaden the interval of probabilities of SΠ (A). The process of focusing can be justified in terms of functions SΠA(B) only, and SΠA(B) can be viewed of as the upper limit of a family of belief functions derived by transferring the belief masses mi to subsets $Ei \cap A$. The latter provides an explanation of the above result of function SΠA(B) informativity decrease. Due to that result, an important remark has to be made. Belief function theory has been developed in order to combine uncertain evidences. In other words, it was designed to implement F-revision only. Any attempts to apply that theory to solving focusing tasks lead to unsatisfactory results.

Conclusions

Active research and development of new approaches to modelling partial ignorance was seen lately. That is caused by practical needs. Currently it is widely accepted that classical probability theory possesses limited possibilities regarding modelling and processing incomplete and uncertain knowledge. To quantify the degree of ignorance, two values are required. In the most general case these can be represented as the values of necessity function SN and of possibility function SΠ. The interpretation of functions SN and SΠ depends on the specific approach to partial ignorance modelling. By upper and lower probabilities partial ignorance related to the probabilistic structure is correctly modelled. Belief and plausibility functions are successfully employed to model partial ignorance that refers to the structure of random event space. Using metaprobabilities is an attempt to structurise partial uncertain knowledge in the space of probability evaluations.

The classification of probabilistic reasoning tasks into tasks of focusing and revision helps correctly evaluate the suitability degree of each specific approach to modelling incomplete knowledge. In classical probability theory all kinds of probabilistic reasoning tasks are solved on the basis of Bayes’ theorem. Its use for solving focusing tasks seems to be quite justified, whereas its application to revision tasks is not so evident.

Belief function theory faces serious difficulties when it is employed to solve focusing tasks. It is much better adapted to solving revision tasks as was planned by its founders.

ISBN 9984 – 779 – 06 – 8

References

1. D.Dubois, H.Prade, Ph.Smets. Representing Partial Ignorance http://iridia.ulb.ac.be/~psmets/Rep_Partial_ignorance
2. P.E.Lehner, K.B.Laskey, and D.Dubois. An Introduction to Issues in Higher Order Uncertainty. IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans, Vol.26, No 3, May 1996, pp. 289 – 293
3. A.Mosleh and V.M.Bier. Uncertainty about Probability: A Reconciliation with the Subjectivist Viewpoint. IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans, Vol.26, No 3, May 1996, pp. 303 – 310
4. R.E.Neapolitan. Is Higher-Order Uncertainty Needed? IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans, Vol.26, No 3, May 1996, pp. 294 – 302
5. Ph.Smets. Varieties of ignorance and the need for well-founded theories. http://iridia.ulb.ac.be/~psmets/Variety Ignorance
2. O.Uzhga-Rebrov. Uncertain Probabilities. Proceedings of the 4th International Conference „Environment. Technology. Resourses", June 26-28, Rezekne, Rezekne Higher Education Institution, pp. 377 - 384
3. O.Uzhga-Rebrov. A Survey of Modern Extensions of Probability Theory. Proceedings of the International Conference „Scientific Achievments for Wellbeing and Development of Society", March 4-5, 2004, Rezekne, Rezekne Higher Education Institution, pp. 107 – 112
4. P.Walley. Statistical Reasoning with Imprecise Probabilities. Thomson Press (India) Ltd, New Delphi, 1991

ISBN 9984 – 779 – 06 – 8

ILGTSPĒJĪGĀS LAUKSAIMNIECĪBAS PROBLĒMAS

PROBLEMS OF SUSTAINABLE AGRICULTURE

ISBN 9984 – 779 – 06 – 8

SUSTAINABLE DEVELOPMENT MANAGEMENT AND TRANSFRORMATION OF PLANNED ECONOMY TO MARKET ECONOMY
ILGTSPĒJĪGAS ATTĪSTĪBAS VADĪŠANA UN PĀREJA NO PLĀNVEIDA EKONOMIKAS UZ TIRGUS EKONOMIKU

REMIGIJUS CIEGIS, RIMANTAS PAREIGIS

Kaunas Faculty of Humanities, Vilnius University Muitines 8,
Kaunas LT-42280, Lithuania
Phone: + 370 37 422344, *e-mail*: remigijus.ciegis@vukhf.lt, rimantas.pareigis@vukhf.lt

Abstract. *In the article the main requirements for sustainable economic development management system were formed using theoretical approach. According to the collected theoretical material, approaches of sustainable management of economic systems from the viewpoint of principles of sustainability are reviewed. The article evaluates the content and issues related to the environmental indicators, including the environmental space and the ecological footprint concepts, applied in sustainability measurement, as well.*

Keywords: *development, environmental indicators, management, sustainability.*

Introduction

The main attention in the paper are given to the process of the management of sustainable development and to analyze the indicators of sustainable development.

The theoretical principles of management of socially and ecologically oriented economic development realization and the content of environmental indicators, including concepts of ecological space and ecological footprint are critically investigated in the paper.

The essence of the sustainable development concept and management principles

The today"s dilemma of the world, mostly governed by economic powers, lies in the following: *at what scope sustainable development could be adequately analyzed and realized, referring to contemporary economic theories*. It should be noted that economic development orientations and concepts, valid in the previous century, cannot satisfy the humanity"s needs and they have only a limited application spectrum in environmental protection studies. The situation supposes the necessity to propose new approaches and to define the essence of economic theory, its potential role and tasks, in solving issues related to critical human existence and civilization survival in the future.

It is obvious that *unlimited growth is impossible in a limited system*, i.e. *economic growth beyond the limits of biosphere capacity would necessarily cause the environmental collapse, as there is no feedback mechanism to guarantee unregulated market economy would never exceed its ecological capacity of the environment* [2]. Thus, economic theory should eventually recognize the basic principles of science, entropy among them, and admit that economy is no longer a perpetual engine, but a one-way process. It can be more effective but it cannot be reversible.

The basic idea of sustainable development is a firm understanding that all resources, renewable as well as non-renewable, are limited. Human activities should not exceed the buffering capacity of the earth"s ecosystems.

It can be stated that alternative approach to economics was evolving as a standpoint of *relationship of complex natural-ecological systems, economic organizations and human communities*, hoping that modern world could be transformed into a better one from ecological and humanitarian point of view.

ISBN 9984 – 779 – 06 – 8

It is worth noticing that the economy of steady state can *develop qualitatively*, but *cannot grow quantitatively*. In case of sustainable development, the economy can improve from the standpoint of knowledge, organization, technical effectiveness and wisdom. *Development without growth is what we call sustainable development*.

Though the *essence* of the *sustainable development* concept is clear enough, the exact interpretation and definition of *sustainable development* has caused strong discussions. It is possible that the terminology problem occurs in the *dual* nature of the *sustainable development* concept, covering *development* as well as *sustainability*.

But the problems of precise definition of sustainable development term and content in the economics, in the management theory can be considered as advantage, because in all levels leaved *the space for the discussions, the variety of the possible models of development*.

In the analysis of consequences of society development it is possible to distinguish a) *ecological* dimension, b) *economic* dimension, c) *social* dimension. So, in order to achieve sustainable development the three corner stones of sustainability, i.e. *economy*, *ecology* (*environment*) and *society*, must be considered. Also it is possible to distinguish three society sustainable development *management approaches*: a) *economic*, b) *ecological*, c) *social*.

Taking into consideration these three society sustainable development management approaches, it is possible to formulate generalized principle of management of *sustainable development (complexity principle)*, which require to analyze *sustainable development* as the interface of *three systems – ecological, economic and social*.

Thus, the *sustainable development* concept merges two urgent *goals*: a) *to ensure appropriate, secure, wealth life for all people* – its is the goal of *development*, and b) *to live and labor in accordance with bio-physical limits of the environment* – it is the goal of *sustainability*. These goals might seem contradictory but, despite that, they have to be achieved in unison.

Sustainable development, as elaborated in Agenda 21, has three explicit dimensions, the *social*, the *economic* and the *environmental* one, and implicitly a fourth, the *institutional* one. (The ignorance of this *dimension* is one of the biggest shortages of management of implementation of society sustainable development). This can be visualized by the "*prism of sustainability*" (Fig. 1).

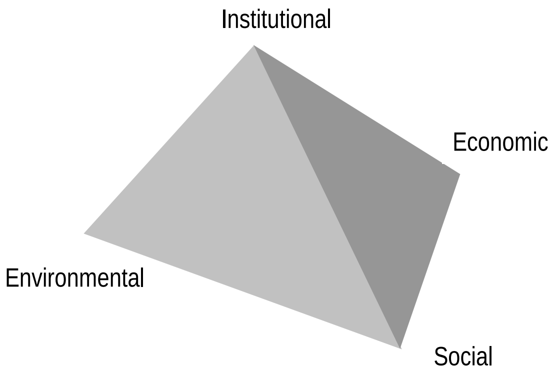


Fig. 1. **The four dimensions of sustainability [8]**

Since the concept of sustainability becomes relevant only as we understand the non-sustainability inherent in the current activities of society, it is logical to design principles for sustainability as restrictions, i.e. principles that determine what human activities must not do it under to avoid destroying the system.

Additionally, redirecting our societies and economies towards sustainability is a task that cannot be attributed to any subgroups of society, but one needs to involve society as large if it is to mastered effectively.

ISBN 9984 – 779 – 06 – 8

Management without yardsticks is not possible. If we don"t can to *measure* society"s sustainable development targets, it is impossible to *govern*. Therefore if we want to manager sustainability, the society is in charge of formulating sustainability objectives, which should be constantly review and assessed. *Sustainable development indicators* can successfully measure the degree of objective implementation.

By using a set of well-defined indicators it becomes easier to communicate Sustainable development, and in particular, the Local Agenda 21 implementation process. Using the *Prism of Sustainable Development* model in this process enforces prioritizing, by reducing the number of indicators down to 12 to 15 (each connected with targets), while at the same time supporting a broad and balanced coverage of environmental, social, economic and institutional issues. Together with indicators for the four sustainability dimensions so-called inter-linkage indicators are needed, that link progress towards the four dimensions together.

Measurements of the Sustainability Management

The contemporary indicator of economic development is considered to be *Gross National Product (GNP)*. But GNP cannot serve as a feasible indicator for evaluating the economic growth. Therefore [3] calculated an "*Index of Socio-Economic Welfare*" (ISEW). ISEW makes different adjustments to GNP from MEW, including giving consideration to resource depletion and environmental damage, so the two indices are not strictly comparable.

Indicator – is the measure, differentiating from other values with its specific objectives, outreaching everything what could be directly measured. Indicators of sustainable development should concentrate the attention on the *start of the development cycle*, such as energy, resources, chemicals and other development sources and measures.

An optimal quantity of environmental indicators should be selected in order to improve the current indicator system and to assess competitive tendencies and system requirements.

In order to find a feasible answer how to evaluate sustainability goals of economic development, the two concepts of "the *environmental space*" and "the *ecological footprint*" can be applied. The *"environmental space"* is a more complex approach where various important resource sectors are being analyzed on the national level. Thus, the *"environmental space"* faces application difficulties in practice, comparing it to the *"ecological footprint" concept*, where resources are brought together into a single indicator at the desirable aggregated level. Besides, the *ecological footprint* makes the sustainability challenge more transparent.

It is known that those current projects, which applied the *environmental space* and *ecological footprint* concepts, have not presented a thorough developed scenario for securing sustainability, but have only produced presumptive framework of directives and major implementation principles. In the future this evaluation should be supplemented by actual figures, assuming the quantity of resources the world could utilize in sustainable way.

The basic idea of the *ecological footprint* concept, developed by *W. Rees* and *M. Wackernagel* [7], predisposes every individual process, activity and region as influencing the utilization of the Earth"s resources, waste accumulation and consumption of nature"s services. This complex impact caused by utilization of resources and the environment can be converted into a one-dimensional measure (that is where the substantiality of the method comes into force), namely into a biologically active land plot which should be presented in a calculated form.

Applying this method to land distribution per person demonstrates that the average ecological footprint in the world would amount to about 1.8 hectare per head. The ecological footprint in most developed countries reaches 3- 5 hectares per head. Bearing in mind the fact that most developed regions exceed the ecological footprint limits of local ecological capacities, this inevitably leads to claiming extra ecological capacity from the global fund [1].

Some critique can also be found towards the *ecological footprint* concept. How could the calculation of the ecological footprint be improved? On the first hand, the *actual* figures, not *hypothetical* should be used in comparing two types of ecological footprint, which would reflect actual sustainable and non-sustainable land utilization per person. On the other hand, more

ISBN 9984 – 779 – 06 – 8

flexibility should be allowed in the ecological footprint calculations. Probably it would be best to use the scenario method, which permits to research complex processes under the circumstances of big changes. The modeling method, not the accounting one, should be selected to realize economically valid conclusions.

The *ecological space* concept constitutes that at any time there are limits to the degree of environmental pressure, the Earth"s ecological systems could cope without irreversible damage to these systems. (Fig. 2).

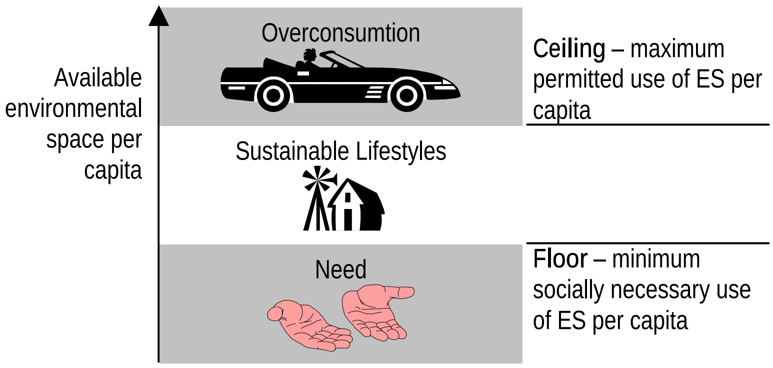


Fig. 2. **Living with our Environmental Space**

Mechanisms of progressive resource taxation based on the environmental space as a "threshold concept" should be considered as a necessary instrument for the enforcement of sustainable development.

It is beyond any doubt that it will not be possible to prepare further strategies of effective environmental protection without clarifying, how much ecological space we have globally.

Thus, the amount of the ecological space is *limited* in its nature and at least it can be measured *quantitatively* up to some degree. In addition, the *environmental space* concept offers an opportunity to determine, how much environmental space of one country is used by inhabitants of the other one, by comparing the *global* utilization of an individual resource, expressed as the average per person in *national* consumption.

Economic System Change Influence on Environmental Management Processes

During independence restoration and economical independence gaining processes it was stressed the importance of environment. The big activity of those days society also determined that the problems of environmental quality improvement would be integrated beside other immediate problems. It is believable, that market economy system would be much more superior solving ecological problems that have reached the crucial limits. The centralized ruled system will be estimated as unable operatively, flexible and effective co-ordinate the relations between economical enlargement and environment. But the idea to pass the solution of ecological problem to market was too much optimistic and not rational at all. The experts with great experience [5] indicated that market economy is ecologically blind enough and socially deaf enough. So rational solution of economical enlargement and environmental quality relations is possible only actively functioning State regulation.

Emphasizing that economical transformation is a very complicated processes, it is indicated that in the first stage it consists of three elements: liberalization, macro economical stabilization and systemic transformation. The systemic transformation at first is understood as privatization. Private propriety is a basis of market economy functioning; privatization is a foundation – stone of transformation. The estimation of effectiveness of privatization processes in Lithuania is not synonymous. Naming its negative sides it is necessary to specify that it be not used the possibilities of ecological situation improvement in companies during the process of privatization. The problems of privatization and diminution of negative influence of companies

ISBN 9984 – 779 – 06 – 8

to environment were successfully solved in some neighbor countries, which fulfilled the transformation. In Lithuania it was not tried to do it in case of overdue estimation of such possibility or in case of other reasons.
On the basis of monitoring system in Lithuania it was tried to compare the gathered information about main polluting materials throwing out to environment – common emission in millions of ton per year with Gross National Product tendencies (Fig. 3).

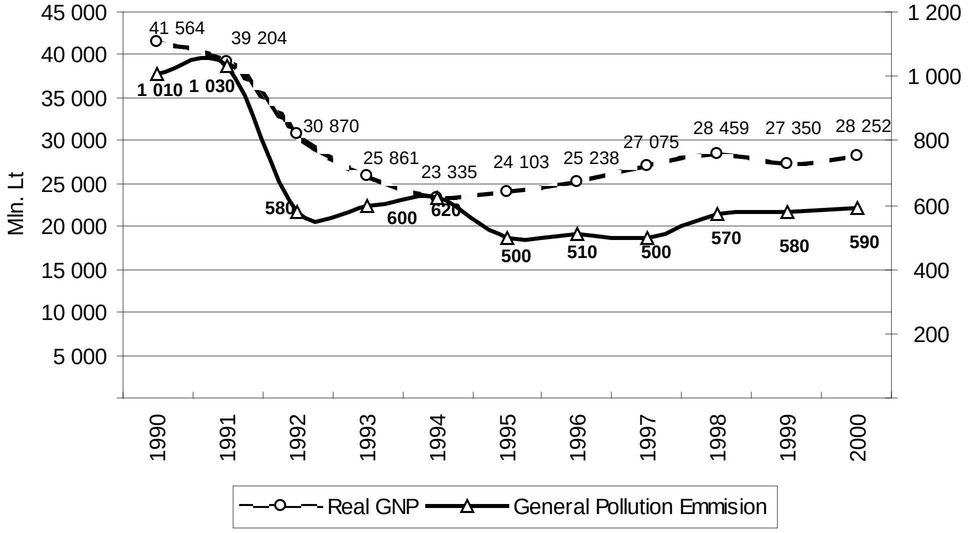


Fig. 3. **GNP and general pollution emission in Lithuania**

The calculations shows, that even if there is such diminution of the pollution economical damage for anthropogenic pollution makes about 1,7 milliard Lt., or it is about one tenth of GNP. Comparing with other European countries analogical indexes it is possible to state that ecological stability as one of three sustainable development components is in operatively improvable situation.
The period of economical systems transformation in Lithuania matched with global sustainable development tendencies development, with the solution of its localization problems. Quickly becoming clearer the advantages of sustainable development coordinating the questions of economical development and environment it becomes one of the most important problems of the country.
Analyzing the process of economical transformation it was stressed that there was a lack of comprehensive and effective strategy of this question. For the first five transformation years environmental reforms also were accomplishing without clear strategic goals. Just in autumn 1996 the Lithuanian environmental protection strategy was confirmed. The project that got juridical power was prepared by Lithuanian and foreign experts, who tried as accurate as possible to foresee and to ground tendencies of environmental changes till 2010. Every strategy has to include three main elements: purposes (at first permanent), activity directions, and resources necessary for achieving the purpose. The weakest link in country"s environmental protection strategy is the third element. In strategy formation group worked investments group was often unable to defend its suggestions based on economical calculations. Probably, that if there was a more real consideration to the demands of the third strategic element, the strategy would be more precise.
At this time it is more often used the concept "preparation for the European Union integration" that means in environmental usage respect that Lithuania in this field must be able to solve problems the way European Union directives demand. Estimating the dilemma of to join or not to join European Union in environmental usage respect, the merits are very bright. At first, the country in a short time would adopt what is accumulated in the solution of most progressive economical development and environmental quality keeping problems. Secondly, it would

ISBN 9984 – 779 – 06 – 8

appear a possibility to Lithuania using the support of European Union rapidly to realize ecological projects. In conformity with the goals of EU the main Lithuanian projects would be connected with waters cleaning, with diminution of air pollution and with waste regulation.

Analyzing the environmental usage evolution in the period of centralized ruled economy it was stressed the importance of information about environmental quality changes. EU directives especially stress the significance of such kind of information and present the rational system of sustainable development indicators. This indicators system includes integrated sustainable development indicators that reflect the interaction of environmental, economical, social aspects. Basing on such information it will be possible to compare operatively the changes of environmental quality, to estimate the rapidity of acting progress. At this time in Lithuania functioning monitoring system will have to be corrected according to the demands of stabile environment indicators system.

Trying to estimate economical changes in the period of economical transformation, it is purposeful to periodize it. Estimating the period of integration into EU its positivism to the outlook to environmental quality stabilization and improvement becomes apparent. It is believable that realization of integration demands to environmental usage and stabile development in Lithuania will let to state the approach to the end of the period of economical system transformation. Also it should be a further development to stabile social – ecological market economical system.

One of the most important reasons determined the crisis environmental state in the period of centralized economy market was insufficient investments to environment. In last years of centralized economy period there were prepared the projects of ecological situation improvement of the whole country and its separate regions. These projects had a very indefinite and not-concrete financial background.

The restoration of the independence is connected with today and from the distance of time real enough estimated euphoric outlook to the rapid increase of environmental investments of that time. The wish to start using market economy mechanism instruments in environmental management as quickly as possible did not correspond with the situation of that period. In the act of law of Environmental Protection, passed in the beginning of 1992, it is indicated that ecological and economical interests of the State are coordinated applying economical mechanism of environmental protection. This mechanism consists of taxes for nature resources and environmental pollution, subsidies and credits of the State, State regulated tariffs and customs system, system of economical stimulation sanctions and compensation.

Sustainability will be won on the *market* – or not at all. We are needing a new approach, which would have to be an integral part of the market economy where self-interest would drive ecological improvements yielding profits rather than generating added costs by government edict. In market economy ecological taxes are very important instrument of environmental usage processes management. On the basis of these taxes collected means are returning to environment as the investments influencing balance of economical and environmental processes. Countries that are progressively developed in market economy use different kinds of ecological taxes. It is the taxes for nature resources usage, taxes for environmental pollution, taxes for ecologically dangerous production, compensational payments for diminution of nature resources quality, etc.

The insufficiency of income collected from ecological taxes, the inefficiency of other sources of investment was noticed in the first year of market formation. When the State strategy of environmental protection was started to be prepared, in which project preparation group also participated the author of this text, one of the main accents was the determination of eventual sources and the size of investments necessary to strategy realization.

Estimated the environmental conditions and calculated costs necessary for its improvement it became clear that in the next decade till the year 2005, to which the realization of this strategy was orientated, it will be impossible to solve the most important ecological problems for the same as earlier reason – the lack of the financial resources. Optimistic regulations that during economical systems changing period, which is never followed with rapid speed of economical

ISBN 9984 – 779 – 06 – 8

growth, it would be possible to solve effectively ecological problems, were denied. Referring to results of internal and external experience and trying to keep the equilibrium between the optimistic and pessimistic poles of economical development perspectives, strategically necessary investments were assigned following to priority directions.

The priorities of environmental investments were grouped into two blocks: environmental quality keeping and environmental protection in economical activity sphere. Such kind of management of investment corresponds with general investments theory propositions that firstly the blocks of investments are divided, later on their base investments politics is formed and made decisions of possible sources of investments [4]. The priorities investment directions of the first block in State environmental protection strategy were named the cleaning of flowing waters, the stabilization of air pollution and gradually diminution, the regulation of waste. Effective investments in these directions would improve environmental quality till necessary standards, which were approved while Lithuanian orientating to European Union demands.

The second block of priorities investments direction includes environmental problems salvation in economical activity sphere, the necessary condition of effective investments is to create such kind of legal-economical system for minimizing contradictions between economical qualitative growth and its influence to environment. Environmental policy here must orientate at first to preventive means, which give an opportunity to realization sustainable development principles. With this main direction directed the goal of the State environmental protection strategy indicating that strategy strives for “making a presumption for sustainable development of the country keeping clean and sound nature environment, saving biological and landscape variety and optimizing nature usage”. The State environmental protection strategy in this block of priorities presents the detailed activity programs for separate economical branches.

Finally, legal and other instruments, suitable new institutional arrangements – among many other things – can be developed with the common goal to approach sustainability in the most reliable, transparent and systematic way possible. Sustainable environmental management can make use of economic policy mechanisms, but in the final analysis needs to be cognizant of the fundamental laws of nature, as much as those of economics.

And it is clear that corporate philosophy and responsibility will face crucial changes. Increasing demand for sustainable development during the last decades has initiated actions from firms. Firms have expanded the scope of corporate responsibility to include environmental issues in all levels of their operation, and a major development of environmental corporate strategies, as well as a green-washing of industry has been observed in the world [9,10], and in Lithuania too. M. Porter and C. van der Linde [6] suggest corporate strategy changes to enhance environmental as well as business performance of firms. But despite all these preventive actions a continuous increase in environmental impact has been observed.

Sustainable development is currently one of the leading driving forces for the greening of industry. Within the sustainability framework, the substance chain management manages the economically and ecologically oriented cooperation between companies in production or value – added chain.

Conclusions

According to theoretical presumptions of various theoreticians, three major groups of sustainable development management approaches – economic, ecological and social – can be interpreted and identified, which allows sustainable development to be analysed as the interface of ecological, economic and social systems.

Sustainable development, as elaborated in Agenda 21, has three explicit dimensions, the *social*, the *economic* and the *environmental* one, and implicitly a fourth, the *institutional* one. The *“prism of sustainability”* can visualize this.

In search for solutions of adequately evaluating the achievements of sustainability in economic development, the concepts of “the *environmental space*” and “the *ecological footprint*” can be applied.

ISBN 9984 – 779 – 06 – 8

Change of economic system was linked with basic positive changes in environmental processes management. Passing ecological problems solution to market was too optimistic and not rational. Experience of developed countries emphasize that market economic is quite blind and deaf in ecological meaning. General pollutions were compared to gross national product. There were decreases of both these indicators in Lithuania in the years of 1990 – 1994. Later, until the year of 2000 both gross national product and general pollutions increased.
Economical development performs insufficiently taking into account influence to environment and trying to reduce it. Decrease of influence to environment increasing influencing activities at the same time is possible only establishing more perfect technologies and defining regulations of environmental quality. It is easier because of coincidence of economic systems" transformation period in Lithuania with global evolution of sustainable development principles and solution of sustainable development localization problems.
Sustainable development localization meets with some difficulties like un – ecological finance markets, economical indicators prevailing over environment, distortional system of subsidies, lockage of financial means, scantiness of local administrations" authority.
Sustainable development should be a core value in any business organization because it supports a strategic vision of firms surviving over the long term. And, if businesses are serious about the concept of sustainable development, then many of the sacred tenets of doing business will have to be re-examined.

References

1. Ciegis R. Sustainable Development and Environment: Economic Approach. (In Lithuanian). Vilnius, 2002.
2. Daly H. E. Steady-State Economics, 2nd edition. San Francisco, 1991.
3. Daly H. E., Cobb J. B. For the Common Good: Redirecting the Economy Toward Community, the Environment and Sustainable Future. Boston, 1989.
4. Fabozzi, F., J. Investment Management. – Prentice: Hall Inc, 1995.
5. Hopfman, J., Winker, G. Zukunftsstandort. – Deutschland: Droemer Knaup, 1997.
6. Porter M., van der Linde C. Toward a New Conception of the Environment: Competitiveness Relationship // Journal of Economic Perspectives 1995. N 9. P. 97–118.
7. Rees W. E., Wackernagel M. Ecological footprints and appropriated carrying capacity: Measuring the natural capital requirements of the human economy. / In: A-M. Jansson, C. Folke, R. Costanza (Eds.), Investing in natural capital: The ecological economics approach to sustainability. Washington, 1994. P.362-390.
8. Spangenberg, J. H., Pfahl, S., Deller, K. Indicators for institutional sustainability. /In: I. Malkina-Pykh (Ed.), Indices and Indicators of Sustainable Development: A System Approach. Proceedings of the Second Biannual INDEX Conference, St. Petersburg, Oxford, 1999.
9. Welford R. Corporate Environmental Management 3: Towards Sustainable Development. London, 2000.
10. Welford R. (Ed.). Hijacking Environmentalism: Corporate Responses to Sustainable Development, Earthscan Publications, London, 1997.

ISBN 9984 – 779 – 06 – 8

RACIONĀLA ZĀLAUGU BIOLOĢSKĀS DAUDZVEIDĪBAS IZMANTOŠANA KVALITATĪVAS LOPBARĪBAS IEGUVEI
RATIONAL USE OF HERBAGE BIOLOGICAL DIVERSITY FOR HIGHT-QUALITY FORAGE PRODUCTION

ALEKSANDRS ADAMOVIČS, MAIJA BEČA, JĀZEPS SPRUŽS

Latvijas Lauksaimniecības universitāte, Liela iela 2, Jelgava, LV – 3001, Latvija
e-mail: aleksandrs.adamovics@llu.lv, jazeps.spruzs@llu.lv

Abstract. *Research goal – information of floristically rich and hight – productive agrocenosis for the production of qualitative forage. Long – term field experiments were established on two types of soils using species of grasses with biological and economic traits different from forage legume and grass families.Persistence, productivity and quality of forage grasses have been determined in mixed swards in different utilization regimes and on different fertilizer backgrounds. It was stated that the rational use of the forage grasses gene fund as well as aperies and varieties of grasses introduced into Latvia can contribute to the formation of night – productive meadows and pastures with the average dry matter (DM) yield 8.5 – 14.0 t ha^{-1}. The produced grasses may he helpful in making top – quality hay and silage which, by their quality parameters (protein, amino acids, mineral substances, ADF and NDF content) are fully corresponding to standards set in high – productive animal feeding.*

Key words: *herbage, productivity, grass forage, quality.*

Ievads

Lopbarības ražošanai Latvijas agroklimatiskajos apstākļos vispiemērotākie ir daudzgadīgie zālaugi. Tieši tie nodrošina dzīvniekus ar nepieciešamām barības vielām, enerģiju un vitamīniem. Zemnieku saimniecībās Latvijā ap 80% no zālāju sējumu struktūras sastāda zelmeņi, kurus veido sarkana āboliņa un timotiņa maisījumi.[1] Pārējo zālaugu ģenētiskie resursi un bioloģiskās īpašības tiek izmantotās salīdzinoši maz. Tāpēc zālāju zelmeņu bioloģiskās daudzveidības paplašināšana, produktivitātes paaugstināšana un kvalitātes uzlabošana ir ļoti aktuālā problēma.

Lopbarības ražošanai vēl salīdzinoši maz tiek izmantotas lucernas, austrumu galega, auzeņairenes. Plašāka lopbarības tauriņziežu un jaunāko stiebrzāļu sugu izmantošana dažādās lopbarības ražošanas sistēmās, it īpaši organiskās, veicina videi draudzīgāku saimniekošanu, ļauj ievērojami samazināt minerālmēslojuma normas. [2, 3]

Ēdināt liellopus saskaņā ar viņu prasībām nepieciešams ne tikai viņu veselības un optimālās peļņas dēļ, bet arī , tāpēc lai samazinātu atkritumu uzkrāšanas apkārtējā vidē. Lai apmierinātu dzīvnieku vajadzības, pēc iespējas precīzāk jāzina uzņemamās barības vērtību. Barības enerģētiskā vērtība ir visnozīmīgākais faktors, kas nosaka barības devu pašizmaksu.

Pētījumi dažādu barības sagatavošanas veidu ietekmi uz aminoskābju sastāvu parāda, ka skābbarības sausnā trīs limitējošo aminoskābju – lizīna , metionīna un triptofāna , kā arī serina un glutamīnskābes daudzuma izmaiņas, salīdzinot ar zaļmasu, ir niecīgas.[4,5]

Pētījumu mērķis – noteikt labākus tauriņziežu- stiebrzāļu un stiebrzāļu sēklu maisījumus augstražīgu zelmeņu veidošanai un kvalitatīvas lopbarības ieguvei.

Materiāli un metodes

Par izmēģinājumu bāzi kalpoja plašie lauka izmēģinājumi par tauriņziežu un stiebrzāļu dažādu zālāju agrofitocenožu noturību un produktivitāti, kuri bija ierīkoti uz lesivētām brūnaugsnēm (pH_{KCl} 6.7, P–52, K–128 mg kg^{-1}, organisko vielu saturs 21-25 g kg^{-1} augsnes).

Lauka un laboratorijas izmēģinājumus veica ar vienkomponentu, divkomponentu un daudzkomponentu zelmeņiem. Tajos bija iekļautas tauriņziežu sugas: hibrīdā lucerna (*Medicago varia.*), austrumu galega (*Galega orientalis.*), baltais āboliņš (*Trifolium repens*) un 7 stiebrzāles: pļavas lapsaste (*Alopecurus pratensis*), kamolzāle (*Dactylis glomerata*), ganību airene (*Lolium perenne*), pļavas auzene (*Festuca pratensis*), sarkanā auzene (*Festuca rubra*), pļavas skarene

ISBN 9984 – 779 – 06 – 8

(*Poa pratensis*) un timotiņš (*Phleum pratense*) Pētījumus veica ar 30 austrumu galegas - stiebrzāļu, 30 baltā āboliņa – stiebrzāļu un 30 lucernas - stiebrzāļu un 30 stiebrzāļu sēklu maisījumiem. Zelmeņu izmantošanas biežums veģetācijas periodā bija 3- reizēja un 4- reizēja pļaušana. Abi zelmeņu izmantošanas varianti bija ierīkoti uz diviem slāpekļa mēslošanas foniem: N - 0 un N - 90 $_{(45+45)}$ kg ha $^{-1}$ Kopējais pētāmo variantu skaits lauka izmēģinājumos ir - 480.
2002. gadā tika ierīkoti lauka izmēģinājumi uz velēnu podzolētām augsnēm (pH_{KCl} 7.1, P–253, K– 198 mg kg^{-1}, organisko vielu saturs 31 g kg^{-1} augsnes) ar 8 auzeņaireņu un aireņu hibrīdu šķirnēm no Dānijas, Vācijas un Lietuvas. Par kontroli kalpoja Latvijā selekcionētās šķirnes. Zelmeņi tika veidoti izmantojot ganību airenes šķirni „Spidola”(kontrole), auzeņaireņu šķirnes: „Perun” *(Lolium multiflorum x F. pratensis),* „Punia” *(Lolium multiflorum x F. pratensis),* „Lofa” *(Lolium multiflorum x F. arundinacea),* „Felina” *(Lolium multiflorum x F. arundinacea),* „Hykor” *(Lolium multiflorum x F. arundinacea)* un hibrīdu aireņu šķirnes: „Tapirus” *(Lolium multiflorum x L. perenne),* „Ligunda” (*Lolium multiflorum x L. perenne*). Zelmeņu mēslošanai pielietoja sekojošas minerālmēslojumu normas: P 79, K 90 un divas N normas N 120$_{(40+40+40)}$ un N 180$_{(60+60+60)}$ kg ha^{-1}.Visiem zelmeņiem, kurus izmantoja kā pļaušanas tā arī ganīšanas režīmā pirmā pļāvuma zālei ir noteikts botāniskais sastāvs un ražas kvalitāte.
Neitrāli skalotas (NDF) un skābi skalotas(ADF) kokšķiedras frakcijas un barības enerģētisko vērtību noteica pēc Van Soesta (1980),aminoskābju saturu un sastāvu ar aminoskābju analizatoru AAA339, buferkapacitate pēc Zubrilina (1967), fermentācijas koeficientu aprēķināja pēc formulas FC=DM+8*WSC/BC (Weiβ et.al.,1998)

Rezultāti

Zelmeņu produktivitāte. Lai nodrošinātu bioloģisko lopbarības ražošanu sistēmu ilgspējīgumu, nepieciešams atrast augu barības režīma nodrošinājuma alternatīvus risinājumus. Viens no tiem varētu būt tauriņziežu plašāka izmatošana zālāju zelmeņu struktūrā, sakarā ar to spēju saistīt atmosfēras slāpekli.
Mūsu pētījumos noskaidrots, ka tauriņziežu - stiebrzāļu zelmeņi augstas zaļmasas un sausnas ražas nodrošina pat ekstremāli sausos gada laika apstākļos. Tas ir izskaidrojams ar ļoti dziļu un spēcīgi attīstītu sakņu sistēmu tauriņziežiem. Spēcīgi attīstītā sakņu sistēma palīdz izmantot ūdeni no augsnes dziļākajiem slāņiem un veicina ražas veidošanos
Austrumu - galegas stiebrzāļu zelmeņi. Lesivētā brūnaugsnē austrumu galega tīrsējā, pļaujot to divas reizes veģetācijas sezonā, nodrošināja vidēji augstas zaļmasas ražas un 8.1–9.13 t ha^{-1} sausnas ieguvi.(1.tab). Divkomponentu austrumu - galegas stiebrzāļu zelmeņu produktivitāte vidēji bija 7.98 t ha^{-1} sausnas bez slāpekļa mēslojuma izmantošanas un 7.31 t ha^{-1} pielietojot slāpekļa minerālmēslojumu dalītā veidā veģetācijas sākumā un pēc pirmā pļāvuma. No tā var secināt, ka augstražīgi zelmeņi veidojās sējot austrumu galegu maisījumos ar dažādām stiebrzāļu sugām arī bez slāpekļa mēslojuma pielietošanas, iekļaujot sēklu maisījumā līdz 60 % stiebrzāļu sēklu no maisījuma kopējās izsējas normas. Visaugstākās sausnas ražas ieguvi – 8.15 t ha^{-1} nodrošināja lielākā daļa daudzkomponentu sēklu maisījumu. Ražīgākie no daudzkomponentu maisījumiem bija tie galegas – stiebrzāļu zelmeņi, kuri veidoti no divu - četrkomponentu sēklu maisījumiem - vidēji 7.80 – 8.15 t ha^{-1} sausnas. Ļoti augstražīgs bija zelmenis – *austrumu galega 40 % + timotiņš 20 % + pļavas skarene 20 % + sarkanā auzene 20 %* - 10.72 t ha^{-1} sausnas. Kamolzāle un sarkanā auzene, kā komponenti maisījumu sastāvā, ir visnoderīgākie sausajos gados, jo tām ir salīdzinoši spēcīgi attīstīta sakņu sistēma. Komponentu skaita palielināšana līdz 5-6 būtiski neietekmēja austrumu galegas- stiebrzāļu zelmeņu ražas līmeni salīdzinājumā ar 2 - 4 komponentu zelmeņiem.

ISBN 9984 – 779 – 06 – 8

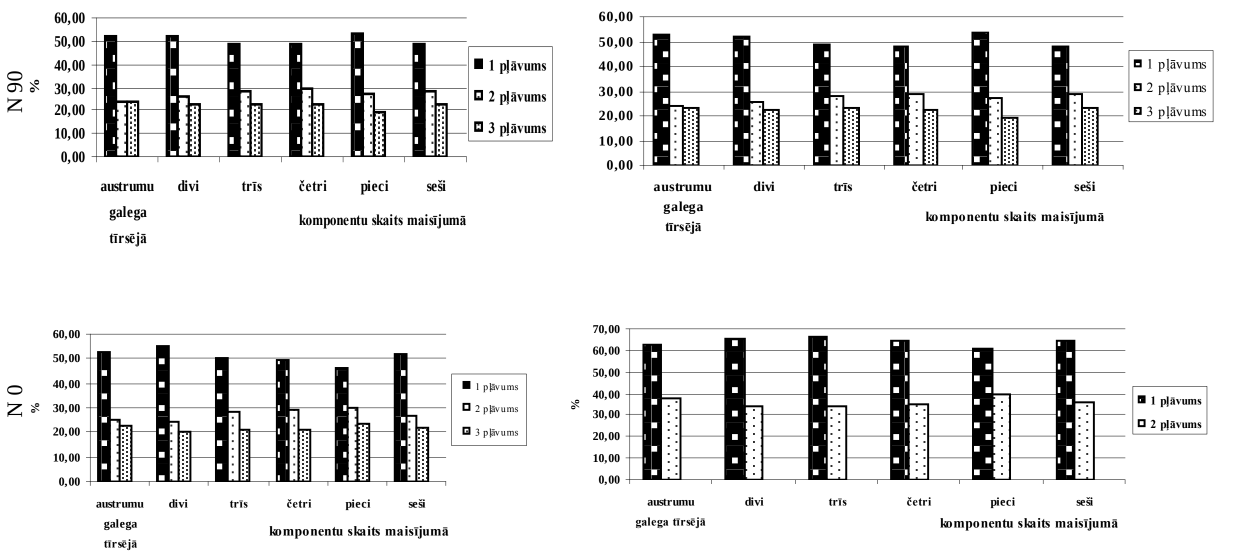
1.tabula

Austrumu galegas-stiebrzāļu zelmeņu sausnas ražas atkarībā no komponentu skaita maisījumā, t ha^{-1} (vidēji 2001 - 2004)

Pļaušanas režīms (F_A)	Slāpekļa mēslojums, kg ha^{-1} (F_B)	Zelmeņa sastāvs, (F_C) Komponentu skaits maisījumā: austrumu galega tīrsējā	divi	trīs	četri	pieci	seši	Vidēji	Vidēji (F_A) $\gamma_{.05}$=0.28	Vidēji (F_B) $\gamma_{.05}$=0.15
Divreizēja pļaušana	N-0	9.13	9.95	10.30	10.29	10.35	9.97	10.00		8.24
	N-90	8.17	8.51	8.34	8.86	8.73	8.51	8.52	9.26	7.42
Četrreizēja pļaušana	N-0	7.14	6.62	6.22	6.66	6.15	6.13	6.49		
	N-90	7.07	6.11	5.97	6.80	5.71	6.25	6.32	6.40	
Vidēji(F_C) $\gamma_{.05}$=0.13		7.88	7.80	7.71	8.15	7.73	7.72	7.83		

Minerālslāpekļa mēslojuma pielietošana kopumā negatīvi ietekmēja austrumu galegas-stiebrzāļu zelmeņu produktivitāti. Sausnas raža samazinājās vidēji par 1.25 t ha^{-1}. Tas izskaidrojams ar austrumu galegas īpatsvara samazināšanos ar slāpekli mēslotos zelmeņos.

Pie divreizējas zelmeņu pļaušanas režīma lielāko ražas daļu 60 % no zelmeņa gada ražas nodrošināja pirmais pļāvums, bet otrais - 40 procentus. Vidēji no četriem pļāvumiem šajā izmantošanas režīmā ieguva 6.49 t ha^{-1} sausnas bez slāpekļa minerālmēslojumu pielietošanas. Arī pie šo zelmeņu izmantošanas režīma lielāku sausnas ražas daļu – 51 % sastādīja pirmais pļāvums, otrajā pļāvumā ieguva 27.3 un trešajā – 21.7 % no kopējās ražas (1.att.)



1.attēls. **Austrumu galegas - stiebrzāļu zelmeņu sausnas ražas sadalījums pa pļāvumiem, %**

Hibrīdās lucernas - stiebrzāļu zelmeņi. Pētījumos ar hibrīdo lucernu noskaidrots, ka tās ražību mazāk ietekmē meteoroloģiskie apstākļi- gaisa temperatūra un nokrišņu daudzums.

Īpaši labi, salīdzinot ar citiem tauriņziežiem, lucerna pacieš sausumu. Sausumizturība lucernai palielinās tās zelmeņu izmantošanas gadu gaitā, kad sakņu sistēma paliek arvien attīstītāka un spēcīgāka.

No hibrīdās lucernas tīrsējas zelmeņiem četros izmantošanas gados pie trīsreizējas pļaušanas, bez slāpekļa mēslojuma pielietošanas vidēji četros gados ieguva 11.04 t ha^{-1} sausnas. (2. tab.)

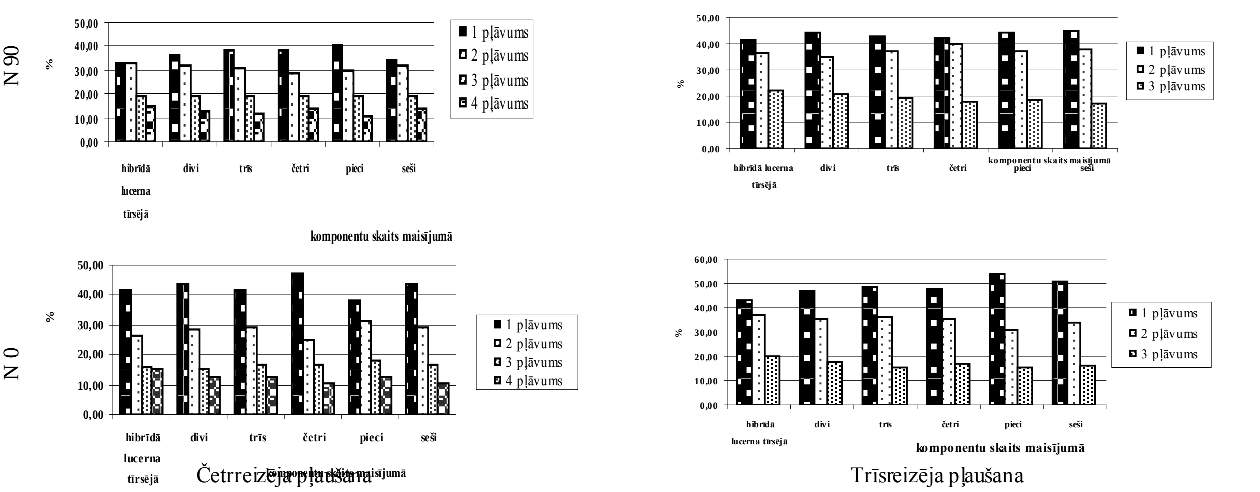
ISBN 9984 – 779 – 06 – 8

2.tabula

Lucernas-stiebrzāļu zelmeņu sausnas ražas atkarībā no komponentu skaita maisījumā, t ha^{-1} (vidēji 2001 - 2004)

Pļaušanas režīms(F_A)	Slāpekļa mēslojums, kg ha^{-1} (F_B)	Zelmeņa sastāvs, (F_C)						Vidēji	Vidēji (F_A) $\gamma_{.05}$=0.32	Vidēji (F_B) $\gamma_{.05}$=0.16
		Komponentu skaits maisījumā								
		hibrīdā lucerna tīrsējā	divi	trīs	četri	pieci	seši			
Trīsreizēja pļaušana	N-0	11.04	11.45	10.94	11.43	11.64	11.21	11.29		9.87
	N-90	10.83	11.20	10.89	11.47	10.56	11.13	11.01	11.15	9.70
Četrreizēja pļaušana	N-0	8.59	8.46	8.32	8.30	8.56	8.56	8.46		
	N-90	8.67	8.25	8.14	8.30	8.57	8.44	8.40	8.43	
Vidēji(F_C) $\gamma_{.05}$=0.14		9.78	9.84	9.57	9.87	983	9.83	979		

Pļaujot hibrīdās lucernas tīrsējas zelmeņus četras reizes veģetācijas periodā, ražas līmenis ievērojami samazinājās un sastādīja tikai 8.59 t ha^{-1} ar slāpekli nemēslotos variantos un 8.67 t ha^{-1} sausnas mēslojot zelmeņus ar slāpekli. Jaukto lucernas - stiebrzāļu zelmeņu vidējā sausnas raža sastādīja 9.87 t ha^{-1} bez slāpekļa mēslojuma un 9.70 t ha^{-1} ar slāpekli mēslotos zelmeņos. Ražas līmenis bija ļoti atkarīgs no sēklu maisījumu sastāva. Divkomponentu zelmeņu produktivitāte vidēji sastādīja 10.76 t ha^{-1} sausnas, pļaujot tos trīs reizes veģetācijas sezonā. Produktīvākie bija zelmeņi: *hibrīdā lucerna 40 % + kāmolzāle 60 %* - 12.02 t ha^{-1} un *hibrīdā lucerna 40 % + pļavas lapsaste 60 %* - 12.37 t ha^{-1}sausnas. No daudzkomponentu zelmeņiem visproduktīvākais bija maisījums, kurā bija iekļauti sekojoši komponenti – *hibrīdā lucerna 40 % +ganību airene 20 % + timotiņš 20 % + sarkanā auzene 20 %* - 11.68 t ha $^{-1}$ sausnas.



2.attēls. **Lucernas - stiebrzāļu zelmeņu sausnas ražas sadalījums pa pļāvumiem, %**

Zelmeņu biežāka izmantošana negatīvi ietekmēja lucernas – stiebrzāļu zelmeņu produktivitāti, vidējā sausnas raža pie četrreizējas pļaušanas sastādīja tikai 8.43 t ha^{-1} jeb par 2.73 t ha^{-1} (24.4%) zemāka, salīdzinot ar trīsreizēju pļaušanu.

Zelmeņu sausnas ražas sadalījums pa pļāvumiem atkarībā no komponentu skaita maisījumā un slāpekļa mēslojuma parādīts 2. attēlā. Pie trīsreizējas zelmeņu pļaušanas lielāko ražas daļu, vidēji 43.3 % ieguva no pirmā pļāvuma, otrajā- 37.3 %, bet trešajā – 19.4 %.(2.att.)

Pie četrreizējas pļaušanas sausnas ražas sadalījums pa pļāvumiem bija vienmērīgāks, bet arī šeit otrais pļāvums bija produktīvāks. Vidējais hibrīdās lucernas - stiebrzāļu zelmeņu ražas sadalījums pa pļāvumiem bija sekojošs: pirmais pļāvums – 42.9%, otrais pļāvums – 28.3 %, trešais pļāvums 16.5 % un ceturtais pļāvums – 12.3%.

ISBN 9984 – 779 – 06 – 8

Baltā āboliņa – stiebrzāļu zelmeņu ražas veidošanu vairāk ietekmēja mainīgie laika apstākļi, nekā galegas un lucernas zelmeņus. Sakarā ar to, ka baltajam āboliņam ir sekla sakņu sistēma, tā zelmeņi ļoti cieta no pārmērīgā sausuma.Pie trīsreizējas izmantošanas, bez slāpekļa mēslojuma pielietošanas vidēji ieguva 5.85 t ha^{-1} sausnas. Minerālslāpekļa mēslojums N 90_{45+45} kg ha^{-1} palielināja ražas līmeni līdz 6.63 t ha^{-1}. (3. tab.)

3.tabula

Baltā āboliņa-stiebrzāļu zelmeņu sausnas ražas atkarībā no komponentu skaita maisījumā, t ha^{-1}(vidēji 2001 - 2004)

Pļaušanas režīms (F_A)	Slāpekļa mēslojums, kg ha^{-1} (F_B)	Zelmeņa sastāvs, (F_C) Komponentu skaits maisījumā: baltais āboliņš tīrsējā	divi	trīs	četri	pieci	seši	Vidēji	Vidēji (F_A) $\gamma_{.05}$=0.24	Vidēji (F_B) $\gamma_{.05}$=0.12
Divreizēja pļaušana	N-0	5.85	6.66	6.51	6.51	6.72	6.80	6.51		6.28
	N-90	6.63	7.36	7.62	7.43	7.61	7.60	7.38	6.94	6.97
Četrreizēja pļaušana	N-0	5.77	5.86	6.17	6.45	5.99	6.10	6.06		
	N-90	6.04	6.33	6.69	7.05	6.40	6.83	6.56	6.31	
Vidēji(F_C) $\gamma_{.05}$=0.11		6.08	6.55	6.75	6.86	6.68	6.83	6.62		

Pļaujot baltā āboliņa tīrsējas zelmeņus četras reizes veģetācijas periodā, ražas līmenis sastādīja 5.77 t ha^{-1} ar slāpekli nemēslotos variantos un 6.04 t ha^{-1} sausnas mēslojot zelmeņus ar slāpekli. Jaukto baltā āboliņa - stiebrzāļu zelmeņu vidējā sausnas raža sastādīja 6.28 t ha^{-1} bez slāpekļa mēslojuma un 6.97 t ha^{-1} ar slāpekli mēslotos zelmeņos.

Baltā āboliņa - stiebrzāļu produktivitāti vidējā sausnas raža pie četreizējas pļaušanas sastādīja 6.31 t ha^{-1}, jeb par 0.63 t ha^{-1} zemāka, salīdzinot ar trīsreizēju pļaušanu.

Stiebrzāļu zelmeņi salīdzinājumā ar tauriņziežu stiebrzāļu zelmeņiem bija ievērojami mazāk produktīvi. Tie vairāk cieta no pārmērīgā sausuma. Bez slāpekļa mēslojuma pielietošanas vidēji ieguva 1.06 t ha^{-1} sausnas. Minerālslāpekļa mēslojums N 90($_{45+45}$ kg ha^{-1} palielināja ražas līmeni līdz 2.70 t ha^{-1}, tātad slāpekļa mēslojums veicinājis sausnas ražas pieaugumu stiebrzālēm vidēji par 1.64 t ha^{-1} (4. tab.).

4. tabula

Stiebrzāļu zelmeņu sausnas ražas atkarībā no komponentu skaita maisījumā,t ha^{-1} (vidēji 2001 - 2004)

Pļaušanas režīms (F_A)	Slāpekļa mēslojums, kg ha^{-1} (F_B)	Zelmeņa sastāvs, (F_C) Komponentu skaits maisījumā: stiebrzāles tīrsējā	divi	trīs	četri	pieci	Vidēji	Vidēji (F_A) $\gamma_{.05}$=0.20	Vidēji (F_B) $\gamma_{.05}$=0.11
Divreizēja pļaušana	N-0	0.77	1.00	0.98	1.02	1.04	0.96		1.06
	N-90	2.21	2.49	1.90	2.44	2.60	2.33	1.65	2.70
Četrreizēja pļaušana	N-0	1.32	1.20	1.04	1.15	1.13	1.17		
	N-90	3.18	2.91	3.15	2.88	3.21	3.07	2.12	
Vidēji(F_C) $\gamma_{.05}$=0.09		1.87	1.90	1.77	1.87	2.00	1.88		

Kopējo ražas līmeni pa veģetācijas sezonu ļoti būtiski noteica 1. pļāvuma raža. Pie trīsreizējas zelmeņu izmantošanas daudzkomponentu zelmeņu produktivitāte bija lielāka un sastādīja vidēji 2.12 t ha^{-1} sausnas.

Auzeņaireņu un hibrīdo aireņu raža pirmajā zelmeņu izmantošanas gadā bija ļoti augsta un sastādīja vidēji 13.4-17.6 t ha^{-1} sausnas .

ISBN 9984 – 779 – 06 – 8

Botāniskā sastāva dinamika Zelmeņu botānisko sastāvu ietekmēja vairāki faktori, svarīgākie no tiem bija: zālaugu konkurētspēja, zelmeņu izmantošanās biežums un slāpekļa mēslojums. Lucernas - stiebrzāļu zelmeņu botāniskais sastāvs atkarībā no minētajiem faktoriem bija ievērojami atšķirīgāks nekā austrumu galegas - stiebrzāļu zelmeņiem. Pie trīsreizējas pļaušanas, bez slāpekļa mēslojuma, hibrīdās lucernas īpatsvars sastādīja 42.8 %, stiebrzāles - 17.9 %, citas sugas, tai skaitā platlapji - 39.4 %, bet ar slāpekli mēslotos variantos 41.3 %, 30.6 un 28.1 % attiecīgi. Četrreizēja hibrīdās lucernas -stiebrzāļu zelmeņu pļaušana veicināja lucernas attīstību un palielināja tās īpatsvaru ar slāpekli nemēslotos variantos vidēji līdz: 77.4 %, bet ar slāpekli mēslotos variantos 64.3 procentiem. Austrumu galegas - stiebrzāļu zelmeņos vidēji pie trīsreizējas pļaušanas bez slāpekļa mēslojuma galegas īpatsvars sastādīja 45.1%, stiebrzāles - 17.8 %, citas sugas, tai skaitā platlapji - 37.1 %, bet ar slāpekli mēslotos variantos 38.3%, 34.3 un 27.6 % attiecīgi. Biežāka, četrreizēja zelmeņu pļaušana veicināja stiebrzāļu attīstību un savvaļas augu ieviešanos zelmeņos, palielinot to īpatsvaru ar slāpekli nemēslotos variantos. Šajos zelmeņos austrumu galega vidēji sastādīja 41.9 %, stiebrzāles - 34.1 % un citas sugas, tai skaitā platlapji - 24.2 %, bet ar slāpekli mēslotos variantos 48.7 %, 30.3 un 21.0 % attiecīgi.

Lopbarības kvalitāte. Tauriņziežu - stiebrzāļu zelmeņu ražas kvalitāti būtiski ietekmēja to botāniskais sastāvs, zālaugu attīstības fāze un pļaušanas biežums. Ganīšanas režīmā izmantojamiem zelmeņiem vidējais kopproteīna saturs bija 157 – 197 g kg^{-1} sausnas, NDF – 369 - 438, ADF – 274 - 372 g kg^{-1} sausnas. Pļaušanas režīmā izmantojamo zelmeņu pirmā pļāvuma vidējā ražas kvalitāte bija sekojoša: proteīna saturs – 127 – 143 g kg^{-1}, NDF – 469 - 552, ADF – 329 – 387 g kg^{-1} sausnas.

Barības pilnvērtīgumu raksturo arī kopējo aminoskābju un atsevišķu, īpaši neaizvietojamo aminoskābju īpatsvars kopproteinā. Visaugstākais kopējo aminoskābju līmenis tika konstatēts balta āboliņa-stiebrzāļu(74.1%) un austrumu galegas (73.2%) zelmeņu ražā. Neaizvietojamām aminoskābēm bagātāka bija austrumu galegas sausna - atkarība no veģetācijas fāzes to daudzums bija no 97.6 līdz 79.1 g kg^{-1}, baltā āboliņa-stiebrzāļu – 74.1-54.1 g kg^{-1}. Zemākais neaizvietojamo aminoskābju saturs (37.8 g kg^{-1}) konstatēts jaukto stiebrzāļu zelmeņu kopproteīnā. Atsevišķu aminoskābju koncentrācijas izpēte ziedpumpuru veidošanas fāzē visu analizēto zelmeņu kopproteīnā visvairāk konstatēts aizvietojamas glutamīnskābes (6.6-10.6 %) un asparagīnskābes (5.5 -6.9 %). Austrumu galegas zelmeņu kopproteīnā, salīdzinot ar pārējiem, augstāks bija arī neaizvietojamo aminoskābju lizīna (4.8%) leicīna (7.0 %) un arginīna (6.2%) īpatsvars.

Pēdējos gados Latvija atgremotāju dzīvnieku barības devā ziemas periodā pieaug skābbarības īpatsvars. Rūpīgi sagatavota skābbarība barības vērtības ziņā ir nepārspējama salīdzinot ar sienu. Zaļmasas ieskābēšana ir ļoti atkarīga no zelmeņu botāniska sastāva, zālaugu attīstības fāzes, sagatavošanas tehnoloģijas, glabāšanas laika uzturētas anaerobas vides un sekojošas fermentācijas. Par skābbarības fermentācijas kvalitāti vispārīgi spriež pēc fermentēto skābju un amonjaka, kas radies, noārdoties proteīnam, attiecības. Vislabāk zaļmasas skābējamību raksturo fermentācijas koeficients. Mūsu pētījumos tauriņziežu tīrsējas masai bija konstatēta zema skābējamība, fermentācijas koeficients vidēji izmainījās 33-40 robežas. Ievērojami labāk ieskābst tauriņziežu-stiebrzāļu un jaukta stiebrzāļu zaļmasa kur fermentācijas koeficients bija 55-64.

Secinājumi

1. Lucernas - stiebrzāļu un austrumu galegas - stiebrzāļu zelmeņi ir salīdzinoši maz pakļauti meteoroloģisko apstākļu ietekmei. Tiem ir palielināta produktīva ilggadība un tie nodrošina augstas zaļmasas un sausnas ražas ieguvi (vidēji.5.85-11.04 t ha^{-1}) ar augstu barības vērtību.
2. Stiebrzāļu un baltā āboliņa – stiebrzāļu zelmeņu produktivitāte ir ļoti pakļauta meteoroloģisko apstākļu iedarbībai, tie bieži cieš no sausuma veģetācijas periodā.
3. Auzeņairenes un hibrīdas airenes ir perspektīvie zālaugi Latvijā, to izmantošana zālāju zelmeņu veidošanai ļaus ievērojami paaugstināt šo zelmeņu produktivitāti un iegūt dažādus zāles lopbarības veidus.

ISBN 9984 – 779 – 06 – 8

4. Tauriņziežu zelmeņu sausnā ir augsts kopproteīna saturs ar palielinātu neaizvietojamo aminoskābju daudzumu.

Summary

Field experiments were conducted during a 4-years period (2001-2004). Soils at the site were stagnic luvisol (pH_{KCl} 6.7, containing available P 52 mg kg^{-1}, K 128 mg kg^{-1} of soil, organic matter content 21 to 25 g kg^{-1}). Meteorological conditions greatly differed during the experimental period. Binary- and multi-species seed mixtures were composed of fodder galega (*Galega orientalis)* „Gale, alfalfa (*Medicago varia*) „Skriveru" and „Vernal", white clover (*Trifolium repens*) „Priekulu 61" and 7 grass species: *Alopecurus pratensis, Dactylis glomerata, Lolium perenne, Festuca pratensis, Phleum pratense, Poa pratensis, Festuca rubra.* The botanical composition of the sward was determined at each cut for all treatments and chemical analyse were done for in all treatments of all cutting regimes.

Fodder galega-grass swards. Our studies show that fodder galega, due to a slow growth pattern, provided high green fodder and dry matter yields only in the third to fourth production years. Inclusion of a grass species in a mixture resulted in yield increases by 26 to 32 % already in the first production year. In 4 production years of pure galega, the following average yields of dry matter (DM) and crude protein (CP) were attained in early flower: 8.17-9.13 t ha^{-1} DM and 1.74 t ha^{-1} CP .The productivity of binary fodder galega-grass swards was the following: the average yield 7.98 t ha^{-1} DM in swards receiving no fertiliser N, and 7.31 t ha^{-1} DM in swards splitting the fertiliser into two applications – at the beginning of the growing season and after cut 1. Fodder galega-grass swards contributed to the crop yield and made N available for the benefit of companion grasses.

Alfalfa-grass swards. Field experiments of pure alfalfa-grass swards were conducted during a 4-years period. Without usage of nitrogen fertilizers and three cuttings per annum the average DM yield was 11.04 t ha^{-1}. The average DM yield of 9.87 t ha^{-1} for mixed alfalfa-grass swards was observed without usage of nitrogen fertilizers and 9.70 t ha^{-1} respectively for swards having nitrogen fertilizers. For the current year the level of yield was also dependent on the proportions of seeds mixtures.

White clover-grass swards. the average productivity for three-cutting mode without nitrogen fertilizers have resulted in the average DM yield of 5.85 t ha^{-1}. The average DM yield has reached 6.63 t ha^{-1} when the mineral nitrogen fertilizers were used in the amount of N 90_{45+45} kg ha^{-1}. For the pure white clover-grass swards with four cutting regime during vegetation period the average DM yield was 5.77 t ha^{-1} for variances without using nitrogen fertilizers and 6.04 t ha^{-1} accordingly for variances that have received nitrogen fertilizers. For mixed alfalfa-grass swards without nitrogen fertilizers average DM yield has reached 6.28 t ha^{-1} and 6.97 t ha^{-1}. The productivity of white clover-grass- grass swards in four-cutting regime has reached the average of 6.31 t ha^{-1}, which is 0.63 t ha^{-1} less comparing to the three-cutting mode.

Grass swards. The productivity of *grass* swards without usage of nitrogen fertilizers was on average 1.06 t ha^{-1} of DM yield. Nitrogen fertilizers in the amount of N 90_{45+45} kg ha^{-1} increased the level of productivity and the average DM yield was 2.70 t ha^{-1}. For three-cutting mode the productivity of multi-species swards was higher with the average DM yield of 2.12 t ha^{-1}. The intensified use of swards has resulted in the double reduction of productivity indicators.

Dynamics of the botanical composition of swards. The proportion of grass components in the determination of sward productivity was greatly dependent on cenotic activity and competition ability of plant species. In the first production years the companion grasses, such as *Dactylis glomerata, Lolium perenne,* contributed to the total yield of the sward. The proportion of creeping grasses, such as *Alopecurus pratensis, Festuca rubra, Poa pratensis,* increased beginning with 3rd, 4th production years. The proportion of grasses in mixed stands accounted for 32.4-46.2% on average, in the 1st cut in treatments receiving no fertilizer N. Application of fertilizer N resulted in the increase of grass species in swards 44.3 to 61.8 % and had a declining effect on the competition ability of legumes. Legumes was always the dominating plant species in cut 2 and cut 3. Inclusion of most competitive grasses, such as cocksfoot, meadow foxtail,

ISBN 9984 – 779 – 06 – 8

perennial ryegrass as well as intensive cutting treatments essentially affected survival of legumes in mixed swards as well as the productive longevity of these swards.

Indices of photosynthesis activity. In different legume-grass stands the average values of the leaf area index were as follows: 8.25 for fodder galega-grass stands, 5.16 for alfalfa-grass, and 6.80 for white clover-grass stands. Indices of net photosynthetic productivity indicated that a large leaf area during particular years resulted in a negative effect on the DM production. During the growth period, net photosynthetic productivity accounted for 8.52 in fodder galega-grass stands, 8.61 in alfalfa-grass stands and red clover-grass stands 6.80 g m^{-2} day^{-1}. There was a negative correlation between the leaf area and net photosynthetic productivity in most of the stands. The maximum values of net photosynthetic productivity were achieved in early stages of sward development in plots that received no N-fertiliser. The increase of leaf area significantly reduced interception of light by plants, thus having a negative effect on the formation of sward productivity.

Yield quality. The yield quality for legume-grass swards was heavily dependent on the botanic content and cutting intensity. In the mode of pasture the average total content of protein was 157-197 g kg^{-1} of DM, NDF-369-438, ADF-274-372 g kg^{-1} of DM. For the swards in cutting mode the average quality indicators of first cutting are as follows: content of protein-127-143 g kg^{-1}, NDF-469–552, ADF-329-387 g kg^{-1} of DM

Literatūra

1. Adamovičs A., Kreišmane D., Narvils M. Zālāju ierīkošana un izmantošana zemnieku saimniecībās. Ozolnieki 1998, 40 lpp.
2. A. Adamovich, O. Adamovicha, I. Gutmane. Yield and persistance of alfalfa – grass swards. European Agriculture in global context. Book of proceedings. Copenhagen, Denmark, 2004, p. 569 -570.
3. Adamovich A. and Adamovicha O. Productivity and forage quality of *Festulolium/*legume mixed swards in response to cutting frequency. EGF, Grassland Science in Europe, vol. 8, 2003, pp. 453 – 456.
4. Мичулис Я. Д. Содержание аминокислот в некоторых видах корма. Сельское хозяйство Советской Латвии – Nr. 9 (149), c. 50 – 52.
5. Харибутова З. М., Эльхессер. Влияние саособа заготовки кормов на их аминокислотный состав. Вопросы кормленя животных и заготовки кормов. Сб. науч. работ, выпуск 22, c. 44 – 47.

ISBN 9984 – 779 – 06 – 8

INVESTIGATION AND USE OF THE LITHUANIAN FLAX GENETIC RESOURCES IN THE BREEDING PROGRAMS

LIETUVAS LINU ĢENĒTISKO RESURSU IZPĒTE UN IZMANTOŠANA AUDZĒŠANĀ

KĘSTUTIS BACELIS, ZOFIJA JANKAUSKIENE

Upyte Research Station of the Lithuanian Institute of Agriculture
Lininink 3, Upytė, Panevėžys district, 38 294, Lithuania
Phone: + 370 45555413, *fax*: + 370 45555573, *e-mail*:soja@upyte.lzi.lt

Abstract. *The profusion, diversity and value of genetic resources significantly contribute to the success of flax breeding. Of special value are genotypes of local origin, highly adapted to the local climatic and soil conditions. Storage of genetic resources in Lithuania was started in 1994-1995. During the period 1995-1997 25 flax varieties and local accessions were studied at the Upytė Research Station of LIA. In 1998-2000 we tested 21 varieties and breeding lines, in 2001-2002 18 accessions, in 2003-2004 12 accessions. The best genotypes were included in flax breeding programs. About 50 genotypes have been transferred to the Gene Bank of the Lithuanian Institute of Agriculture after assessment for biological-agronomical characters following UPOV descriptors.*
Keywords: *accession, breeding, breeding lines, genetic resources, fibre flax, Gene bank, genotype, variety.*

Introduction

Collection, storage and investigation of plant genetic resources have become a very important task in many countries [1, 3, 5, 7, 8]. Many authors report that plant genetic resources have a national value for each country [2, 4, 5, 6, 7, 8, 10]. Different local varieties, accessions, and breeding lines serve as a solid basis for the development of new plant varieties [1, 3, 4, 10].
The aim of the present study was to collect and store fibre flax varieties created earlier and recently, different local accessions (landraces), valuable breeding lines as well as registered fibre flax varieties in our Republic and to assess those accessions as a fibre flax Gene Fund of Lithuania, describe them following the guidelines and criteria of international organizations, and to transfer the evaluated and described accessions to the Gene Bank stationed at the Lithuanian Institute of Agriculture.

Materials and methods

Collection and storage of flax genetic resources in Lithuania was started in 1994. The investigations were carried out in different stages: in 1995-1997, in 1998-2000, and in 2001-2002. In 2003-2004 12 accessions consisting of fibre flax varieties currently registered in our Republic and registered some time before were investigated.
The flax preceding crop was winter wheat. Conventional agricultural practices were applied. The trials were conducted on a sandy loam Endocalcari-Endohyphgleic Cambisol. The main agrochemical parameters of the arable soil layer were as follows: pH_{KCl} – 7.2-7.6, humus content - 1.64-2.24 %, total nitrogen content – 0.12-0.16 %, available P_2O_5 – 145-205 mg kg^{-1}, available K_2O – 140-185 mg kg^{-1}.
All the investigated varieties and local accessions were compared to the standard varieties registered in Lithuania at the time of the investigations (such as „Belinka", „Baltučiai" (1995-1997), „Ariane" (1998-2000 and 2001-2002), „Hermes" (2003-2004).
Flax was sown in a 1 m wide band with 10 cm interrows, in three replication at the beginning of May. The size of an experimental plot was 1 m^2 and the seed rate was 25 million viable seed per hectare. Flax crop was treated with insecticides and herbicides.
The phenological stages were recorded during the growing period [9]. During the growing season great attention was paid to flax lodging and disease resistance, plant height and length of the growing season. At harvesting flax fibre quantitative (fibre content) and qualitative parameters (fibre tenacity, flexibility, thinness) were determined [9]. For this flax plants were

ISBN 9984 – 779 – 06 – 8

pulled up in the early yellow ripeness stage, threshed with a thresher of the "Eddi" type. Stems were soaked in hot water, straw was breaked with a scutching tool SMT-200. Flax fibre was hackled with combs Nb. 9 and Nb. 13. Quality of long fibre was determined in the laboratory: flexibility – by a device G-2, tenacity – by a device DK-60, fineness – by measuring individual fibres in a specific fibre sample [9]. The incidence of the diseases (*Fusarium* spp., *Septoria linicola*, *Colletotrichum lini*, *Plyspora lini* etc.) was estimated on the natural background in the field conditions [9].

Over experimental years (1995-2004) the weather conditions were diverse, which gave us a good chance to estimate the performance of the varieties and local accessions under various conditions.

Results and discussion

Storage of plant genetic resources in Lithuania was started in 1994-1995. In 1995-1997 25 flax varieties and local accessions were investigated at the Upytė Research station of the Lithuanian institute of Agriculture. In 1998-2000 the investigation of 21 varieties and breeding lines, in 2001-2002 – of 18 accessions, in 2003-2004 – of 12 accessions was carried out. The last 12 accessions will be tested for another year, and the data will be presented later. Tables 2 and 3 present the data of only some tested varieties.

<u>Evaluation of Lithuanian flax Gene Fund during 1995-1997</u>. Averaged data from three years, show that the highest seed yield (131-141 g m^{-2}) was produced by the varieties „Belinka", L-1120-1, K-5497 and „Vega 2", a little lower yield (121-127 g m^{-2}) was obtained from the following varieties: F-5-398-4, E-4-430-2, M-4-126-1, 777, K-5978, K-5583 (Table 1). High seed yield is a valuable character of a variety or of a local accession. It depends on the length of the growing season, crop resistance to lodging and diseases, and seed size.

The investigated varieties differed in plant height, too. The tallest plants (76-82 cm) were identified for the varieties F-5-398-4, „Upytė 2", „Vaizhgantas, 1890-32, E-4-430-2, „Orshanskij 2", „T-10", „L-1120", 1885-14, D-5-344-4. Varieties „Svetoch", „806/3", K-5978, K-5497 and K-5583 produced short plants (59-68 cm).

Varieties „Belinka", 1660-40, L-1120-1, „L-1120", K-5978, K-5497 and K-5583 are characterised by a long growing season (92 days), varieties „1288/12", „Svetoch" and „Baltuchai" by a short growing season (85-87 days).

Lodging resistance is a very important character of the variety, because it is very difficult to pull up lodged flax, and the lodged flax is of a rather poor quality [4, 9]. Averaged data from 1995-1997 suggest that the following varieties were selected as lodging resistant: „Upytė 2", „Belinka", „L-1120", L-1120-1, „Vega 2", „Baltuchai", D-5-344-4, M-4-126-1, E-4-430-2, F-5-398-4, K-5978, K-5497, 1885-14, 1890-32 and K-5583. Non-resistant to lodging (7.9 points) were flax varieties „Orshanskij 2" and „806/3".

The largest seed (1000 seed weight 6.46-5.55 g) was produced by accessions L-1120-1, 1885-14, „Upytė 2", „Vega 2" and „L-1120". Varieties „Vaizhgantas", „Banga" and breeding line Nb.1660-40 produced the smallest seed (1000 seed weight 4.78-4.52 g).

The chief quality parameters of flax fibre are tenacity, flexibility and divisibility (it shows fibre thinness). Averaged data from 1995-1997 show that the highest fibre tenacity (18-19 kg f) was identified for the accessions „Vaizhgantas", „806/3", 1660-40, and K-5583 (Table 2). Accessions „Vaizhgantas", „Vega 2", „Belinka", „Orshanskij 2", „806/3", „1288/12" and 777 were selected as possessing the highest fibre flexibility (40-45 mm), and accessions „Vaizhgantas", „Baltuchai", „Belinka", M-4-126-1, „806/3", K-5583 and „1288/12" – as having the thinnest fibre (divisibility of which was 230-330 units).

ISBN 9984 – 779 – 06 – 8

Table 1.

Characteristics of some flax varieties and breeding lines investigated in 1995-1997

Accession	Country of origin	Linseed yield, g m^{-2}	1000 seed weight, g	Plant height, cm	Growing period, days	Lodging resistance, points
„Svetoch”	RUS	94	5,01	68	86	8,1
„Vaizhgantas”	LTU	112	4,52	79	91	8,2
„Upytė 2”	LTU	103	5,62	80	90	9,0
„Vega 2”	LTU	131	5,79	74	89	9,0
„Baltuchai” (stand.)	LTU	120	5,13	73	87	9,0
„Belinka” (stand.)	NLD	141	5,20	75	92	9,0
„Orshanskij 2”	BLR	118	4,89	77	90	7,9
D-5-344-4	LTU	113	5,34	76	91	9,0
M-4-126-1	LTU	122	5,00	75	91	9,0
E-4-430-2	LTU	122	5,08	78	90	9,0
„Banga 48”	LTU	115	5,09	75	89	8,6
„806/3”	RUS	114	4,80	68	89	7,9
„T-10”	RUS	121	5,10	77	88	8,1
„Banga”	LTU	112	4,63	71	88	8,2
1660-40	LTU	111	4,78	70	92	8,6
L-1120-1	LTU	139	6,46	75	92	9,0
„L-1120”	RUS	130	5,55	76	92	9,0
F-5-398-4	LTU	122	4,98	82	91	9,0
K-5978	LTU	126	4,88	61	92	9,0
K-5497	LTU	136	4,87	59	92	9,0
„1288/12”	RUS	100	5,00	75	85	8,2
777	LTU	124	5,20	73	89	8,2
1885-14	LTU	109	5,61	76	90	9
1890-32	LTU	105	4,95	79	90	9
K-5583	LTU	127	5,31	62	92	9

Evaluation of Lithuanian flax Gene Fund in 1998-2000. The highest seed yield (130-150 g m^{-2}) was produced by the accessions „Laura”, 0249-4, 1732-6 and 1959-7 (Table 3).

The tallest plants (70-77 cm) were obtained from the accessions 1959-7, 1953-20, „Ariane”, „Mogiliovskij 2”, 0917-10 and 1687-24-23. „Saldo”, and 01125-32 produced slightly shorter plants (66 cm).

Over the experimental period the varieties „Laura”, „Ariane” and 0861-42 were selected as late ripening, and the accessions 0917-10 and 1687-24-23 were medium late (growing period 98 days).

Varieties with complete resistance to lodging were not found among the accessions investigated in 1998-2000. The most resistant to lodging were plants of accessions „Laura”, „Ariane and 1547-11-7 – their lodging resistance was estimated as 8.0-8.3 points.

Accessions „Laura”, „Saldo” and 1547-11-7 produced the largest seed (1000 seed weight 5.30-5.38 g), accession 0861-42 – the smallest seed (1000 seed weight 4.53 g).

ISBN 9984 – 779 – 06 – 8

Table 2.

Long fibre parameters of some flax accessions investigated in 1995-1997

Accession	Country of origin	Long fibre parameters		
		Flexibility, mm	Firmness, kg f	Divisibility, units
„Vaizhgantas”	LTU	44,9	18,5	232
„Vega 2”	LTU	41,9	16,1	225
„Baltuchai” (stand.)	LTU	32,0	15,3	245
„Belinka” (stand.)	NLD	42,0	14,3	325
„Orshanskij 2”	BLR	45,6	13,2	234
M-4-126-1	LTU	36,8	13,4	294
„806/3”	RUS	42,2	19,1	291
„1288/12”	RUS	40,7	15,0	269
1660-40	LTU	33,8	18,9	218
777	LTU	40,5	16,6	199
K-5583	LTU	35,5	18,5	241

Table 3.

Characteristics of some flax varieties and breeding lines investigated in 1998-2000

Accession	Country of origin	Linseed yield, g m^{-2}	1000 seed weight, g	Plant height, cm	Growth period, days	Lodging resistance, points
„Ariane” (stand.)	FRA	122	4,75	75	103	8,0
„Mogiliovskij 2”	BLR	124	4,64	73	100	6,7
„Laura”	NDL	141	538	70	104	8,3
„Saldo”	EST	121	5,30	66	102	4,7
01125-32	LTU	114	4,86	66	100	5,7
0249-4	LTU	139	4,99	69	99	6,5
0861-42	LTU	121	4,53	69	103	6,0
0917-10	LTU	128	4,72	71	98	5,0
1687-24-23	LTU	121	5,09	71	98	6,0
1732-6	LTU	146	4,60	69	99	5,0
1826-5	LTU	126	5,22	68	102	7,8
1547-11-7	LTU	121	5,32	69	102	8,0
1959-7	LTU	138	5,01	77	100	6,3
1953-20	LTU	125	4,71	77	100	6,0

Accessions „Ariane”, „Mogiliovskij 2”, 01125-32, 0249-4, 0861-42, 0917-10 and 1826-5 were distinguished themselves for high long fibre content – 26-28 %, and accessions „Laura”, „Saldo, 1687-24-23, 1732-6, 1959-7 and 1953-20 – for low fibre content (22-24 %) (Fig.1).

Fibre quality parameters of the investigated accessions were different (Table 4). The most flexible fibre (38.2-39.8 mm) was identified for accessions 1547-1-7, 1732-6 and 1959-7, and finest fibre (divisibility 240-260 units) – for accessions 1959-7, 1547-11-7 and 1687-24-23.

ISBN 9984 – 779 – 06 – 8

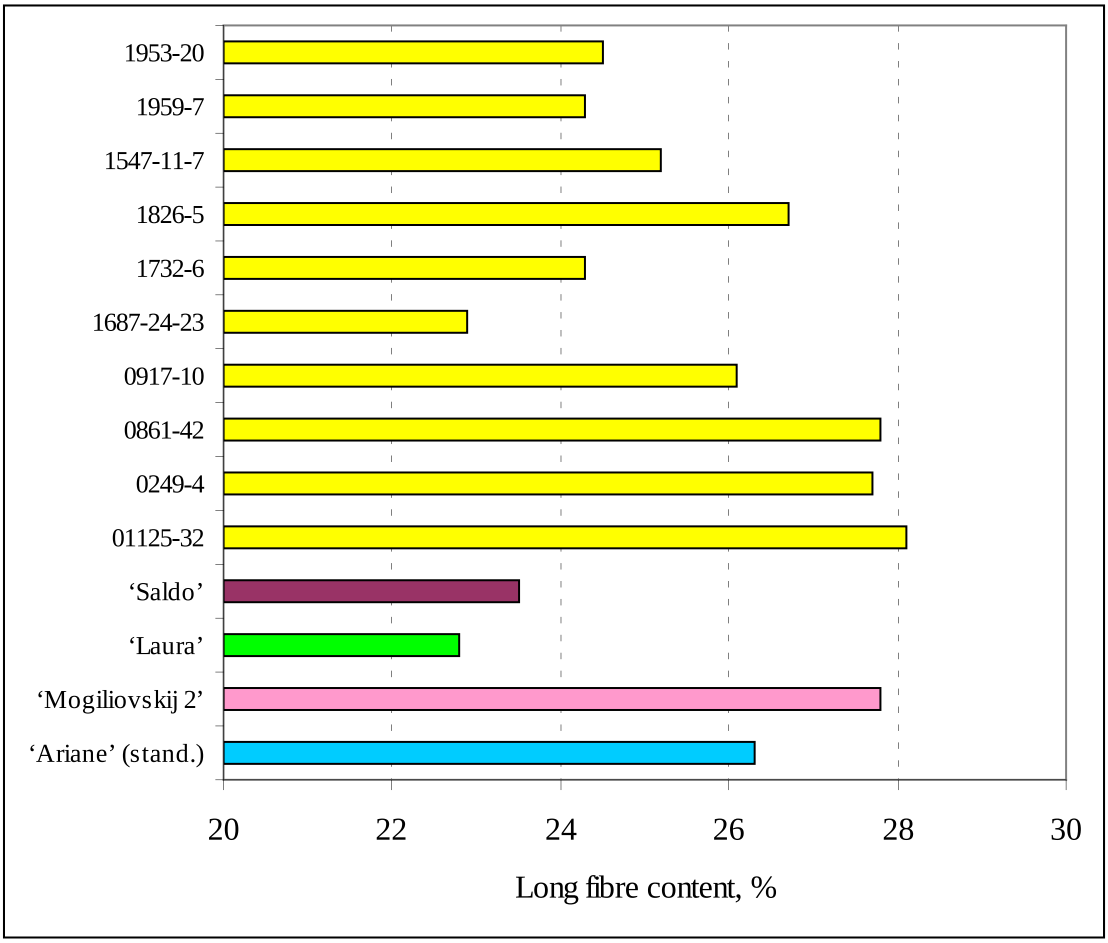


Fig. 1. **Long fibre content of accessions investigated in 1998-2000**

Table 4.

Long fibre parameters of some flax accessions investigated in 1998-2000

Accession	Country of origin	Long fibre parameters		
		Flexibility, mm	Tenacity, kg f	Divisibility, units
„Ariane" (stand.)	FRA	34,0	12,0	200
0249-4	LTU	34,1	11,6	210
0861-42	LTU	38,8	12,9	199
0917-10	LTU	35,5	11,5	228
1687-24-23	LTU	35,9	11,8	266
1732-6	LTU	39,8	11,1	225
1547-11-7	LTU	39,2	11,8	260
1959-7	LTU	39,2	10,2	243

<u>Evaluation of Lithuanian flax Gene Fund in 2001-2002.</u> Averaged data from 2 testing years revealed that the accessions „Alfa-B", 0877-5 and 1827-30 produced the highest seed yield (98-111 g m^{-2}) (Table 5). The lowest seed yield (98-111 g m^{-2}) was produced by the accessions 0964-12 and 1790-10. Flax stems of the accessions „Banga 2", „Ariane", 1790-10, 0964-12 were the tallest. Growth period of all tested accessions was very similar. Accessions „Ariane" and „Banga 2" had a little bit longer growing season period (90-92 days), and accession 01186-6 had the shortest growing season (86 days). In terms of lodging resistance, the most resistant (9 points) were accessions 1826-26, 1827-5, 1827-30 0877-5 01032-5 and 1790-10. The seed size was very similar for all investigated accessions. Accessions 1910-5, 1463-43, 0877-5 and „Banga 2" produced larger seeds (1000 seed weight 4.76-4.90 g).

ISBN 9984 – 779 – 06 – 8

The highest fibre content (27.3-28.5 %) was obtained from the flax of accessions 1826-26, 1463-43, 01032-5, 1827-5 and 1827-30 (Fig. 2).

Averaged data from 2001-2002 indicate that flexible fibre (41-44 mm) was specific to the accessions „Alfa-B”, 0964-12, 1827-30 and 1951-5 (Table 6). Accession „Alfa-B” also had the highest fibre tenacity (16.7 kg f). Fibre tenacity of the other investigated accessions was between 12-13 kg f. Fibre of accessions „Alfa-B”, 0964-12, 1827-5, 1827-30 and 1951-5 was thin (divisibility 248-289 units).

Table 5.

Characteristics of some flax varieties and breeding lines investigated in 2001-2002

Accession	Country of origin	Linseed yield, g m^{-2}	1000 seed weight, g	Plant height, cm	Growth period, days	Lodging resistance, points
„Banga 2”	LTU	87	4,76	80	90	8,9
„Alfa-B”	LTU	98	4,33	71	87	8,8
0964-12	LTU	83	4,51	72	88	8,9
0877-5	LTU	111	4,87	67	87	9,0
01032-5	LTU	93	4,55	62	87	9,0
01186-6	LTU	90	4,28	69	86	8,8
01186-8	LTU	90	4,25	70	87	8,8
1463-43	LTU	88	4,78	70	87	8,3
1790-10	LTU	80	4,31	73	99	6,9
1826-26	LTU	91	4,48	68	87	9,0
1827-5	LTU	90	4,3	67	88	9,0
1827-30	LTU	104	4,68	66	89	9,0
1910-5	LTU	85	4,90	68	87	8,8
1951-5	LTU	91	4,36	67	88	8,8
„Ariane” (stand.)	FRA	88	4,70	75	92	9,0

Table 6.

Long fibre parameters of some flax accessions investigated in 2001-2002

Accession	Country of origin	Long fibre parameters		
		Flexibility, mm	Tenacity, kg f	Divisibility, units
„Ariane” (stand.)	FRA	35,7	12,6	146
„Alfa-B”	LTU	41,6	16,7	255
0964-12	LTU	43,4	12,6	261
1827-5	LTU	37,5	13,6	248
1827-30	LTU	42,9	12,4	251
1910-5	LTU	37,3	12,3	212
1951-5	LTU	44,2	13,7	289

ISBN 9984 – 779 – 06 – 8

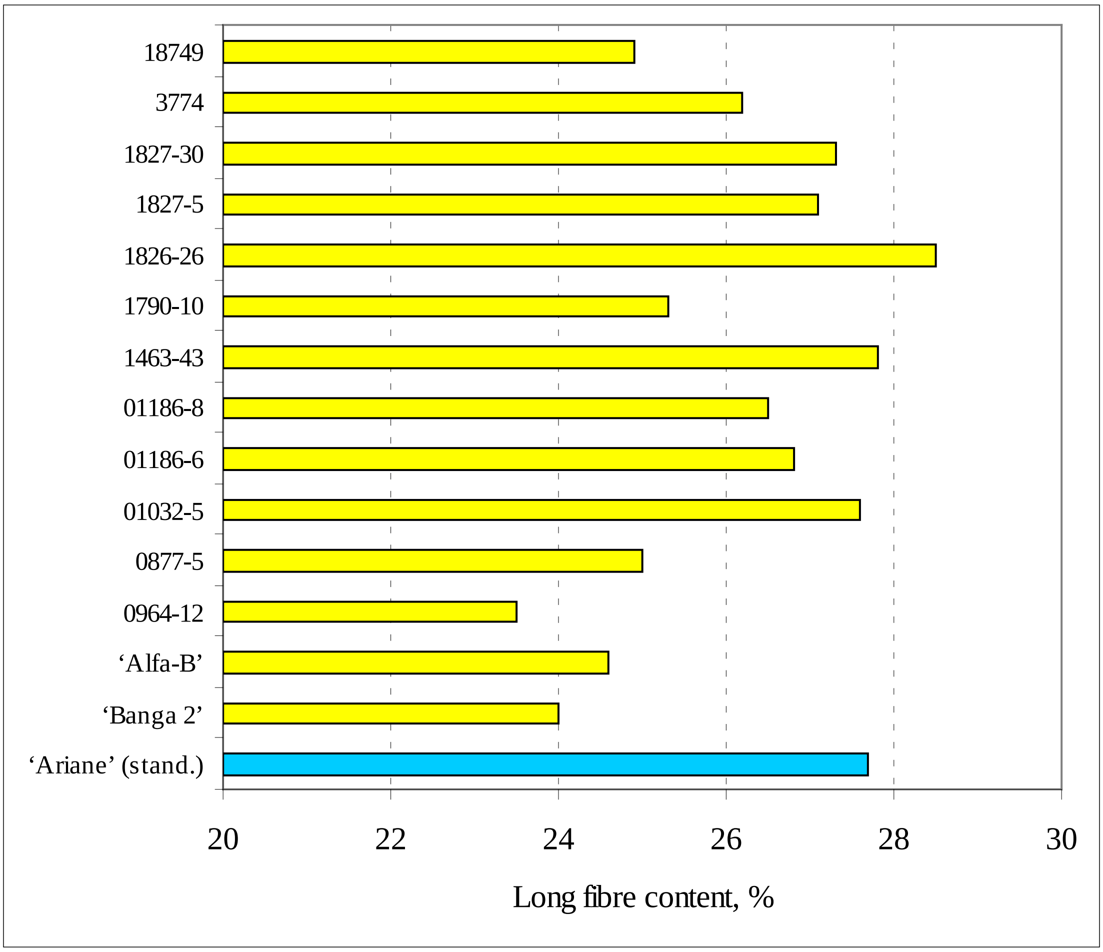


Fig. 2. **Long fibre content of accessions investigated in 2001-2002**

Conclusions

Based on flax accessions testing carried out at the Upytė Research Station of the Lithuanian Institute of Agriculture during the period 1995-2002, the following conclusions were drawn:

1. Storage of genetic resources in Lithuania was started in 1994.
2. In 1995-1997 25 flax varieties and local accessions were investigated, in 1998-2000 21 varieties and breeding lines, in 2001-2002 – 18 accessions. In 2003-2004 12 accessions were investigated and the investigation process will be continued for another year.
3. The main test parameters of flax Gene Fund were biologically and agronomically valuable characteristics such as seed productivity, long fibre content and quality, plant height, length of flax growing season, lodging resistance.
4. In total, 60 different flax genotypes were found to posses some valuable characters:
   4.1. Lodging resistance: „Upytė 2", „Baltuchai", „Belinka", D-5-344-4, M-4-126-1, E-4-430-2, L-1120-1, „L-1120", F-5-398-4, K-5978, K-5497, 1885-14, 1890-32, K-5583, 0877-5, 01032-5, 1826-26, 1827-5, 1827-30, „Ariane";
   4.2. Highest seed yield: „Vega 2", „Belinka", L-1120-1, „L-1120", K-5497, „Laura", 0249-4, 1732-6, 1959-7;
   4.3. Tallest plants: „Vaizhgantas", „Upytė 2", E-4-430-2, „L-1120", F-5-398-4, 1890-32, „Banga 2";
   4.4. Early maturity: „Svetoch", „Baltuchai", „1288/12", 0917-10, 1687-24-23, 01186-6;
   4.5. Late maturity: 1660-40, L-1120-1, „L-1120", K-5978, K-5497, K-5583, „Laura", 0861-42, „Ariane";
   4.6. Largest seed: „Vega 2", L-1120-1, 1885-14, „Upytė 2", „Laura", 0877-5;
   4.7. High fibre quality: „Vaizhgantas", „Vega 2", „Belinka", „Orshanskij 2", „806/3", „1288/12", „Alfa-B".

ISBN 9984 – 779 – 06 – 8

5. After investigation and description of the flax accessions the seeds of the above-mentioned flax genotypes and description data were transferred to the Gene Bank of the Lithuanian Institute of Agriculture for long-term storage.

References

1. Annamaa K. Conservation of plant genetic resources in the gene bank of the Jogeva plant breeding institute. Cereal breeding: achievements and prospects for improvement. Jogeva, Plant Breeding Institute, 1999, p. 44-46.
2. Balabanova A., Atanassov A. Preservation, evaluation and utilisation of Linum L. germaplasm in the AgroBioinstitute, Kostinbrod, Bulgaria – Current status and strategy. Flax Genetic Resources in Europe: Ad hoc meeting, 7-8 December 2001, Prague, Czech Republic (compilers: Maggioni L., Pavelek M., van Soest L.J.M., Lipman. E.), IPGRI, 2002, p. 19-21.
3. Hintum van. Th.J.L., Soest van L.J.M. Conservation of plant genetic resources in the Netherlands. Plant varieties and seeds. 1997, Nb.10, p. 145-152.
4. Kutuzova S. N. The Gene Fond of flax in VIR and prospects of it"s use in breeding. New ways of the use of flax and it"s residuals from processing. Minsk, 1994, p. 20-21 (in Russian).
5. Nozhkova J., Brindza J., Pavelek M. Evaluation of the genetic resources of the Linen (Linum spp.) in Slovakia. Natural Fibres, 2001, Nb. 1, p. 109-110.
6. Pavelek M. Analysis of current state of international flax database. Natural Fibres, 1998, Nb. 2, p. 36-44.
7. Pavelek M., Tejklova E., Horaček J. Flax national collection, international flax data base and breeding of flax, linseed and both types in the Czech Republic. Natural Fibres, 2001, Nb. 1, p. 64-78.
8. Rašals I., Klovane T., Stramkale V. Latvijas linu genetisko resursu saglabašana, izpete un izmantošana selekcija. Agronomijas vestis. Riga, 1999, Nb. 1, p. 131-134.
9. Rogash A. P., Marchenkov A.N., Alexandrova T.A. et al. Methodical rules for the fibre flax breeding. Torhzok, 1987, 63 p. (in Russian).
10. Zhuchenko A.A., Ushapovsky I. V., Kurhakova L.N. et al. National collection of Russian flax. Torzhok, 1993, 99 p.

ISBN 9984 – 779 – 06 – 8

THE INFLUENCE OF MIXTURES OF GROWTH REGULATORS AND FUNGICIDES ON THE SPRING RAPE SEEDS YIELDS AND QUALITY

AUGŠANAS REGULATORU UN FUNGICĪDU MAISĪJUMU IETEKME UZ VASARAS RAPŠA RAŽU UN TĀS KVALITĀTI

LILIJA BOROVKO

Research Institute of Agriculture Agency of LUA Latvia
Zemkopibas institute 7, Skrīveri – 1, Aizkraukles distr., LV-5126 Latvia,
Phone: + 372 5197639, *fax*: + 372 5197512, *e-mail*: borovko@e-apollo.lv

Abstract. *Our trial aims at investigating the impact performed by the mixture of a growing-regulator and fungicides upon summer rape productivity, the crop structure, and quality, to justify applying of agrochemicals in smaller doses thus eliminating environment pollution and winning labour-saving resource and financial applying per unit of sowing- fields, and per unit of the gained production. In 2001 – 2003, Research institute of Agriculture preparations during the trial were tested applying half doses (0,5 1 ha*$^{-1}$*), creating the preparation mixtures: Moddus+ Folicur, Modus + Juventus; Cycocel + Folicur Cycocel + Juventus, through spraying them throughout plant florescence-bud formation (GS 50). Owing to the mixtures of preparations, the number of side branches increased, on average, for 1-2, the number of legumes on a plant – for 22-25, the number of seeds per legume for 2-4, the mass of 1000 seeds: from 3,7 to 4,2 g, at the same time the length of rape"s stem"s shorted down to 10-20 cm, and the branching height to 5-14 cm. The highest efficiency, however, was reached when applying the mixture of Cycocel and Juventus.On average, throughout all the three years, thanks to applying of growing-regulators and fungicides the summer oilseed rape harvesting essentially increased, if compared to the Control. The increase of harvest was 0,53-0,81 t ha* $^{-1}$ *(*$\gamma_{0,05}$ *0,24 t ha*$^{-1}$*). During the trial-years the very best preparation mixture was nominated, and it was the Cycocel + Juventus, which, on average, provided the seed harvest 3,31 t ha* $^{-1}$*, and the oil output 1409 kg ha* $^{-1}$*. Other mixtures ensured a related seed output – 3,03-3,15 t ha* $^{-1}$*, and the oil output 1270-1302 kg ha*$^{-1}$*.*

Keywords: *spring oilseed rape, growing-regulator and fungicides mixtures, oilseed yield.*

Introduction

Plants grow and develop in a complex way interacting with phytohormones that stimulate stretching and growing of cellules (gibberellins, auxins), and those hindering the above-mentioned processes (growing-inhibitors, cytocinins etc.). Their concentration in plants is determined by many causes including external environment conditions and the genotype of a plant. The higher above sea level the place of growing, the less hormones; for instance, those stimulating stretching of plants [2, 4]. All growing-regulators, applied currently in sowing-fields, are enclosed in a gibberellins and auxins growing-hormone system. In the production branch better are the regulators of azoli group that increase in plants the cytocinins, which inhibit in plants the impact of gibberellins and auxins. The influence of the regulators of increase on the harvest of seeds was studied in essence on the winter rape, for the purpose of the shortening of the stem of plants, the stimulation of the formation of lateral flights and auxiliary buds, reduction in the danger of lodging, quaranteesing the high content of oil and uniform ripening of pods on the main and lateral flights [2, 3, 5]. For the first time under the conditions of Latvia, the strengthening actions of azole-preparations (fungicides) were used compounded with the regulators of increase on the basis of chlormequate and trineksapak-ethyl, for the purpose of influence on harvest and quality of the seeds of spring rape. Our trial aims at investigating the impact performed by the mixture of a growing-regulator and fungicides upon summer rape productivity, the crop structure, and quality, to justify applying of agrochemicals in smaller doses thus eliminating environment pollution and winning labour-saving resource and financial applying per unit of sowing-fields, and per unit of the gained production.

ISBN 9984 – 779 – 06 – 8

Materials and Methods

Field trials were conducted in soddy- podzolic sandy clay pH- 6,2, organic matter content 33 г kg^{-1} (method of Tiurin), phosphorus content (high) 195 kg ha^{-1}, potassium content (medium) 147 kg ha^{-1} (DL method). The clay parameters fit for cultivating oilseed rape. Its predecessor is autumn fallow. Conventional farming techniques were used. Prior to sowing spring oilseed rape `Olga`, there were applied mineral fertilizers P_2O_5 70 кg ha^{-1} in the form of superphosphate, K_2O 120 кg ha^{-1} in the form of potassium chloride and nitrogen (N 120 кg ha^{-1}) in the form of ammonium nitrate. In 2001–2003, Research Institute of Agriculture tested the following preparations with the aim to expound the impact performed by the applied growing-regulators/fungicide mixture on the growth and development of rape, the elements that determine harvest, seed quality and efficiency concerning disease elimination: Folicur – active substance: tebucanazole 125 g 1^{-1}, triadimephone 100 g 1^{-1}, fungicides that hold a lasting, protective system against diseases, in addition acting as plant-growing regulators.Juventus – natural substance: metconazole– 60 g kg 1^{-1}, a system effectiveness fungicide, and a plant-growing regulator.Moddus 250 e.k.: an active substance: trinexapac-ethyl 250 g 1^{-1}, a plant-growing regulator. Cycocel 750– an active substance: chlormequate chloride 750 g 1^{-1}, a plant-growing regulator. Preparations during the trial were tested applying half doses, creating the preparation mixtures: Moddus (0,5 1 ha^{-1})+ Folicur (0,5 1 ha^{-1}), Modus (0,5 1 ha^{-1}) + Juventus (0,5 1 ha^{-1}) ; Cycocel (0,5 1 ha^{-1}) + Folicur (0,5 1 ha^{-1}); Cycocel (0,5 1 ha^{-1}) + Juventus (0,5 1 ha^{-1}), through spraying them throughout plant florescence-bud formation (GS 50). As a rule, preparation effectiveness within mixtures increased. Data analysia for significante was done by ANOVA [1]. Interactions between faktors were calculated using by dispersion analysis. Meteorological conditions during the research period were extremely variable. In 2001, meteorological conditions during vegetation stage were changeable. Owing to the lack of precipitations the rape germination was belated. Frequent rainfalls with outrageous winds in June brought drooping rape sowing-fields. During florescence period, the crop was badly affected by frosts. Abundant precipitations during the final phases of florescence and ripening in July, promoted increase in rape branching, consequently, florescence and seed ripening were delayed. In 2002, the sow-period took place in congenial weather conditions. The optimal humidity provision within soil was satisfactory ass well. Nevertheless, in the beginning of May and June, the plants were short of humidity, and this obstacle left a harmful impact on the plant development, and the formation of productive elements. Warm, humid weather conditions in July promoted the extension of plant diseases. On rape leaves and legumes the dark leaf spot of crucifers appeared. Rape ripened in the conditions of increased temperatures and was short of humidity. During the test-year 2003, meteorological conditions were rather unfavorable for summer rape growing. Rainy weather destructively affected growing of summer rape, as well as its florescence and seed ripening. The rape was drooping; the ripening was slow and heterogeneous, seeds in lower legumes started to germinate. Rape harvesting was troubled.

Results

The results of field experiences confirm that the application of regulators of increase in the mixture with the fungicides had a positive impact on the harvest of the seeds of spring rape. Our summer rape research displays different harvests every year. This proves that meteorological conditions every year occupied an important place among other harvest-affecting factors. In 2001 the productivity of rape varied from 2,59-3,18 t ha^{-1}. Analysis of the results showed, that actual the value of test $F = 2,38 < F_{crit} = 3,06$ and P-value = 0,0982 > 0,05. It means between average by harvest on the versions with the application of preparations there are no significant differences (See Table 1).

ISBN 9984 – 779 – 06 – 8

Table 1.

The influence of different of mixtures of growth regulators and fungicides on the spring rape „Olga" yields (2001 - 2003)

Variations	Seed harvest t ha^{-1}				Oil output kg ha^{-1}			
	2001	2002	2003	On average	2001	2002	2003	On average
Control	2.59	1.97	2.95	2.50	1050	862	1186	1033
Moddus + Folicur	3.08	2.48	3.89	3.15	1248	1080	1579	1302
Moddus + Juventus	2.79	2.53	3.78	3.03	1135	1123	1551	1270
Cycocel + Folicur	2.84	2.79	3.61	3.08	1131	1267	1480	1293
Cykocel + Juventus	3.18	2.82	3.93	3.31	1314	1286	1628	1409
$\gamma_{0,05}$	0.34	0.24	0.53	0.24				

Applying the mixtures of Moddus + Folicur – 0,49, and Cycocel + Juventus - 0,59 t ha $^{-1}$, essential increase of harvest was reached, if compared to Control data ($\gamma_{0,05}$ = 0,34 t ha $^{-1}$). The influence of the mixtures of preparations into 2002 wassuschestvennym ($F = 18,55 > F_{crit} = 3,06$; P-value = 1,13 E-05 < 0,05). Increase in the harvest of seeds was 0,51-0,85 t ha^{-1} (to the smallest essential difference $\gamma_{0,05}$ 0,24 t ha^{-1}). Under the conditions 2003 influence of the mixtures of preparations to the harvest were essential ($F = 4,38 > F_{crit} = 3,06$; $P < 0,05$). Increase in the harvest it was 0,66-0,98 n ha^{-1} ($\gamma_{0,05}$ = 0,53 t ha^{-1}). However, the highest seed-harvests every year were achieved wherein Cycocel + Juventus was applied: in 2001- 3,18 t ha $^{-1}$, in 2002- 2,82 t ha $^{-1}$, and in the year 2003 - 3,93 t ha^{-1}. The oil output, respectively, was 1314, 1286, and 1628 kg ha $^{-1}$. In accordance with harvest data most outstanding was the year 2003 when as a result of the applying of plant regulator/ fungicide mixture there was gathered the highest harvest, and the highest harvest increase was achieved. In our experiences(2001-2003) the utilized mixtures of preparations had inpractive idential influence on the harvest of the seeds of rape(F=0,81< Fcrit=3,48; P = 0,54 > 0,05). On average, throughout all the three years, thanks to applying of growing-regulators and fungicides mixtures the summer rape seed harvesting essentially increased, if compared to the Control. The increase of harvest was 0,53-0,81 t ha $^{-1}$ ($\gamma_{0,05}$ 0,24 t ha^{-1}). During the trial-years the very best preparation mixture was nominated, and it was the Cycocel + Juventus, which, on average, provided the seed harvest 3,31 t ha^{-1}, and the oil output 1409 kg ha^{-1}. Other mixtures ensured a related seed output – 3,03-3,15 t ha^{-1}, and the oil output 1270-1302 kg ha^{-1}. Applying of the plant-regulators and fungicides mixtures influenced chemical composition of seeds as well. It was different every year (See Table 2).

ISBN 9984 – 779 – 06 – 8

Table 2.

Full protein and Full grease content in the spring rape seeds „Olga" (2001 - 2003)

Variations	Full protein, %				Full grease, %			
	2001	2002	2003	On average	2001	2002	2003	On average
Control	23.22	19.86	25.53	22.87	44.80	47.58	43.70	45.36
Moddus+ Folicur	24.16	20.02	24.42	22.87	44.06	47.32	44.13	45.17
Moddus+ Juventus	23.14	19.78	25.06	22.66	44.21	48.24	44.61	45.69
Cycocel+ Folicur	24.31	20.89	24.68	23.29	43.30	49.36	44.57	45.74
Cycocel+ Juventus	23.68	20.18	24.49	22.78	44.92	49.56	45.04	46.51

On average, and every single year, depending on the applied mixture, full grease was 45,17 – 46,51 %. On average, every single year, full grease content increased most, when Cycocel + Juventus mixture was applied. Among the plant diseases in rape sowing-fields, there prevailed the false blight, *Perenospora parasitica*, and the dry spotting *Alternaria brassica*. The highest efficiency while limiting the false blight, the dry rotting, *Phoma lingam*, and the white rotting, *Sclerotinia sclerotiorum*, was achieved when applying the variation of mixture Cycocel + Juventus (up to 80 %). Concerning the legumes, in order to limit the dry spotting and the dry rotting, the uppermost biological efficiency (up to 70 %) was achieved when applying the variation of Moddus and Juventus. The research proved: while applying the azoli preparations in mixture with the preparations of chlormequate and trinexapac-ethyl junctions and employing minified doses (Moddus + Folicur, Modus + Juventus, Cycocel + Folicur, Cycocel +Juventus), there was observed the impact on rape plant development, and harvest-structure formation elements (See Table 3).

Table 3.

Influence of mixture of growth regulators and fungicides upon the harvest-formation elements of spring rape „Olga" (average figures, 2001 - 2003)

Variations	Height of plant cm	Branching height, cm	Number of first grade branches	Number of legumes on plant	Number of seeds in legumes	Mass of 1000 seeds, g
Control	140	67	4	84	21	3,7
Moddus + Folicur	128	60	5	107	24	4,0
Moddus + Juventus	130	61	5	107	23	3,9
Cycocel + Folicur	126	62	6	106	24	4,0
Cycocel + Juventus	120	53	6	109	24	4,2

Owing to the mixtures of preparations, the number of side branches increased, on average, for 1-2, the number of legumes on a plant – for 22-25, the number of seeds per legume for 2-4, the mass of 1000 seeds: from 3,7 to 4,2 g, at the same time the length of rape"s stem"s shorted down to 10-20 cm, and the branching height to 5-14 cm. The highest efficiency, however, was reached when applying the mixture of Cucocel and Juventus. Throughout the research period it was

ISBN 9984 – 779 – 06 – 8

observed that plant-growing regulators if mixed with fungicides, provided evenness of florescence and legume ripening.

Conclusions

1. Applying of fungicides and growing-regulators in mixtures, in minified doses, provides evenness of florescence and legume ripening, and grants essential increase of rape harvest, improving its quality as well.
2. The applications of the studied mixtures of preparations it ensured the addition of the harvest of seeds 0,53-0,81 t ha^{-1} and oil outlet on 237-376 kg ha^{-1}.
3. The applications of mixtures of Cucocel and Juventus it ensured the highest harvest of seeds 3,3 t ha^{-1} and the significant addition of harvest 0,81 t ha^{-1} ($\gamma_{0,05}$ = 0,24 t ha^{-1}). The oil outlet together 1409 kg ha^{-1}. Other mixtures ensured a related seed output – 3,03-3,15 t ha^{-1}, and the oil output 1270-1302 kg ha^{-1}.
4. The applications of mixtures of preparations positively it influence increase in the number of legumes stems, number of pods on the plant, the number of seeds in the pod and mass 1000 seeds.
5. Biological efficiency of the mixtures of preparations concerning the limitation of plant diseases is satisfactory in order to manage disease outspread in sowing-fields.

References

1. Arhipova I., Bāliņa S. Statistika ekonomikā. Datorzinību Centrs. 2003, 349 lpp.
2. Makowski N., Gienapp Ch. Entscheidungshilfen fur die Rapsbestellung. Neue Landwirtschaft., 7, 1998, 54-55.
3. Vošak a kolektiv. Repka. Praha , 2000, 321.
4. Шпаар Д., Гинапп Х. и др.. Рапс. Минск, 1999, 205 стр.
5. Шпаар Д., Маковский Р., Шульц Р. Влияние агротехнических мероприятий на зимостойкость озимого рапса. НТИ и Рынок, 8, 1997, стр. 14-17.

ISBN 9984 – 779 – 06 – 8

BIOMASS AS AN ALTERNATIVE PRODUCTION IN AGRICULTURE
BIOMASA KĀ ALTERNATĪVS LAUKSAIMNIECĪBAS PRODUKTS

TADEUSZ CHRZAN

University of Zielona Góra, Ul. Podgórna 50, Zielona Góra, Poland,
Phone: + 071 3282674

Abstract. *Utilisation of energy from renewable sources can bring great positive ecological effects. The greatest hope related to renewable sources of energy is with biomass, the stocks of which present huge reserves of energy. Biomass can be used for energy purposes in the process of direct incinerating of bio-fuels (timber, straw seed, hay) or in the form of gas.*
In this paper, described are the economical effects of pro-ecological enterprises dealing with energy. Described is the example of biomass application and presented is its efficiency.
Keywords: *biomass, renewable sources, effectiveness of biomass.*

Introduction

The agricultural products that are incinerated can be used in production of thermal power and electric power. The sources of biomass can be willows (grown in plantations), hay or straw. These products represent renewable sources of energy. They renew themselves every year, unlike the traditional sources of energy. The resources of bituminous coal, lignite or oil are limited and each year their volume decreases. In addition, the incineration of coal increases the levels of carbon dioxide in the atmosphere, causing the global warming.
On average, the coal mined in Poland contains 22% of ash and 0.9% of sulphur, while incineration of biomass creates the same way 3% of ash and 0.01% of sulphur [2]. The volume of renewable energy that is used in Poland constitutes 2.6% of the total volume of energy produced in Poland. The guidelines of the EU say that in 2010 the consumption of energy from renewable sources should amount to 12% of the total energy produced. That concerns all countries of the EU. According to the European Centre of Renewable Energy [3], the potential resources of renewable energy in Poland amount to:

energy of water courses:	43 PJ (1 x 10^{15}J)
geothermal energy (of warm waters):	200 PJ
energy of wind:	36 PJ
energy of the Sun:	1340 PJ
energy of biomass and biogas:	895 PJ
Total:	2514 PJ

In 1998, the total consumption of energy in Poland amounted to 4070 PJ. Thus, energy that can be potentially obtained from the renewable sources can constitute 62% of the currently consumed one.

Materials and methods

According to the European Centre of Renewable Energy, the structure of renewable sources of energy in Poland is as follows [2]:

ISBN 9984 – 779 – 06 – 8

Table 1.

Source of energy	Number of installations	Power	Production of electric power GWh	Production of thermal power TJ
Heat and power plants powered by the wastes from the paper and furniture industries	3	330.0	449.1	5,298.5
Heat plants incinerating timber > 500 KW	150	600.0	-	9,633.6
Heat plants incinerating straw > 500 KW	35	50.0	-	802.8
Boiler houses incinerating timber	110,000	5,500.0	-	88,308.0
Boiler houses incinerating straw	150	45.0	-	722.5
Municipal and landfill-based bio gas-works	46	54.8	81.5	352.0
Total	110,384	6580	531	105,117

The most popular are the boiler houses that incinerate timber. Currently, increased is the number of the boiler houses that incinerate straw.

Below, described is an example of heating, using straw, of buildings of a school, local administration and sports hall in the town of Trzebiechów in Lubuskie province. This town, populated by 3500, is an agricultural centre of the area of 8100 ha. The boiler houses that were used to provide heat and hot water (Q_C) were incinerating coal and heater oil. As a result of modernisation, constructed was one boiler house of 1000 KW; used were two incinerators for straw; constructed was a heat distribution line of the length of 350 m and a straw storage house. The heat was provided for the following buildings [1]:

elementary school: V = 23,850 m^3, area of 3525 m^2 and demand for heat of Q=350 KW and hot water of Q_C= 85 KW,

sports hall: V = 10110 m^3, area of 1240 m^2, Q = 150 KW, Q_C = 110 KW

administration building: V = 6500 m^3, area of 1044 m^2, Q = 100 KW, Q_C = 30 KW.

Until then, a total annual consumption of fuels amounted to 50 t of heater oil and 295 t of bituminous coal. The cost of this investment project (in Euro) amounted to [1]:

technical design:	8,919.00 + VAT =	10,881.00
heat distribution network:	78,518.00 + VAT =	84,014.00
construction works:	65,849.00 + VAT =	70,459.00
boiler house equipment:	121,600.00 + VAT =	130,113.00
electrical installation:	12,216.00 + VAT =	13,071.00
fire safety installation:	1,548.00 + VAT =	1,888.00
connection to the straw storage house:	15,384.00 + VAT =	16,461.00
heating installation in sports hall:	8,825.00 + VAT =	9,442.00
TOTAL:		336,329.00

The operational costs (EK) in the past and after modernisation (EN), in Euro:

Table 2.

COSTS	EK	EN
Costs of fuels	48,589.00	13,254.00
Costs of electric power	19,091.00	1,622.00
Costs of maintenance and renovations	2,297.00	1,892.00
Salaries for employees	9,065.00	7,252.00
Ecological charges	1,333.00	-
TOTAL	80,375.00	24,020.00

EK/EN = 3.35

ISBN 9984 – 779 – 06 – 8

The cost of production of heat from straw is 3 times lower than with incineration of heater oil and coal. In incineration of straw, outside cheap heat, one obtains the ecological effect, i.e. lower pollution of air. During incineration of coal, heater oil and straw, one gets the following volumes of pollution annually in Mg:

Table 3.

Pollution	Coal	Oil	Total	Straw	Total/straw
SO_2	4.248	0.335	4.583	0.767	5.97
CO	13.275	0.035	13.310	0.00	13.31
NO_2	0.295	0.294	0.589	0.877	0.67
Dust	5.900	0.106	6.006	2.077	2.89

Conclusions

1) the usage of straw in heating of buildings and providing heat to installation of hot water is 3 times cheaper than usage of coal and heater oil,
2) incineration of straw causes lower pollution of air with SO_2, CO and dust than incineration of coal and heater oil.

References

1. Herbut S. 2003, Niekonwencjonalne źródła energii w Polsce, master"s thesis, Institute of Environmental Engineering, Zielona Góra University, Poland.
2. Małecki A. 2003, Wykorzystanie biomasy na przykładzie kotłowni w Trzebiechowie, Natura No. 9. Polish Association of Friends of Earth Sciences, Ziemia Lubuska Branch.
3. Ott. Z. 2003, Przykłady wykorzystania odnawialnych źródeł energii jako narzędzie aktywizacji gospodarczej regionu. Regional forum of renewable energy. Przysiek, Lubuskie province.

ISBN 9984 – 779 – 06 – 8

RELATIONSHIP BETWEEN FIBRE FLAX YIELD AND DIFFERENT FORMS OF NITROGEN IN THE SOIL
SAKARĪBA STARP LINU ŠĶIEDRU DAUDZUMU UN DAŽĀDĀM SLĀPEKĻA FORMĀM AUGSNĒ

ZOFIJA JANKAUSKIENĖ, ALGIMANTAS ENDRIUKAITIS, ELVYRA GRUZDEVIENĖ

Upytė Research Station of the Lithuanian Institute of Agriculture
Linininkų 3, Upytė, Panevėžys district, 38 294, Lithuania
Phone: + 370 45555413, *fax*: + 370 45555573, *e-mail*:soja@upyte.lzi.lt

Abstract. *Research on fibre flax yield response to the amount of different nitrogen forms in the soil was carried out at the Upytė Research Station of the Lithuanian Institute of Agriculture (LIA). Humus content (as a source of nitrogen) (%), total nitrogen (%), ammonium nitrogen (NH_4^+) (mg kg^{-1}), nitrate nitrogen (NO_3^-) (mg kg^{-1}), total mineral nitrogen (N_{min}) (mg kg^{-1}) were measured in the soil samples collected from the plough layer, and the correlation between the mentioned - above soil variables and fibre flax yield was calculated. In most cases the relationships were weak but significant. Seed, stem, and long fibre yields responded to the soil nitrogen differently. The strongest correlation was established between flax yield and humus content.*

Keywords: *correlation, fibre flax, humus content, nitrogen, soil.*

Introduction

Safe and clean environment is of paramount importance for the existence of life on our planet. To minimize the hazardous effects of agricultural production on our natural environment we have to be environment-conscious while planning agricultural inputs, especially those of nitrogen. Our task was to study fibre flax yield as affected by different soil nitrogen forms so that we could predict and advocate rational use of fertilizers.

The first research findings on how flax responds to the soil agrochemical properties in Lithuania were reported in 1992-1996 [5, 6, 7, 8], where focus was placed on the effects of humus content on flax yield. Increasing humus content (up to 2.6 %) increased seed, stem, and long fibre yield.

Research carried out with fibre flax during 1995-1997 revealed a relatively strong relationship between fibre flax stem and long fibre yield and the content of mineral nitrogen in the soil plough layer [3].

Further studies were focused on the impact of some soil agrochemical properties on linseed yield, particularly the effects of humus, nitrate nitrogen, ammonium nitrogen, and total mineral nitrogen contents. Linseed seed yield was positively influenced by nitrate nitrogen and humus content and negatively – by the ammonium nitrogen in the soil. Stem yield for linseed increased with increasing contents of nitrate nitrogen, ammonium nitrogen, total mineral nitrogen and humus. Long fibre yield for linseed was positively influenced by increasing contents of nitrate nitrogen, total mineral nitrogen, and humus [9].

Materials and methods

The response of fibre flax yield to the amount of different forms of nitrogen in the soil was studied at the LIA"s Upytė Research Station. The trial was conducted on a sandy loam Eutri-Endohypogleyic Cambisol [1]. In 1996-1998 in the trial where different zinc sulphate rates (0.35-4 kg ha^{-1}) have been investigated soil samples taken from the 0-20 cm layer before flax sowing (in 84 trial plots each year) were assayed for contents of humus, total nitrogen, ammonium nitrogen (NH_4^+) mg kg^{-1}, nitrate nitrogen (NO_3^-) mg kg^{-1}, total mineral nitrogen (N_{min}) mg kg^{-1}, as wel as soil pH, content of P_2O_5 and K_2O. The content of P_2O_5 in the soil arable layer was 165-254 mg kg^{-1}, content of K_2O – 143-170 mg kg^{-1} (determined in A-L extraction), pH_{KCl} level – 7.3-7.5 (potenciometrically). Humus content was determined by Tyurin method,

ISBN 9984 – 779 – 06 – 8

content of total nitrogen – by Kjeldahl method, content of nitrate nitrogen (NO_3) and content of ammonium nitrogen (NH_4) – in 1 N KCl extraction by calorimetrical method and content of total mineral nitrogen (N_{min}) – by adding up the amount of nitrate nitrogen and ammonium nitrogen.
$N_{15}P_{20}K_{60}$ before flax sowing have been applied. Flax cv. Baltučiai was sown by a sowing machine SNL-16 at a seed rate of 22 million viable seed per hectare with 10 cm row spacings. In the field rotation, flax followed winter wheat. Herbicide Valinate 0.3-0.4 l ha^{-1} was used to control broad-leaved weeds, herbicides Fusilade (2 l ha^{-1}) or Agile (1 l ha^{1}) – to control grasses. Insecticides Fastac (0.1 l ha^{-1}) and Decis (0.3 l ha^{-1}) were used to control flea-beetles. Flax was grown and the assessments were done following the standard methodology [11]. Flax was pulled at the stage of early yellow ripeness, threshed by a MS thresher, stems were retted in warm (33-37˚C) water, then were breaked up by a machine tool SMT-200, threshed by a MS thresher, fibre was hackled using combs number 9 and 13. Seed, stem and long fibre yield was established in the plots and the correlation between fibre flax yield and amount of different forms of nitrogen in the soil was calculated. More than 250 paired cases were used for the calculation of correlation.

Results and discussion

Variation of the contents of different nitrogen forms in the soil. Some authors report that the content of nitrate nitrogen or ammonium nitrogen depends on soil pH level. In acid soils the content of ammonium nitrogen is higher than that of nitrate nitrogen and in the soils having pH reaction close to neutral, the content of nitrate nitrogen is higher than that of ammonium nitrogen [3, 4, 10]. In our trials the soil was slightly alkaline and close to neutral reaction.
The content of nitrate nitrogen varied slightly in the plots and via time – from 5.10 to 7.32 mg kg^{-1}, but the content of ammonium nitrogen varied more markedly (especially in different years) – from 1.90 to 4.32 mg kg^{-1}. The content of total mineral nitrogen varied from 7.63 to 10.91 mg kg^{-1}. According to the grading system [2] tested soils could be described as having low amount of total nitrogen (up to 0.2 %). The amount of total nitrogen in the soil varied from 0.104 to 0.148 %. Humus content in the tested plots varied from 2.65 to 4.33 %, and tested soils could be described as having high or very high humus content [2].
Seed yield. The seed yield varied (from 625 to 1120 kg ha^{-1}) between plots and years, therefore a possibility to calculate the correlation occurred. Linear and quadratic correlations were calculated, but in most cases the quadratic correlation had higher probability level. In most cases the relationship between fibre flax seed yield and different soil nitrogen forms was weak, but significant at the 95 % probability level.
Flax seed yield was affected by the content of ammonium nitrogen and total mineral nitrogen, humus content and amount of total nitrogen in the soil and was not influenced by the content of nitrate nitrogen. The equations of correlation and their probability data are presented; "r / η" means coefficient of linear or quadratic correlation, "r_{95}/η_{95}" – statistically significant coefficient of linear or quadratic correlation at 95 % probability level. Statistically significant cases are presented in bold (Table 1).
Seed yield increased with an increase in ammonium nitrogen content from 1.90 to 4.32 mg kg^{-1} and the content of total mineral nitrogen increased from 7.63 to 10.91 mg kg^{-1}. Total nitrogen had different influence on flax seed yield. When the content of total nitrogen varied between 0.104-0.136 %, flax seed yield tended to decline. With an increase in the content of total nitrogen from 0.136 to 0.148 %, the seed yield increased. Seed yield was increasing until humus content had reached 4.06 %. From this point and onwards flax seed yield declined.
The strongest significant correlation (of the investigated nitrogen forms) showed ammonium nitrogen and humus.
Stem yield. The stem yield varied in the plots from 3191 to 7624 kg ha^{-1} (the main variation was found between years). Linear and quadratic correlations were calculated, and in most cases weak, but significant correlation was established (quadratic as well as linear correlations were found to be significant). Stem yield was not affected by the content of nitrate nitrogen (Table 2). The changes in the content of ammonium nitrogen and in the content of total mineral nitrogen

ISBN 9984 – 779 – 06 – 8

affected stem yield differently compared with seed yield. Stem yield decreased with an increase in ammonium nitrogen content from 1.90 to 4.32 mg kg^{-1} and the content of total mineral nitrogen increased from 7.63 to 10.91 mg kg^{-1}. The increase in the content of total mineral nitrogen from 0.104 to 0.148 % and the increase in humus content from 2.65 to 4.33 % had a positive effect on flax stem yield.
The strongest significant correlation (of all investigated nitrogen forms) exhibited ammonium nitrogen and total mineral nitrogen.

Table 1.

The influence of different soil nitrogen forms (x) on flax seed yield (y_1, kg ha^{-1})

N form (x)	x variation	Equation	r / η	r_{95}/ η_{95}
N-NO_3, mg kg^{-1}	6.21 ± 1.106	y_1= 955.52 – 15.39x	- 0.100	0.135
	6.21 ± 1.106	y_1= 969.66 – 19.77x + 0.3280x^2	0.100	0.135
N-NH_4, mg kg^{-1}	**3.11 ± 1.207**	**y_1= 761.84 + 31.60x**	**0.223**	**0.135**
	3.11 ± 1.207	**y_1= 686.24 + 67.70x – 3.2957x^2**	**0.234**	**0.135**
N_{min}, mg kg^{-1}	**9.27 ± 1.638**	**y_1= 720.18 + 15.09x**	**0.145**	**0.135**
	9.27 ± 1.638	**y_1= 770.66 + 5.10x + 0.4756x^2**	**0.146**	**0.135**
N_{total}, %	0.126 ± 0.0217	y_1= 875.81 – 125.34x	- 0.016	0.135
	0.126 ± 0.0217	**y_1= 1559.50 – 10585.74x + 38807.7895x^2**	**0.170**	**0.135**
Humus, %	**3.49 ± 0.838**	**y_1= 740.70 + 34.22x**	**0.168**	**0.135**
	3.49 ± 0.838	**y_1= 372.11 + 256.18x – 31.5254x^2**	**0.220**	**0.135**

Table 2.

The influence of different soil nitrogen forms (x) on flax stem yield (y_2, kg ha^{-1})

N form (x)	x variation	Equation	r / η	r_{95}/ η_{95}
N-NO_3, mg kg^{-1}	6.21 ± 1.106	y_2= 6020.75 – 88.96x	- 0.080	0.135
	6.21 ± 1.106	y_2= 7223.02 – 461.21x + 27.8837x^2	0.093	0.135
N-NH_4, mg kg^{-1}	**3.11 ± 1.207**	**y_2= 6485.27 – 327.11x**	**- 0.321**	**0.135**
	3.11 ± 1.207	**y_2= 8322.56 – 1204.60x + 80.0890x^2**	**0.399**	**0.135**
N_{min}, mg kg^{-1}	**9.27 ± 1.638**	**y_2= 7545.31 –224.06x**	**- 0.298**	**0.135**
	9.27 ± 1.638	**y_2= 8881.11 – 488.45x + 12.5854x^2**	**0.306**	**0.135**
N_{total}, %	0.126 ± 0.0217	**y_2= 4499.04 + 7701x**	**0.136**	**0.135**
	0.126 ± 0.0217	**y_2= 1556.17 + 52727.22x – 167044.7980x^2**	**0.169**	**0.135**
Humus, %	**3.49 ± 0.838**	**y_2= 4576.42 + 255.90x**	**0.174**	**0.135**
	3.49 ± 0.838	**y_2= 6261.35 – 758.72x + 144.1104x^2**	**0.196**	**0.135**

Long fibre yield. During the experimental years the yield of long fibre varied from 368 to 1595 kg ha^{-1}. The calculated quadratic and linear correlation was found to be significant at 95 % probability level. The relationship between long fibre yield and content of nitrate nitrogen, content of ammonium nitrogen and content of total mineral nitrogen, humus content in the soil was established. The amount of total nitrogen did not affect long fibre yield of flax. Long fibre yield decreased when the content of nitrate nitrogen rose from 5.10 to 7.32 mg kg^{-1}, the content of ammonium nitrogen rose from 1.90 to 4.32 mg kg$^{-1,}$ and the content of total mineral nitrogen rose from 7.63 to 10.91 mg kg^{-1}. Humus content had a positive effect on long fibre yield of flax. Long fibre yield increased with an increase in humus content from 2.65 to 4.33 %.
Humus content exhibited the strongest significant correlation (of the investigated nitrogen forms).

ISBN 9984 – 779 – 06 – 8

Table 3.

The influence of different soil nitrogen forms (x) on long fibre yield of flax (y_3, kg ha^{-1})

N form (x)	x variation	Equation	r / η	r_{95}/ η_{95}
$N\text{-}NO_3$, mg kg^{-1}	6.21 ± 1.106	**y_3= 1422.89 – 78.09x**	**- 0.231**	**0.135**
	6.21 ± 1.106	**y_3= 1444.96 – 84.92x + 0.5118x^2**	**0.231**	**0.135**
$N\text{-}NH_4$, mg kg^{-1}	**3.11 ± 1.207**	**y_3= 133.47 – 62.80x**	**- 0.203**	**0.135**
	3.11 ± 1.207	**y_3= 1595.49 – 283.46x + 20.1398x^2**	**0.282**	**0.135**
N_{min}, mg kg^{-1}	**9.27 ± 1.638**	**y_3= 1534.95 – 64.38x**	**- 0.282**	**0.135**
	9.27 ± 1.638	**y_3= 2061.34 – 168.56x + 4.9594x^2**	**0.296**	**0.135**
N_{total}, %	0.126 ± 0.0217	y_3= 952.51 – 112.76x	- 0.006	0.135
	0.126 ± 0.0217	y_3= 935.50 + 147.40x – 965.2154x^2	0.007	0.135
Humus, %	**3.49 ± 0.838**	**y_3= 395.90 + 155.56x**	**0.348**	**0.135**
	3.49 ± 0.838	**y_3= 555.33 + 59.55x + 13.6360x^2**	**0.350**	**0.135**

Conclusions

In most cases the relationship between fibre flax yield and different soil nitrogen forms was weak, but significant at 95 % probability level.

In most cases the quadratic correlation had a higher significance level for seed yield and, while for stem and long fibre yield the quadratic as well as linear correlations were found to be significant.

Flax seed, stem and long fibre yield exhibited a different response to soil nitrogen. The changes in the content of ammonium nitrogen and in the content of total mineral nitrogen had the same effect on stem and long fibre yield, whereas they had a different effect on seed yield.

Flax seed and stem yield was not affected the by the content of nitrate nitrogen (when it varied from 5.10 to 7.32 mg kg^{-1}).

The correlation between long fibre yield and the content of total nitrogen (0.104 to 0.148 %) was not found.

Only increasing humus content (from 2.65 to 4.06 %) increased all three kinds of flax yield (seed, stem, and fibre).

The strongest significant correlation (of investigated nitrogen forms) for seed and stem yield exhibited ammonium nitrogen and total mineral nitrogen, for long fibre yield humus content.

References

1. Buivydaitė, V.V., Vaičys, M., Juodis, J. et al. 2001. The classification of Lithuanian soils. Vilnius: Person. Įm. "Lietuvos mokslas". P. 76 (in Lithuanian).
2. Encyclopaedia of Agriculture. Vilnius, 1998, p. 359, 368 (in Lithuanian).
3. Ežerinskienė N., Jankauskienė Z., Matusevičius K. et al. The dependence of flax yield upon the content of mineral nitrogen in the soil and upon rates of nitrogen. Agriculture. Scientific articles. Dotnuva-Akademija, 2000, t. 71, p. 164-178 (in Lithuanian).
4. Freer B. The ups and down of growing linseed. Arable Farming. 1989, vol. 16, Nb. 2, p. 52, 53.
5. Jankauskienė Z. The influence of soil agrochemical properties on flax yield. Mineral nutrition of plants at the background of glacigenic relief. Proc. of the conf., Vilnius, 1992, p.43-46 (in Lithuanian).
6. Jankauskienė Z. The influence of soil agrochemical properties on flax yield. Fertilizer application systems of and soil fertility. Proc. of the conf., 1994 June 16. Vilnius, 1994, p.166-173 (in Lithuanian).
7. Jankauskienė Z. Determination of neccessarity for flax fertilizing according to the soil agrochemical properties. Farming and environment. Proc. of the intern. conf., Kaunas-Akademija, 1996, p. 17 (in Lithuanian).
8. Jankauskiene Z. The influence of soil agrochemical characteristics on flax yield. Producing for the market. Proc. of the 4th European regional workshop on flax, Rouen, France, September 25-28 1996), p. 75-82.
9. Jankauskienė Z. The dependence of linseed yield upon main soil agrochemical properties. Agriculture. Scientific articles. Dotnuva-Akademija, 2000, t. 71, p. 179-187 (in Lithuanian).
10. McGrath S. P., Robinson J.H. The influence of nitrogen source on the tolerance of Holcus lanatus to manganese. New Phytologist. 1982, vol. 91, p, 443-452.
11. Methodical rules to carry out the trials on fibre flax. Torhzok, 1987, 72 p. (in Russian).

ISBN 9984 – 779 – 06 – 8

DIFFERENT BIOLOGICALLY ACTIVATED SYSTEMS RESISTANCE TO INHIBITION
DAŽĀDU BIOLOĢISKI AKTIVĒTU SISTĒMU PRETESTĪBA INHIBĪCIJAI

V.RAČYS, D.KLIAUGAITĖ, D.JANKŪNAITĖ, I. URNIEŽAITĖ

Kaunas University of Technology, Department of Environmental Engineering
Radvilėnų pl. 19, Kaunas, LT-50270, Lithuania
Phone: + 370 37300182, *fax*: + 3702 37300152, *e-mail*: daina.kliaugaite@stud.ktu.lt

---

Abstract. *Biologically activated sorbent (BAS) are believed to be more efficient than separate conventional activated sludge and sorbents systems in removing phenols and others persistant organic pollutants from wastewater. These days, applications of biological activated systems treatment for various kinds of industrial wastewater are attracting greater attention as one of the efficient technologies. But the process is not very good understood, and there is not much parameter, which could describe stability and reliability of system and which could compare different BAS systems.*

The aim of this study was to investigate the resistance of different biologically activated sorbents to inhibition using respirometric measurements. To choose the most resistant to inhibition biologically activated system from five BAS: BAS-A, BAS-B, BAS-C, BAS-D and conventional activated sludge for comparing. Also to evaluate potential applicability of respirometric method for monitoring bioactivity in BAS systems.

The pesticide 3,5-dichlorfenol was chosen as inhibitor compound for experiment. The respiratory inhibition measurements were done with different biologically activated systems using different concentration of pesticide. The experiment was accomplished using respiratory inhibition method which described in Lithuanian normative document for environmental protection (Land 45-2001): activated sludge respiratory inhibition test. In parallel saprophyte bacterial counts were determined by spread plate technique and calculated as amount of saprophyte in one litter.

The results from both tests showed that the most resistance system to respiratory inhibition was BAS-A. Respirometric method is applicable for monitoring bioactivity in BAS systems.

Keywords: *biologically activated systems, respiratory inhibition, bacteria.*

Introduction

Environmental protection needs are facing a new phase that is why wastewater management requires a much higher purification level of industrial wastewater. These days, investigation and applications of biological activated carbon (BAC) treatment for various kinds of industrial wastewater is attracting greater attention as one of the efficient technologies [1, 2, 3, 6, 7, 8].

Wastewater usually contains various kinds of organic and/or inorganic pollutants and some of them may inhibit the microbial activity. Therefore, it is necessary for the design/operation of BAS systems to elucidate their resistance to inhibition. While the inhibition influence onto conventional biological treatment systems, e.g. the activated sludge have been studied for a long time, there are not so many studies carried in this area for the BAS systems [4, 5].

The aims of this study were: to investigate the resistance of different biologically activated systems to inhibition using respirometric method, to choose the most resistant to inhibition biologically activated system, to evaluate the potential applicability of respirometric method for monitoring bioactivity in BAS systems. In parallel saprophyte bacterial counts were performed by spread plate technique.

Materials and methods

Five experimental BAS systems were studied:

1. Microorganisms immobilized on sorbent 1(BAS-A).
2. Microorganisms immobilized on sorbent 2 (BAS-B).
3. Microorganisms immobilized on Zeolite (BAS-C).
4. Microorganisms immobilized on Anthracite (BAS-D).
5. Conventional activated sludge

ISBN 9984 – 779 – 06 – 8

Experimental systems were prepared by placing certain amounts of the commercial media into the preparatory tank.
During few months" adaptation and cultivation of BAS systems took place. In the tanks continuous aeration was applied. Simulated composition wastewater prepared according [9] was fed to the tanks. Once every 24 hours tanks were half emptied and new portion of simulated wastewater was added.
After adaptation period respiratory inhibition experiment was performed using different concentrations of pesticide 3,5-dichlorfenol as inhibitor. The experiment was accomplished using respiratory inhibition test. In parallel BAS systems were evaluated performing saprophyte bacterial counts by spread plate technique.

Respiratory inhibition test method

This method assesses the impact of pollutant on microorganisms under determined conditions. Using different pollutant concentrations the intensity of respiration is measured. Usually this method is used for activated sludge to evaluate inhibition effect of certain pollutant. In our experiment resistance to inhibition of different biologically activated sorbent was evaluated.
As respiratory inhibitor pesticide 3,5-dichlorfenol was used. First 3,5-dichlorfenol concentration interval for the experiment has to be determined.
In the experiment two control samples without pesticide addition are included. One control test is performed at the beginning, another at the end of the experiment. Test results are reliable, if respiratory intensity values in both control samples differ less than 15%.
For the better representation of respiratory process kinetics, method was modified and oxygen consumption testing time was prolonged from 12 till 30 minutes. But in percentage value of respiratory inhibition calculations was used 12 minutes of oxygen consumption interval, because in that time oxygen consumption has linear profile.
The effect of respiratory inhibition of different kind of concentration and respiratory intensity was countable by 2 control values of respiratory intensity average percentage part:

$$S=\left(1-\frac{2R_s}{R_{K1}+R_{K2}}\right)\times 100 \qquad (1)$$

Where:
S = percentage value of respiratory inhibition;
R_S = intensity of oxygen consumption, testing particular pollution concentration;
R_{K1} = intensity of oxygen consumption in 1 control sample;
R_{K2} = intensity of oxygen consumption 2 control sample.
Respiratory inhibition tests were performed in 1 litter glass beakers. Certain amount of BAS system was transferred to the beaker. After adding nutrition media in form of synthetic wastewater or nutrition media with 3,5-dichlorfenol and diluting to 500ml tested systems were continuously aerated for 3 hours (Fig 1-2). Aeration was then stopped, pH value was fixed and oxygen concentration change was measured every 6 min during 30 min period.

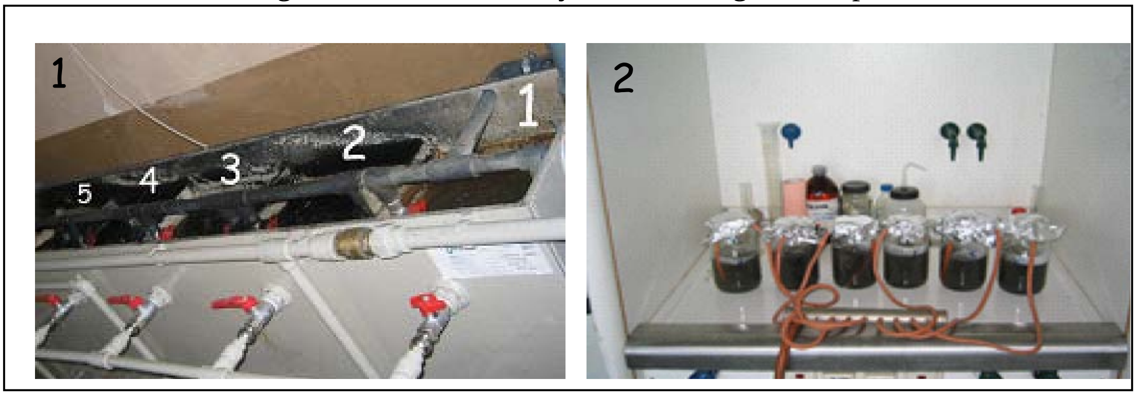


Fig. 1. **Respiratory inhibition experiment: 1 - preparatory tank for biological activated sorbets, (1. Conventional activated sludge, 2. BAS-A, 3. BAS-B, 4. BAS-C, 5. BAS-D); 2 - respiratory inhibition experiment (contact time 3 hours).**

ISBN 9984 – 779 – 06 – 8

In addition to usual lab equipment for the experiment there were also used others instruments as aeration equipment, pH-electrode and measuring equipment (HI 9025 microcomputer), air pump (SLL-50), O_2 measuring instrument (Oxi 315i/SET). According method [9] recommended biomass concentration in the sample mixture – 0,8-1,6 g/l. Biomass concentration was measured using standard method [10]. Biomass concentration in the different biologically activated systems was measured using method [11].

Experimental procedure for each BAS system was performed as follows:

1. *First control sample mixture (K1).* At the time „0“ 16 ml of simulated wastewater was diluted with 300 ml of distillate water, then placed 25 ml of BAS sample. Finally mixture was diluted till 500 ml and aeration was started.
2. *Sample mixture with 5 mg/l of 3,5 – dichlorfenol (C1).* At the time „1 minute“ was everything repeated as in the first control sample, only before diluting sample till 500 ml, 5 ml of 3,5-dichlorfenol solution was added.
3. Analogically were prepared samples mixtures with 10, 20 and 40 mg/l of 3,5 – dichlorfenol (C2, C3, C4).
4. *Second control sample mixture (K2)* was made last and the same as sample K1.

In parallel after 30 min of oxygen measurements from the tested systems samples for the plate count test of saprophyte bacterial were taken.

Spread techniques for saprophyte bacterial counts

Standard plate count by Koch method was used during the experiment, in order to count saprotrophic bacteria [12]. The quantity of saprotrophic bacteria can approximately show the activity of biologically activated sorbent and active sludge. The major part of the procedure deals with a series of successive dilutions of the original culture in sterile test-tubes with sterile water. The diluted culture is poured into Petri dishes along with the nutrient agar. The number of colonies is counted after incubation.

Experimental procedure: dilutions of the original culture in sterile test-tubes with sterile water; diluted sample is spread on the surface of the nutrient agar in the Petri dishes; the plates are incubated in the inverted position at 37ºC for 24 hours; the number of colonies is counted after incubation; only plates between 15 and 300 colonies are counted.

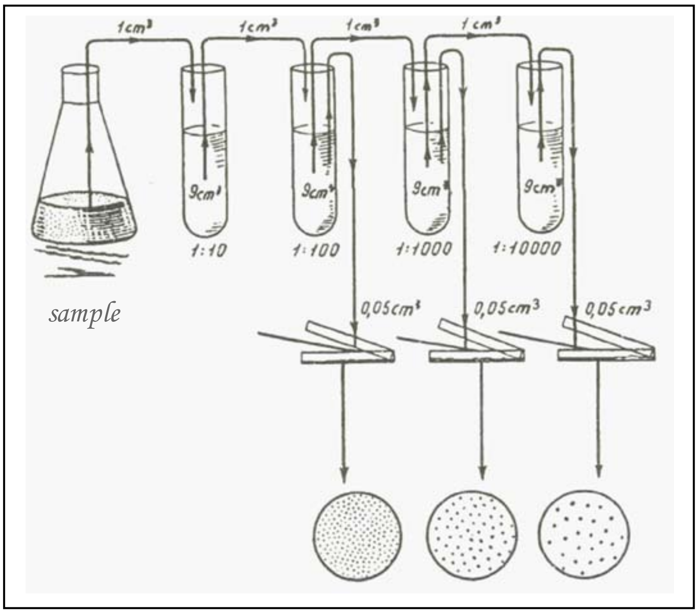


Fig. 2. **Dilutions scheme of sample by inoculatation microorganism"s suspension surface method**

The results obtained using a Plate Count Test are not an accurate assessment of total heterotrophic microorganisms concentrations.

ISBN 9984 – 779 – 06 – 8

Possible explanations: the presence of some bacteria in a viable but non-cultivable state; media do not provide the complex nutritional requirements necessary for the growth of all heterotrophs.

Results and discussion

First 3,5-dichlorfenol concentration interval that is to be used in the main experiment was determined . Results showed that under the contact time of 3 hours 100% respiratory inhibition is reached then 3,5–dichlorfenol concentration is higher than 70 mg/l. It was decided for the further experiment to use lower pesticide concentrations - 5, 10, 20 and 40 mg/l. pH value of sample mixture before respiratory intensity measurements was 7-7,5. Under such conditions pH don"t give any negative impact for the intensity of biochemical process.
Figure 3 shows the oxygen consumption profiles of different BAS systems under several 3,5-dichlorfenol concentrations.
In the BAS-A sample mixture without inhibitor after 24 min, oxygen concentration decreased by 95%. Increasing of inhibitor concentration to 5 and 10 mg/l the oxygen consumption was very similar and reached 90%. When the concentration of inhibitor was 20 mg/l the oxygen consumption was 75%. Under the 40 mg/l of pesticide concentration inhibition effect was high and oxygen consumption was just 39%. That means 2,5 times less comparing with mixture without inhibitor.
In BAS-B system control sample - without added inhibitor - during 24 minutes after stopped aeration, oxygen concentration decreased by 90% comparing to the initial value. Then the 3,5-dichlorfenol concentration was 5 and 10 mg/l inhibiting influence was not very obvious - oxygen consumption was a bit slower and after the same period of time as in previous case it composed 71 and 75% of initial oxygen saturation. Pesticide concentrations – 20 and 40 mg/l make bigger influence to the system. It"s resistance decreases and oxygen consumption by microorganisms after 24 minutes was 45 and 22% respectively. This is 2-4 times less than in the system without inhibition.
Control sample in the BAS-C system oxygen concentration within 24 minutes decreased by 88% from the initial level. Under the inhibitor concentrations 5 and 10 mg/l, oxygen consumption was 78 and 60% respectively. After adding higher 3,5-dichlorfenol amount reaching - 20 mg/l, oxygen consumption was slower and after 24 minutes composed 31%. Then inhibitor concentration rose to 40mg/l almost no changes in oxygen consumption were observed. It means that BAS-D system lost its resistance to inhibition at this concentration.
The BAS-D control sample during 24 minutes consumed period oxygen consumption reached 98%. Under the 5 and 10 mg/l of pesticide concentration oxygen consumption was slower and it composed 88% and 70% respectively. Pesticide concentration - 20 mg/l make bigger influence to the system. Oxygen consumption by microorganisms after 24 minutes was 42%. Reaching 40 mg/l of 3,5-dichlorfenol concentration inhibition of system was significant and oxygen was consumed nearly 10% of the initial value.
As we can see from figure 3 the in activated sludge during 24 minutes period the oxygen concentration decreased 90% in the control sample. Quite low negative influence on oxygen consumption can be seen under 5 mg/l and 10 mg/l concentration of pesticide. Oxygen consumption reached 80% and 85% respectively. But existing 20 mg/l and 40 mg/l of pesticide concentration evidently effected activated sludge system and oxygen consumption during 24 minutes was only 27% and 8% respectively.

ISBN 9984 – 779 – 06 – 8

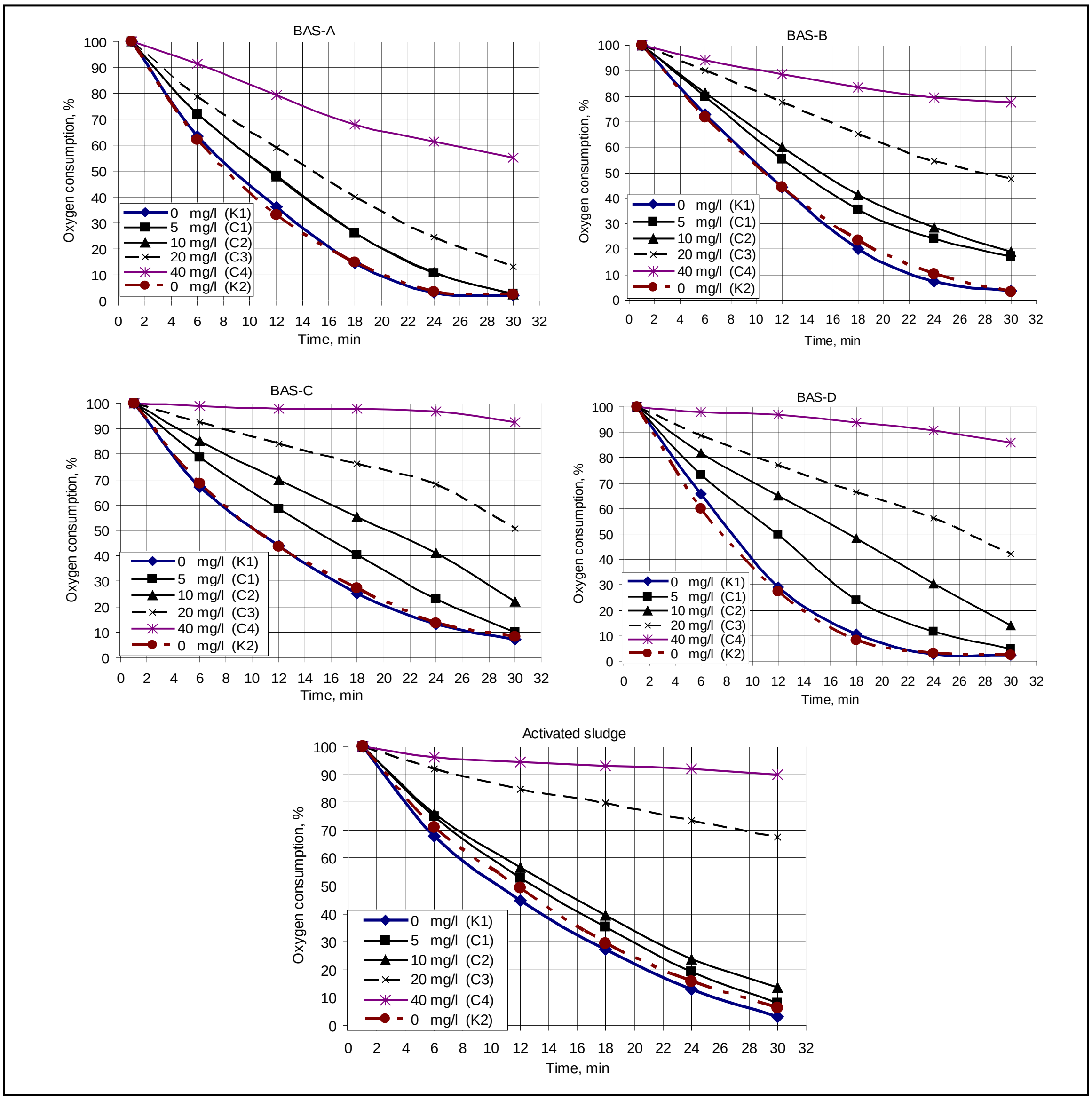


Fig. 3. **Oxygen consumption during 30 min by different BAS and with different amount of 3.5-dichlorfenol concentration**

Comparing between each other different systems it is obvious that systems with microorganisms immobilized on (BAS-A and BAS-B) in general demonstrated higher stability than the other systems, especially in the range of higher inhibitor concentrations. In comparison to the BAS-B system BAS-A is more resistant to inhibition.

Table 1 gives values of oxygen consumption during 12 minutes in the different BAS systems, under different 3,5-dichlorfenol concentrations. It was evaluated reliability of experiment results. Results of experiment are reliable, if values of respiratory intensity in both control experiments differ less than 15%. Values obtained satisfy such requirement.

ISBN 9984 – 779 – 06 – 8

Table 1.

Values of oxygen consumption during 12 minutes in the different BAS systems

3,5-dichlorfenol concentration., mg/l	**Oxygen consumption, mg/l during 12 min**				
	BAS-A	**BAS-B**	**BAS-C**	**BAC-D**	**Activated sludge**
0-K1 (Control sample)	3,9	5,0	4,4	4,8	3,8
5	3,7	4,4	3,4	4,1	3,7
10	3,4	4,4	2,7	3,0	3,2
20	2,0	3,6	1,5	2,0	1,3
40	1,2	1,9	0,2	0,3	0,5
0 – K2 (Control sample)	3,9	5,4	4,2	4,7	3,6
Percentage difference of respiratory intensity values in both control mixtures	0	8	5	2	2

* **Results of experiment are reliable, if values of respiratory intensity in both control experiments differ less than 15%**

Results presented in Table 1 were used to calculate percentage of respiratory inhibition for the different BAS systems according equation1. Obtained values are presented in Figure 4. As it can be seen from the Figure 4 percentage of respiratory inhibition calculated from the oxygen consumption during first 12 minutes data showed the same tendency as oxygen consumption curves in Figure 3 representing measurements during 30 minutes. Systems BAS-A and BAS-B demonstrated higher resistance to inhibition than the BAS-C, BAS-D and activated sludge. Higher percentage of respiratory inhibition in the latest systems show negative effect of 3,5-dichlorfenol on microbial activity in these systems. Under the highest 3,5-dichlorfenol concentration used in experiment percentage of respiratory inhibition for the system BAS-A reached only 56%, BAS-B - 73% and for BAS-C, BAS-D and activated sludge it was 95, 92 and 89% respectively. Therefore it can be concluded that the media causes lower level of inhibition. The fact that biologically activated systems with activated carbon media tend to reduce negative effects of inhibition was also observed studying influence of heavy metals [5].

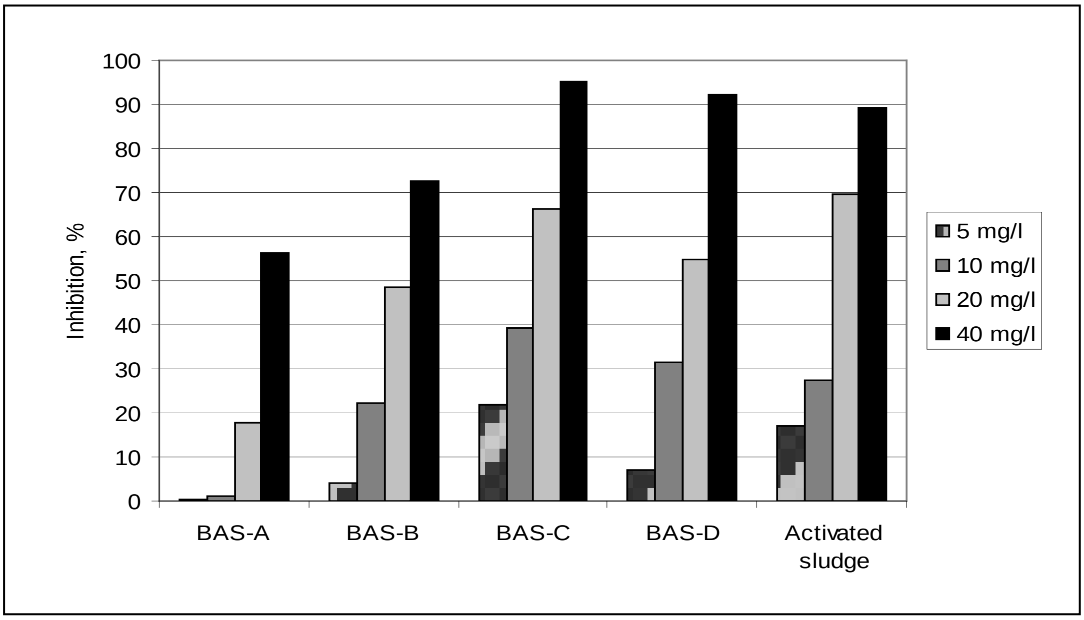


Fig. 4. **Percentage of respiratory inhibition for the different BAS systems**

ISBN 9984 – 779 – 06 – 8

As it was mentioned earlier in parallel to the respirometric measurements saprophyte bacterial counts were performed in all inhibited systems by spread plate technique. It was noticed, that increase of 3,5-dichlorfenol concentration causes decrease in number of microorganisms in all tested systems (Figure 5). At the same time it is obvious that sensitivity to inhibition is not the same. In BAS-C and BAS-D systems microorganisms cultures demonstrated low resistance even to small concentrations of inhibitor. Under the higher concentrations - 20 and 40 mg/l microorganisms cultures in these systems were nearly gone. Activated sludge, BAS-A and BAS-B systems appeared to be more resistant to inhibition than BAS-C and BAS-D. The most stable and viable system is BAS-A, which is almost completely resistant to small doses of inhibitor. Only concentration of 40 mg/l more noticeably affected vital functions of microorganisms and their ability to multiply and to form colonies.

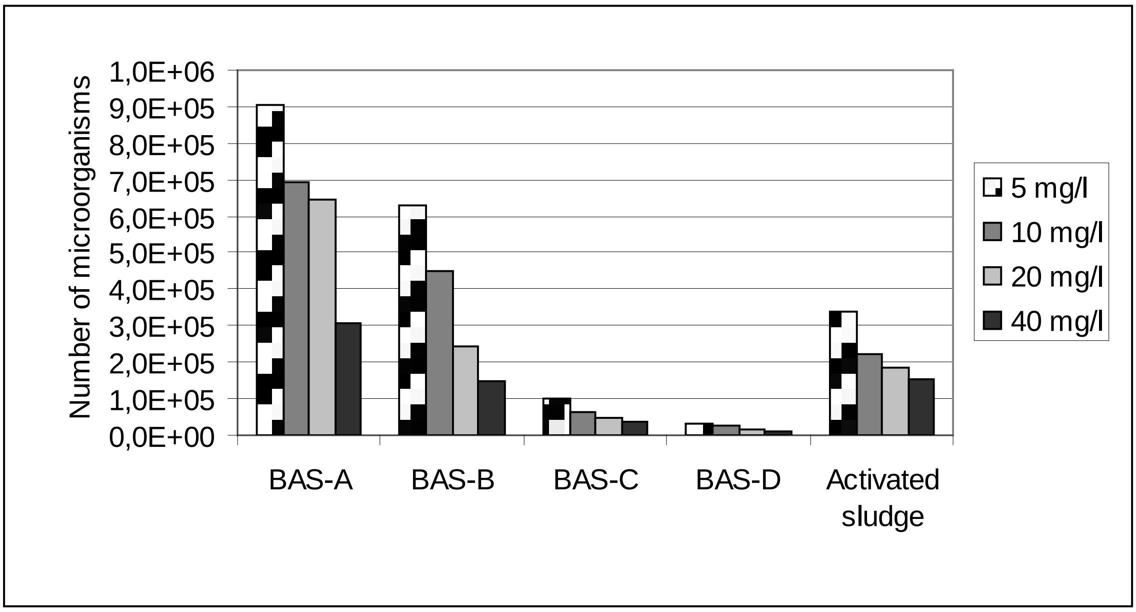


Fig. 5. **Saprophyte bacterial counts in all inhibited systems by spread plate technique**

Comparing all the systems by their viability, number of multiplying microorganisms and decrease in their number under the influence of rising inhibitor concentration shows, that the most resistant to inhibition system is BAS-A.

Experimental results obtained by respirometric measurements and bacterial counts by spread plate technique presented in Figure 4 and Figure 5 show the same tendency. It may be concluded that respirometric method can be used for monitoring bioactivity in BAS systems.

Conclusions

1. From tested five biologically activated systems the higher resistance to inhibition was determined in systems with BAS-A and BAS-B.
2. BAS-A showed the highest resistance to inhibition. Percentage of respiratory inhibition under 5 and 10 mg/l of 3,5-dichlorfenol was only 0 and 1% respectively. Concentrations of 20 and 40mg/l caused respiratory inhibition of 18 and 56%.
3. Results obtained by respirometric measurements and bacterial counts by spread plate technique show the same tendency. Respirometric method is applicable for monitoring bioactivity in BAS systems.

Acknowledgment

The research was carried out within the pale of EUREKA (International science and technology development program agency) project, supported by Agency for International Science and Technology Development Programmes in Lithuania.

ISBN 9984 – 779 – 06 – 8

References

1. Dalmacija B., Tamas Z., Karlovic E and Miskovic D. Tertiary treatment of oil-field brine in a biosorption system with granulated activated carbon. Water Resources, Vol.30, No. 5, 1996, pp. 1065-1068.
2. Suzuki Y., Mochidzuki K., Takeuchi Y., Yagishita Y., Fukuda T., Amakusa H., Abe H. Biological activated carbon treatment of effluent water from wastewater treatment process of plating industries. Separations Technology, No. 6, 1996, pp. 147-153.
3. Jae-Sok Kim, Chung-Hak Lee, Hee-Dong Chun. Comparison of ultrafiltration characteristics between activated sludge and Bac sludge. Water resources, Vol. 32, No 11, 1998, pp. 3443-3451.
4. Ivancev-Tumbas I., Dalmacija B., Tamas Z., Karlovic E. Reuse of biologically regenerated activated carbon for phenol removal. Water Resources, Vol.32, No. 4,1998, pp. 1085-1094.
5. Mochidzuki K., Takeuchi Y. The effects of some inhibitory components on biological activated carbon process, Vol. 33, No. 11, 1999, pp. 2609-2616.
6. Zhao X, Hickey R., Voice T. Long-term evaluation of adsorption capacity in a biological activated carbon fluidized bed reactor system. Water resources, Vol. 33, No. 19, 1999, pp.2983-2991.
7. Chi-Kang Lin, Tsung-Yueh Tsai, Jiunn-Ching Liu, Mei-Chih Chen. Enhanced biodegradation of petrochemical wastewater using ozonation and BAC advanced treatment system. Water Resources, Vol.35, No.3, 2001, pp. 699-704.
8. Sirotkin S.A., Koshkins L., Ippolitov K. The BAC-process for treatment of wastewater containing non-ionogenic synthetic surfactants. Water resources, Vol. 35, No.13, 2001, pp.3265-3271
9. LAND 45-2001. "Cheminių medžiagų ir preparatų ekotoksiškumo tyrimo metodai". Vilnius, 2002 (in Lithuanian).
10. Методика технологического контроля работы очистных сооружений городской канализации. / Министерство жилищно-комунального хозяиства РСФСР. Главное управление водопроводно – канализационного хозяиства.- Москва, Строиздат., 1997 (in Russian).
11. Račys V., Valūnas I., Kliaugaitė D. Biomasės kiekio tyrimai bioosrbcijos procese. Water management Engineering. Vol. 26, No.46, 2004, pp.97-100 (in Lithuanian).
12. J.Pečiulis. Mikrobiologijos praktikos vadovas. Vilnius, 1994, pp 99-101. (in Lithuanian).

ISBN 9984 – 779 – 06 – 8

LIGNOSILĪCIJA IETEKME UZ ZIEMAS RUDZU RAŽĪBU BIOLOĢISKAJĀ LAUKSAIMNIECĪBĀ
INFLUENCE OF LIGNOSILICON ON PRODUCTIVITY OF WINTER RYE IN BIOLOGICAL AGRICULTURE

MARUTA SPĀRNIŅA, SARMĪTE RANCĀNE

LLU aģentūra "Zemkopības ZI", Skrīveri-1, Aizkraukles raj., LV-5126, Latvija
Tālr.: + 371 5197524, *fakss*: + 371 5197512, *e-pasts*: maruta_sp@navigator.lv

GAĻINA ĻEBEDEVA, GAĻINA TELIŠEVA

Latvijas Valsts Koksnes ķīmijas institūts, Dzērbenes 27, Rīga, LV-1006, Latvija
Tālr.: + 371 7555916, *fakss*: + 371 7550635, *e-pasts*: ligno@edi.lv

Abstract. *Ecological friendly products increasing plant productivity, quality and resistance against diseases are widely used in biological agriculture many years. One of such products is lignosilicon. That is developed by Latvian State Institute of Wood Chemistry on the basic of wood processing waste and patented. However up to now effect of lignosilicon on the development of winter rye was not tested. Therefore LLU agency "Zemkopības zinātniskais institūts" (Crop-growing Research Institute) carried out investigation of lignosilicon effect on the winter rye " Duoniai " cultivation on the certified biological field. In spring 2004 "Lignosilicon" was introduced in soil (120 kg/ha) and red clover " Divaja " was sown on the some field.*
The harvest of grain and straw, length and diameter of stem, ear length, numbers and mass of grain in ear increased on the background of lignosilicon.

Keywords: *biological agriculture, lignosilicon, yield, winter rye.*

Ievads

Bioloģiskā lauksaimniecība balstās uz dabas pašregulēšanās procesu veicināšanu un augsnes bioloģiskās aktivitātes palielināšanu. Tā nepieļauj ķīmiskās sintēzes ceļā rūpnieciski iegūtu minerālmēslu un pesticīdu, kā arī ģenētiski modificēto organismu un to produktu lietošanu.
Vairums cilvēku genomi ir saglabājuši pielāgošanās spējas apstākļiem un uzturam, kuri ir līdzīgi senču dzīves veidam, kā arī uztura tradīcijām. Mūsdienu dzīves apstākļi ievērojami atšķiras no senču dzīves un tādēļ risks saslimt ar dažādām slimībām pieaug. Cilvēki dzīvo ļoti atrauti no dabas un lieto stipri pārstrādātus, ilgi uzglabājamus pārtikas produktus [1].
Tādēļ aizvien lielāka nozīme tiek piešķirta bioloģiski ražotiem produktiem. Lai bioloģiskajā saimniecībā varētu sekmīgi darboties, tiek piedāvāti un izmēģināti arvien jauni preparāti. Lignosilīcija produkti ar dažādu silīcija saturu tiek iegūti no lignocelulozes, kas ir bioetanola ražošanas blakusprodukts. Produkti ir patentēti un sertificēti /Produkta higiēniskais novērtējums № 20, 2004. g. 25. februārī/. Lignosilīcija produkti nav toksiski, pēc izmēģinājumu rezultātiem uz žurkām tie ierindoti 4-jā bīstamības klasē [2].
Silīcijs nepieciešams pilnvērtīgai augu attīstībai, tā ietekmē augi spēj labāk pārdzīvot stresa situācijas. Savukārt lignīnam piemīt spēja aktivizēt augšanu. Lignosilīcija produkti palīdz atveseļot arī augsni un sekmē fosfora un kalcija pārvēršanu augiem pieejamā formā. Tādēļ to iesaka lietot gan kā mēslojumu, gan kā biostimulatoru [2,3].
Līdz šim ir pētīta Lignosilīcija (LSP- silīcija saturs 5%) ietekme uz dažādām graudaugu sugām [4,5,6], bet nav datu par tā iedarbību uz ziemas rudziem. Latvijā rudzi uzskatāmi par vienu no svarīgākajiem kultūraugiem, tos audzē galvenokārt kā maizes labību. Rudzi ir arī vērtīga lopbarība un izejviela daudziem pārstrādes produktiem. No iepriekš minētā izriet, ka ziemas rudzi ir viena no pamatkultūrām, kas tiek iekļauta bioloģiskās lauksaimniecības augu sekās. Lai noskaidrotu, kā ziemas rudzu augšanu un attīstību ietekmē Lignosilīcijs, 2004.gadā Skrīveros tika iekārtoti ražošanas izmēģinājumi.

ISBN 9984 – 779 – 06 – 8

Materiāli un metodes

Izmēģinājumi iekārtoti sertificētā bioloģiskā laukā, kas paredzēts zinātnes un sēklaudzēšanas vajadzībām. Laukā izveidota 7 lauku augu seka ar viena lauka platību 4,5 ha. Augsne vidēji iekultivēta, pēc pasaules augšņu klasifikatora atbilst *Orthieurtic Mollic Gleysol (GL euomo)* tipam, granulometriskais sastāvs mālsmilts. Aramkārtas biezums 25 – 30 cm, trūdvielu saturs 3,5%. Lauks drenēts ar slēgto drenāžu, pH_{KCl} 5,8, nodrošinājums ar kāliju vidējs- 155,0 mg kg^{-1}, ar fosforu zems- 84,4 mg kg^{-1}, Ca saturs 1240,0 mg kg^{-1}.

Izmēģinājumi iekārtoti vienā augu sekas laukā, kur 2003.gada rudenī iesēti ziemas rudzi „Duoniai”. Tā ir vidēji intensīva tipa šķirne, augstražīga, uzrāda labu ziemcietību un noturību pret slimībām.

2004.gadā agri pavasarī- 19.aprīlī zem rudziem tika pasēts vēlais tetraploīdais sarkanais āboliņš „Dīvaja”. Dažas dienas pēc āboliņa sējas pirms tā sadīgšanas 22.aprīlī 0,25 ha platībā vienmērīgi izkliedēja un ar vieglajām ecēšām iestrādāja augsnē Lignosilīciju, deva 120 kg ha^{-1}. Ērtāk būtu izsēt to reizē ar sarkano āboliņu, tomēr tas nav iespējams, jo sarkanā āboliņa sēklas ir sīkas un to daudzums neliels- izsējas norma 8 kg ha^{-1}. Pārējā rudzu lauka daļa 4 ha platībā kalpoja kā kontrole.

Ziemas rudzu vārpošanas fāzē (18.jūnijā) tika vērtēta sakņu attīstība. No katra varianta tika noņemtas 10 saknes, kuras skaloja ūdenī, apžāvēja uz filtrpapīra un svēra.

Augu zaļajām lapām spirta izvilkumā vārpošanas fāzē noteica hlorofila un karatinoīdu saturu pēc A.Jermakova augu bioķīmisko pētījumu metodikas [8]. Tika izmantots Perkin Elmer aparāts Lambda 25 UV/VIS Spektrometer.

Ziemas rudzu paraugi vērtēšanai tika noņemti ar rāmīti graudu pilngatavības fāzē 18.augustā. Katrā variantā noņemti paraugi 4 atkārtojumos.

Paraugiem tika noteikts produktīvo stiebru skaits (gab. m^{-2}), vidējais stiebru garums, stiebru diametrs, vārpu garums, graudu skaits vārpā, graudu masa vārpā, 1000 graudu masa, kā arī graudu un salmu ražas lielums.

Ziemas rudzu biometrisko rādītāju novērtēšanai katram paraugam tika mērīti un analizēti 20 stiebri. Iegūtajiem izmēģinājuma rezultātiem veikta datu matemātiskā apstrāde ar dispersijas analīzes metodi.

Rezultāti un to izvērtējums

2003.gada rudenī bioloģiskajā laukā iesētie ziemas rudzi „Duoniai” labi sadīga, saceroja un ziemošanā iegāja labā stāvoklī. Ziemošanas apstākļi rudziem bija apmierinoši.

2004.gada veģetācijas periods Latvijā bija vēss un lietains, bet, tā kā ziemāji nav siltumprasīga kultūra, ziemas rudzu augšana un attīstība laika apstākļu dēļ netika traucēta.

Augu veģetācijas periods 2004.gadā Latvijā sākās 15.aprīlī, tas ir par dažām dienām agrāk kā citus gadus. Mēneša beigās naktis bija vēsas, 26. un 27.aprīli novērotas salnas. Zem ziemājiem pasētais sarkanais āboliņš dīga lēnām un nevienmērīgi. Nokrišņu daudzuma ziņā aprīlis bija ceturtais vissausākais mēnesis pēdējo 80 gadu laikā.

Maijs Latvijā bija nedaudz vēsāks par normu. Gaisā un uz augsnes nereti tika novērotas salnas. Vēsa bija arī jūnija II dekāde, salnas Skrīveros atzīmētas vēl 8. un 9.jūnijā. Kopumā 23 no 30 mēneša dienām gaisa temperatūra bija zem normas. Jūnijs bija lietains, īpaši mēneša III dekāde, 27.jūnijā Skrīveros nolija 62 % no mēneša normas.

Jūlijā laika apstākļi bija tuvu normai. Augustā un septembrī bija mēreni silts un lietains laiks.

Ar Lignosilīciju apstrādātajā ziemas rudzu sējuma daļā efekts bija pamanāms jau pēc 2- 3 nedēļām. Lignosilīcija fonā aktivizējās fotosintēzes procesi. Tas veicināja augu pilnvērtīgāku augšanu un attīstību, par ko liecināja sējuma veselīgais izskats, spēcīgie dzinumi un koši zaļā lapu krāsa. Pieauga rudzu noturība pret slimībām, tika aizkavēta augu saslimšana ar sēnīšu ierosinātajām infekcijām- miltrasu un rūsām. Vizuāli vērtējot pēc 10 ballu skalas stiebrošanas- vārpošanas fāzē ar LSP apstrādātajā sējumā daļā atzīme bija 9,5 balles, kontroles variantā 7 balles. Rezultātā stiebrošanas- vārpošanas fāzē, kad intensīvi formējas graudaugu ražas lielums,

ISBN 9984 – 779 – 06 – 8

Lignosilīcija pielietošanas ietekmē rudzu sējums bija ievērojami spēcīgāks un veselīgāks salīdzinājumā ar kontroles variantu.
Par Lignosilīcija pozitīvo ietekmi liecina arī rudzu sakņu attīstība vārpošanas fāzē. Ar LSP apstrādātajā variantā rudziem veidojās lielāka sakņu masa, kas ļāva augiem pilnvērtīgāk izmantot augsnē pieejamās barības vielas (skat. 1.attēlu).
Sakņu masa palielinājās 2,2 reizes- vidējā sakņu masa vienam augam kontroles variantā bija 9,2 g, ar LSP apstrādātajā variantā 20,0 g. Sakņu sausne lignosilīcija fonā salīdzinājumā ar kontroli attiecīgi pieauga no 4,8 g uz 10,9 g.

1.attēls. **Lignosilīcija (120 kg ha^{-1}) ietekme uz ziemas rudzu sakņu attīstību vārpošanas fāzē**

Lapu analīzes vārpošanas fāzē liecina, ka Lignosilīcija fonā, salīdzinot ar kontroli, hlorofila un karatinoīdu saturs būtiski nepalielinās. Tomēr, spriežot pēc lapu krāsas, agrīnā attīstības stadijā hlorofila saturs bija paaugstināts. Lapās vārpošanas fāzē palielinās polifenolu saturs, par ko liecina UV spektru absorbcijas līniju intensitātes paaugstināšanās: 1,4 reizes absorbcijai pie 270 nm, 1,3 reizes absorbcijai pie 366 nm un 1,2 reizes absorbcijai pie 374 nm. [7].

1.tabula

Ziemas rudzu „Duoniai" biometrisko analīžu rezultāti pilngatavības fāzē

	Produktīvo stiebru skaits, gab. m^{-2}	**Stiebru garums, cm**	**Stiebru diametrs, mm**	**Salmu masa, g m^{-2}**
Kontrole	653	118	3,98	8,84
Lignosilīcijs 120 kg ha^{-1}	678	127	4,44	9,51
+/- salīdz. ar kontroli	+25	+9	+0,46	+0,67
% pret kontroli	104	108	112	108
$RS_{0,05}$	*212,9*	*4,5*	*0,18*	*2,5*

Biometrisko rādītāju analīzes liecina, ka Lignosilīcija ietekmē nedaudz palielinājās produktīvo stiebru skaits (gab. m^{-2}), būtiski pieauga stiebru garums un stiebru diametrs Lignosilīcijs veicināja garāku un daudz izturīgāku ziemas rudzu stiebru veidošanos, kas nodrošināja gan salmu, gan graudu ražas pieaugumu. Salmu masa palielinājās par 0.67 t ha^{-1} jeb 108 % salīdzinājumā ar kontroles variantu. (1.tabula).

ISBN 9984 – 779 – 06 – 8

Lignosilīcija fonā sējums veidojās ievērojami spēcīgākiem stiebriem, tas garantēja augstāku veldres noturību arī nelabvēlīgos laika apstākļos. Īpaši svarīgi tas ir gadījumos, kad zem graudaugiem pasēti daudzgadīgie zālaugi, kuri veldres gadījumā var tikt nomākti. Tādā situācijā cietīs ne tikai graudu raža, bet būs jāatjauno arī pasētais zālājs.

2.tabula

Ziemas rudzu „Duoniai" graudu raža un tās struktūrelementu analīžu rezultāti

	Vārpu garums, cm	Graudu skaits vārpā, gab.	Graudu masa vārpā, g	1000 graudu masa, g	Graudu raža, t ha^{-1}
Kontrole	7,3	35,8	1,19	31,7	5,35
Lignosilīcijs 120 kg ha^{-1}	8,0	41,4	1,51	33,5	6,32
+/- salīdz. ar kontroli	+0,7	+5,6	+0,32	+1,8	+0,97
% pret kontroli	110	116	127	106	118
$RS_{0,05}$	0,59	3,82	0,27	2,05	1,4

Lignosilīcija klātbūtne sekmēja arī būtisku vārpu garuma pieaugumu, būtiski palielinājās graudu skaits un graudu masa vārpā, attiecīgi par 116 % un 127 % (skat. 2.tab.). Graudi veidojās rupjāki, 1000 graudu masa palielinājās par 1,8 g. Tas viss kopumā nodrošināja graudu ražas pieaugumu par 0,97 t ha^{-1} jeb 118 % salīdzinājumā ar kontroles variantu.

Secinājumi

Lignosilīcija izmantošana bioloģiskajā lauksaimniecībā ziemas rudzu sējumos aizkavē augu inficēšanos ar sēnīšu ierosinātajām slimībām agrās graudaugu attīstības stadijās, tādā veidā pagarinot pilnvērtīgas ražas formēšanās laiku un nodrošinot augstākas un kvalitatīvākas graudu ražas ieguvi.

Lignosilīcijs sekmē ziemas rudzu graudu un salmu ražas pieaugumu, 1000 graudu masas palielinājumu, kā arī būtiski paaugstina stiebru garumu un diametru, vārpu garumu, graudu skaitu un graudu masu vārpā.

Lignosilīcija ietekmē veidojas rupjāki un stingrāki rudzu stiebri, paaugstinās veldres noturība, tādēļ drošāk var veikt daudzgadīgo zālaugu pasēju zem ziemas rudziem.

Lauka izmēģinājuma rezultāti liecina, ka Lignosilīcija pielietošana bioloģiskajā lauksaimniecībā rudzu sējumos ir perspektīva.

Summary

Biological agriculture is based on the promotion of nature"s self-regulation processes and the enhancement of the biological activity of soil. It protects against the mineral fertilizers and pesticides obtained by the chemical synthesis way. To ensure a successful activity of the agricultural economy, increasingly new preparations are proposed.

Lignosilicon products with different contents of silicon are obtained on the basis of the lignocellulose raw material, a waste of bioethanol. The products are protected with a patent and certified (Product sanitary assessment No. 20, 2004, February 25). Lignosilicon products are not toxic; they are assigned to 4-hazard class from the results of tests on rats.

Up to now, the effect of Lignosilicon (LSP), a product with the silicon content 5%, on different cereal species has been investigated, but there are no data on its effect on winter rye. In Latvia, winter rye is one of the main cultures, which is included in biological agricultural crop rotation. To elucidate, how the cultivation and development of winter rye is influenced by Lignosilicon, production experiments were conducted in Skrīveri in 2004.

The experiments were carried out in a certified biological field, designed for scientific and seed growing purposes. A 7-field crop rotation with one field area of 4.5 ha has been formed in field conditions. The soil was medium-cultivated, corresponding to the world soil classification type

ISBN 9984 – 779 – 06 – 8

Orthieurtic Mollic Gleysol (GL euomo), granulometric content 3.5%. The field was drained with a closed drainage, pH_{KCl} 5.8, average potassium and phosphorus supplies were 155.0 mg kg^{-1} and 84.4 mg kg^{-1}, respectively, Ca content was 1240.0 mg kg^{-1}.

The experiments were conducted in one crop rotation field, in which the winter rye „Duoniai" was sown in the autumn of 2003.

The winter rye „Duoniai" emergenced well, tillered, and wintering proceeded in a good state. Wintering conditions for rye were satisfactory.

In the early spring of 2004, i.e. on April 19, late tetraploide red clover „Dīvaja" was sown below the rye. In several days after the clover sowing, before its germination on April 22, a 0.25-ha area was loosened evenly, and, with the help of a light harrow, Lignosilicon was dug into the soil at the application rate 120 kg ha^{-1}.

In 2004, the vegetation period in Latvia was cool and rainy.

The effect of the Lignosilicon-treated winter rye sowing part was observed already after 2- 3 weeks. At the Lignosilicon background, the photosynthesis processes were activated. It favoured a more wholesome growth and development, which was testified by a more healthy appearance of the sowing, stronger shoots and bright green leaves. The resistance of rye against diseases increased, and the plants" affection by fungi-induced infections such as mildew and canker was inhibited. Visually, assessing by the 10-point scale, in the heading phase, the LSP-treated sowing part"s mark was 9.5 points, and that for the control was 7 points. As a result, in the shooting-heading phase, when the cereal crop yield is being formed intensively, owing to effect of Lignosilicon, the rye sowing was much stronger and healthy in comparison with the control.

The favourable effect of Lignosilicon was testified also by the development of rye roots in the earing phase – June 18. In the LSP-treated variant, a greater rye root bulk was formed, which enabled a more wholesome use of the nutrients available in the soil by the plants.

The root bulk, in comparison with the control, increased 2.2 times, while the dry matter content in roots at the background of Lignosilicon, in comparison with the control, increased from 52.2 % to 54.5 %.

An analysis of leaves in the earing phase testified that, at the Lignosilicon background, in comparison with the control, the content of chlorophyll and caratinoide contents did not increase essentially. However, judging from the leaf colour, at the early stage of development, the chlorophyll content had been elevated. In the leaves in earing phase, the polyphenol content increased, which was testified by an increase in the intensity of the UV spectra absorption curve: 1.4, 1.3 and 1.2 times for absorption at 270, 366 and 374 nm, respectively.

Lignosilicon promoted the formation of longer and stronger winter rye stems, which ousted the weakly developed ones and ensured an increase in both straw and cereal crops. A somewhat more rare sowing was formed, but with stronger stems, which ensured somewhat higher lodging resistance also in unfavourable season conditions. It was especially important also in the cases, when perennial grasses were sown below the cereals, which, in the case of lodging, can be suppressed. In this case, not only the cereal crop would be affected, but the sown grass would also have to be renewed.

An analysis of biometric parameters shows that, as a result of the Lignosilicon effect, the number of the productive stems (pieces. m^{-2}) increased, and the stem length and diameter increased considerably.

The presence of Lignosilicon also favoured essentially the ear length growth, the grain number and mass in the ear increased dramatically by 116 % and 127 %, respectively. Stronger grains were formed, 1000 grains" mass increased by 1.8 g. All this ensured a grain crop increase by 0.97 t ha^{-1} or 118 % in comparison with the control. The straw mass increase was 0.67 t ha^{-1} or 108 % in comparison with the control.

The use of Lignosilicon in biological agriculture in winter rye sowings inhibits the plants infection with fungi-induced diseases at early stages of cereal development, thereby prolonging the wholesome crop formation time and ensuring an earlier higher-quality grain crop yield.

ISBN 9984 – 779 – 06 – 8

The results of the field experiments testify that the application of Lignosilicon in biological agriculture in rye sowings is promising.

Literatūra

1. Vaivode I. Netradicionālās tehnoloģijas atgriežas no gadsimta dzīlēm.- Rīga, 2003., 224 lpp.
2. Teliševa G., Ļebedeva G., Daugaviete M. Lignosilīcija produkti lauksaimniecībai un mežsaimniecībai.- Zinātniski praktiskā konference, referātu tēzes, Jelgava, 2000., 67.- 69.lpp.
3. Telysheva G., Lebedeva G., Dizbite T., Zaimenko N., Ammosova J., Viesturs U. Use of Silicon- Containing Lignin Product for In Situ Soil Bioremediation. - Bioremediation of contaminated soil, New York, Marcell Dekker, 2000, p. 699 – 725.
4. Lebedeva G., Telysheva G. Efficiency of the use of Lignosilicon fertilizers and growth activators in cereals cultivation. 2nd International scientific practical conference “Earthworms and Soils fertility”. Vladimir, Russia, 17-19 March 2004, p.200-204.
5. Serge I, Biteniece G. Telysheva G., Lebedeva G, Lielpetere A. Application of Lignosilicon and Azobacterine for biological Agriculture. Enviroment. Technology. Resources. Proceedings of the 4th International scientific and practical conference. Rezekne, Latvia, 26-28 June 2003, p. 238-243.
6. Telysheva G., Lebedeva G., Dizbite T., Viesturs U. A prospective product for biological agriculture obtained from the wood chemical processing waste.Proceedings 2nd World conference on Biomass for Energy, Industry and Climate Protection, Rome, Italy, 10-14 May 2004, p. 1659-1661.
7. Блажей А., Шутый Л. Фенольные содинения растительного происхождения. Издательство «Мир», М. 1977, 239 с.
8. Методы биохимического исследование растений . Под. Ред. А И. Ермакова . 1987, стр. 100- 113.

ISBN 9984 – 779 – 06 – 8

RAPŠA SĒKLU APSTRĀDES AR FOSFORU IETEKME UZ DĪGŠANU, FOTOSINTĒZES PIGMENTU DAUDZUMU UN RAŽU

PHOSPHOROUS SEED COATING AFFECT TO GERMINATION, PHOTOSYNTHETIC PIGMENTS AND YIELD OF RAPE

V.STRAMKALE

Latgales Lauksaimniecības zinātnes centrs / Scientific centre of agriculture of Latgale
LLZC, Jaunviļāni, Rēzeknes raj.
Tālr.: + 371 4628140, + 371 9465004, *e-pasts*: aldisstr@apollo.lv

K.JUKĀMA, A.STALAŽS, M.VIKMANE, U.KONDRATOVIČS

Latvijas Universitātes Bioloģijas fakultāte / Faculty of Biology, University of Latvia
Kronvlada bulvāris 4, Rīga, LV-1586
Tālr.: + 371 7034864, + 371 9364133, *e-pasts*:mara.vikmane@lu.lv

Abstract. *Rape (Brassica napus L. var. napus) is long ago-known vegetable of Brassicaceae in agriculture. It is important and valuable oil, forage, green-fertiliser and nectar plant. The experience of last years shows that rape is suitable for growing in conditions of Latvia, but investigations about its cultivars and growing technologies are not wide enough.*

The phosporus-fertilizer adding in the rape plantations is of great importance for increasing of its productivity. With the aim to reduce the expenses the phosphorus treated rape seeds are made use.

In our investigations the velocity of seeds germination, germinating viability, germinating vigour, green pigments" quantity in seed-lobes and seeds" corp are studied. The conclusion is drawn that phosphorus treated seeds are of elevated physiological activity and elevated quantity of chlorophyll in seed-lobes, the seed-corp is increased for 3-70%. The velocity of the seeds" germination, germinating ability and germinat ing viability is increased too.

The making use of phosphorus treated seeds is of great effectiveness because it gives the possibility to prevent phosphorus-lack in plants and to increase physiological activity and productivity of plants.

Key words: *spring rape, mineral nutrition, seed germination, pigments of green plastids, yield.*

Ievads

Rapsis (*Brassica napus* L. var. *napus*) ir piemērots mērenā klimata joslai. Tas ir sens un nozīmīgs kāpostu dzimtas (*Brassicaceae*) kultūraugs. Rapsis ir audzējams relatīvi zemās temperatūrās, un tā attīstībai nepieciešams ievērojami mazāk siltuma nekā citiem eļļas augiem. Pieprasījums pēc rapša arvien pieaug, jo palielinās tā izmantošanas iespējas. No rapša sēklām iegūst augstvērtīgu pārtikas eļļu, bet tā spraukumi ir laba, olbaltumvielām bagāta lopbarība. Papildus rapsi izmanto zaļmēslojumam un kā nektāraugu. Latvijā uzsākta rapša eļļas izmantošana biodīzeļdegvielas ražošanā.

Pēdējo gadu pieredze rāda, ka rapsis ir piemērots audzēšanai Latvijā [1; 2; 3; 4; 5]. Rapša audzēšanas pamatnosacījumi nemainās, bet strauji mainās audzēšanas iespējas. Tās galvenokārt saistītas ar jaunu rapša šķirņu un audzēšanas tehnoloģiju ienākšanu Latvijā. Jaunās šķirnes ir ar iespējami augstāku ražību, tās ir prasīgas pret audzēšanas apstākļiem, īpaši pret mēslojumu. Liela nozīme rapša ražības un tās kvalitātes paaugstināšanā ir fosfora mēslojumam. Fosfors augam ir ļoti nozīmīgs elements, jo tas ir tādu katrai dzīvai šūnai būtisku komponentu kā nukleīnskābju, fosfolipīdu un adenozīntrifosfāta (ATP) sastāvā. Fosfors ir gan dezoksiribonukleīnskābes (DNS) kā ģenētiskās informācijas nesēja, gan ribonukleīnskābes (RNS) kā ģenētiskās informācijas realizētāja sastāvā. Nepārvērtējama ir fosfora savienojumu nozīme šūnu enerģētiskajā metabolismā. Fotosintēzes un elpošanas gaita saistīta ar ATP veidošanos. ATP, nododot fosfātu grupu citam savienojumam, to aktivē. Neorganiskajiem fosfātiem augu šūnā ir ļoti liela regulējoša loma. Neorganiskais fosfors kontrolē fermentatīvas reakcijas kā arī piedalās

ISBN 9984 – 779 – 06 – 8

metabolisma ceļu regulācijā, ietekmē fotosintēzes produktu pārvietošanos, cietes sintēzi un uzkrāšanos [6; 7; 8].

Fosfors ir otrais makroelements pēc slāpekļa, kura visbiežāk trūkst augsnē. Kopējais fosfora daudzums augsnē var būt liels, bet svarīgs ir augiem uzņemamā un pieejamā fosfora daudzums. Fosfors augsnē ir gan organisko, gan minerālsavienojumu veidā. Augsnes organiskos savienojumus mineralizē augsnes mikroorganismi, veidojot fosfātus. Augsnes minerālie savienojumi ir ļoti daudzveidīgi, diemžēl lielākā daļa augsnes neorganiskā fosfora ir nešķīstošu savienojumu veidā, kas augiem ir grūti uzņemami. Šo apstākļu dēļ aramzemē kultūraugiem pieejamais fosfora daudzums ir nepietiekams un, lai iegūtu labu ražu, lieto minerālmēslus. Tomēr sezonā no ienestā fosfora mēslojuma ap 80% kļūst augiem nepieejams, jo absorbējas uz augsnes daļiņām, veido nešķīstošus sāļus vai mikroorganismu darbības rezultātā pārvēršas organiskos savienojumos [9]. Fosfora trūkums ierobežo mikroelementu uzņemšanu [7].

Tāpēc minerālmēslu izmantošanai rapša mēslošanā ir jābūt pēc iespējas racionālākai, jo mēslojuma izmaksas ir lielas, kā arī jāsamazina minerālmēslu pielietošanas negatīvās sekas vidē. Viena no tādām pieejām, kas atļauj samazināt minerālmēslu pielietošanu, ir speciāli ar fosforu apstrādātu sēklu izmantošana. Ar fosforu apstrādāto sēklu pielietošana ir videi draudzīga tehnoloģija, uzlabo minerālmēslu izmantošanu, nepiesārņojot vidi [10], jo saistvielu kapsulā fosfors ir augiem viegli uzņemamā formā [11, 12].

Darba mērķis: noskaidrot, kā sēklu apstrāde ar fosforu ietekmē rapša sēklu dīgšanu, zaļo plastīdu pigmentu daudzumu dīgļlapās, kā arī sēklu ražu.

Materiāli un metodes

Veģetācijas un lauka izmēģinājumos (2002. un 2003. g.) izmantota rapša šķirne „Mozart”. Tā ir augstražīga, vidēji agrīna vasaras 00 šķirne ar ļoti labiem kvalitātes rādītājiem, īpaši augstu eļļas saturu. „Mozart” ir izturīga pret krustziežu sauso puvi *Phoma lingam* un gaišplankumainību *Cylindrosporium concentricum*. Šķirnei ir augsta veldres izturība [4].

Eksperimentos izmantotas šķirnes „Mozart” sēklas, kuras apstrādātas ar pulverveida fosfora mēslojumu, kas nostiprināts pie sēklām ar saistvielu. Apstrādes metodes (iSeed ™) patents pieder Somijas firmai *“Kemira Grow How”*, bet saistvielu sastāva patents – *“Kemira Grow How”* un *“Fortum Oil and Gas”*.

Pētījumos izmantotas gan sēklas, kas apstrādātas ar fosforu, gan sēklas, kas iegūtas audzējot augus no ar fosforu apstrādātām sēklām. Tādejādi skaidrojot, vai apstrādes ar fosforu ietekme izpaužas arī nākamajā paaudzē.

Veģetācijas izmēģinājumos sēklas diedzētas +20°C temperatūrā. Sēklas ievietotas starp filtrpapīra ripām Petri traukos un novietotas tumsā. Lai sēklas neiežūtu, katra Petri trauka filtrpapīra ripa ar filtrpapīra tiltiņu savienota ar destilēta ūdens trauku. Ūdens iztvaikošanu ierobežo Petri traukam uzlikts vāciņš, atstājot spraugu gaisa ventilācijai. Sēklu dīgšana noteikta ik pēc 12 stundām. Atkārtojumu skaits – 5. Katrā atkārtojumā 100 sēklas. Pēc dīgļlapu parādīšanās Petri traukus eksponē gaismā, lai noteiktu zaļo plastīdu pigmentus.

Veģetācijas izmēģinājumos noteica:

1. Rapšu sēklu dīgšanas ātrumu, dīgtspēju un dīgšanas enerģiju [13, 14]. Dīgtspēju izsaka procentos, normāli sadīgušo sēklu skaitu attiecinot pret kopējo dīgtspējas analizē iekļauto sēklu skaitu. Sēklu dīgšanas enerģiju nosaka dīgtspējas analīzes laikā, uzskaitot normāli sadīgušās sēklas visintensīvāk dīgstošajā laikā (1/3 vai 1/2 no dīgšanas perioda). To aprēķina procentos, sadīgušo sēklu skaitu dalot ar vispār sadīgušo sēklu skaitu attiecīgajā variantā [13].
2. zaļo plastīdu pigmentu daudzumu dīgļlapās – spektrofotometriski kopējā pigmentu acetona izvilkumā, nosakot šķīdumu optisko blīvumu (D) gaismas viļņu garumos, kas atbilst hlorofila a, hlorofila b un karotinoīdu absorbcijas maksimumiem.

Pigmentu koncentrāciju (C - $mg \cdot l^{-1}$) aprēķina pēc formulām [15]:

$$C_{hla} = 9{,}784\ D_{662} - 0{,}990\ D_{644}$$
$$C_{hlb} = 21{,}426\ D_{644} - 4{,}650\ D_{662}$$
$$C_k = 4{,}695\ D_{440{,}5} - 0{,}268\ C_a + C_b$$

ISBN 9984 – 779 – 06 – 8

Lauka izmēģinājumus (2003.g.) ierīko pēc randomizēto bloku metodes 4 atkārtojumos. Lauciņa kopējā platība 2 m × 10 m = 20 m^2. Uzskaites platība 1.6 m × 10 m = 16 m^2. Izolācija starp lauciņiem 0.4 m, starp atkārtojumiem 0.5 m. Izmēģinājumu kopējā platība 1259 m^2. Augsnes tips: podzolēta glejaugsne. Organiskās vielas saturs augsnē – 38 g kg^{-1}, pH_{KCl} – 7.3, P – 36.2 mg kg^{-1}, K – 75.6 mg kg^{-1}. Priekšaugs – melnā papuve, pamatmēslojumā *"Kemira Grow How"* kompleksais minerālmēslojums 18:9:9, papildmēslojumā lietots amonija nitrāts (devas saskaņā ar metodiku).

Meteoroloģisko apstākļu raksturojums (2003.g.). Maija otrajā un trešajā dekādē silts un mitrs. Pietiekošais mitruma daudzums labvēlīgi ietekmēja rapša sēklu dīgšanu. Jūnijs – sauss un karsts. Jūlijā – nokrišņu daudzums 1.4 reizes pārsniedza normu. Ražas novākšanas periodā, augusta trešajā dekādē, nokrišņu daudzums 4.2 reizes pārsniedza normu, kas negatīvi ietekmēja ražas novākšanu.

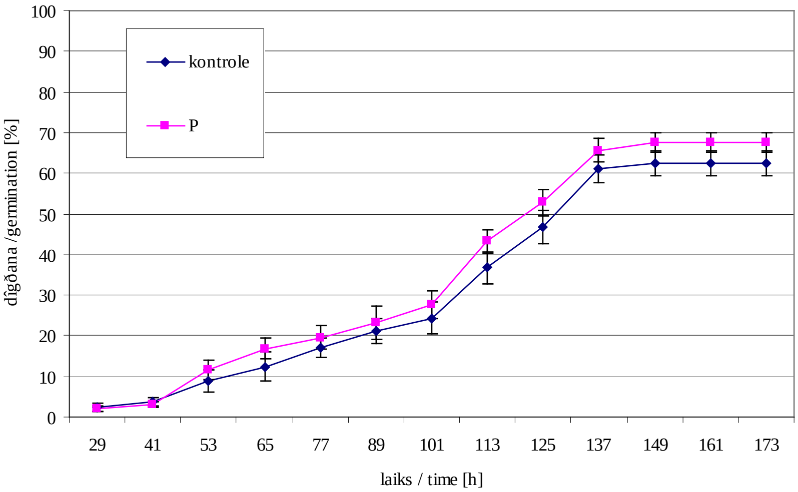
Lauka izmēģinājumos noteikta rapša sēklu raža. Rapsis novākts atbilstoši sēklu gatavībai ar kombainu *Sampo-130*. A/S Rēzeknes Dzirnavnieks laboratorijā ar *Infratex 1241* noteikts kopējais eļļas saturs sēklās.

Datu matemātiskā apstrāde (vidējo aritmētisko, reprezentācijas kļūdas, robežstarpības aprēķini) un attēlu izveide veikta ar datorprogrammu *MS Excel*.

Rezultāti un to izvērtējums

Sēklu dīgšanas procesa norise ir saistīta ar sēklu kvalitāti [16; 13; 17]. Sēklu kvalitāti visbiežāk novērtē, nosakot to fizioloģiskās īpašības – dīgšanas ātrumu, dīgtspēju, dīgšanas enerģiju.

Ar fosforu apstrādātu sēklu dīgšana. Sēklu dīgšanas sākumā vienlīdz intensīvi dīgst gan kontroles varianta, gan ar fosforu apstrādātas sēklas. Jau sestajā stundā pēc sēklu sadīgšanas, ar fosforu apstrādātās sēklas, pēc dīgšanas ātruma, par 3 % pārsniedz kontroles varianta sēklas. Ar fosforu apstrādāto sēklu lielāku dīgšanas ātrumu konstatējām visā eksperimenta gaitā (1.attēls).

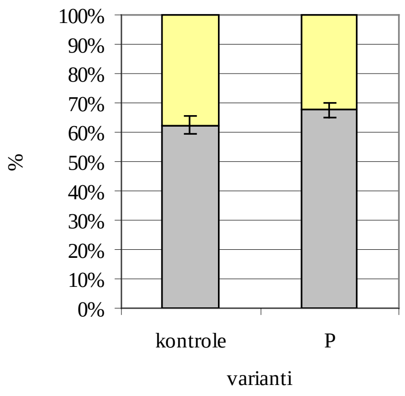


1.attēls. **Rapša šķirnes „Mozart" sēklu dīgšana**
Fig. 1. **Germination of the rape „Mozart" seeds**

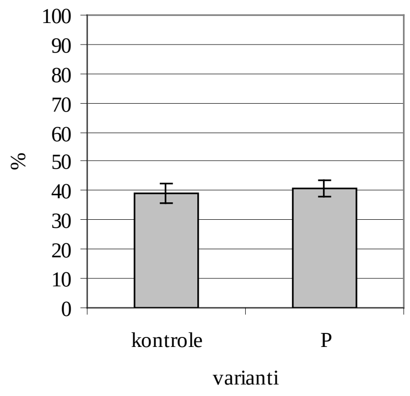
Iespējams, ka mūsu eksperimentā, jau 35. stundā pēc ar fosforu apstrādāto sēklu sadīgšanas, fosfora anjoni ir nonākuši sēklās. Seko intensīva ūdens uzņemšana un sēklu dīgšana notiek straujāk. Literatūrā ir norādes, ka palielinoties osmotiski aktīvo vielu koncentrācijai augu dzīvajās šūnās, tās intensīvāk saista ūdeni [18; 6].

Sēklu dīgtspēju un dīgšanas enerģiju apstrāde ar fosforu nav būtiski ietekmējusi (2., 3.attēls).

ISBN 9984 – 779 – 06 – 8



2.attēls. **Rapša šķirnes „Mozart" sēklu dīgtspēja**
Fig. 2. **Germination viability of the rape „Mozart" seeds**

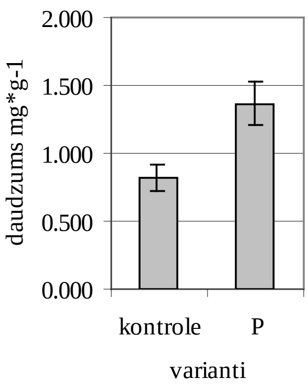


3.attēls. **Rapša šķirnes „Mozart" sēklu dīgšanas enerģija**
Fig. 3. **Germination vigour of the rape „Mozart" seeds**

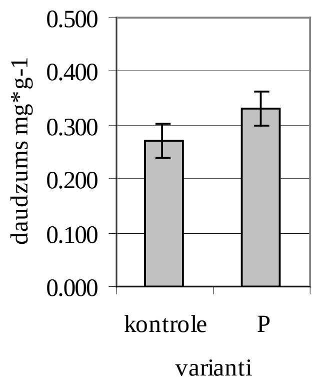
Kaut gan ar fosforu apstrādāto sēklu dīgtspēja ir par 6 %, dīgšanas enerģija par 2 % lielāka, nekā kontroles varianta sēklām, atšķirības ir kļūdu robežās.

Zaļo plastīdu pigmenti. Septītajā dienā, pēc sēklu sadīgšanas, ar fosforu apstrādāto sēklu dīgļlapās hlorofila a un hlorofila b summa ir par 43 % lielāka, nekā kontroles varianta sēklu dīgļlapās. Dīgļlapās palielinās arī karotinoīdu daudzums (4., 5 attēls).

Dažu autoru darbos ir norādes par pozitīvu korelāciju starp hlorofila daudzumu un fotosintēzes intensitāti [19; 20; 21]. Iespējams, ka fosfora apstrādes ietekmē dīgstos fotosintēze notiek intensīvāk un veidojas vairāk enerģētisko un plastisko vielu.



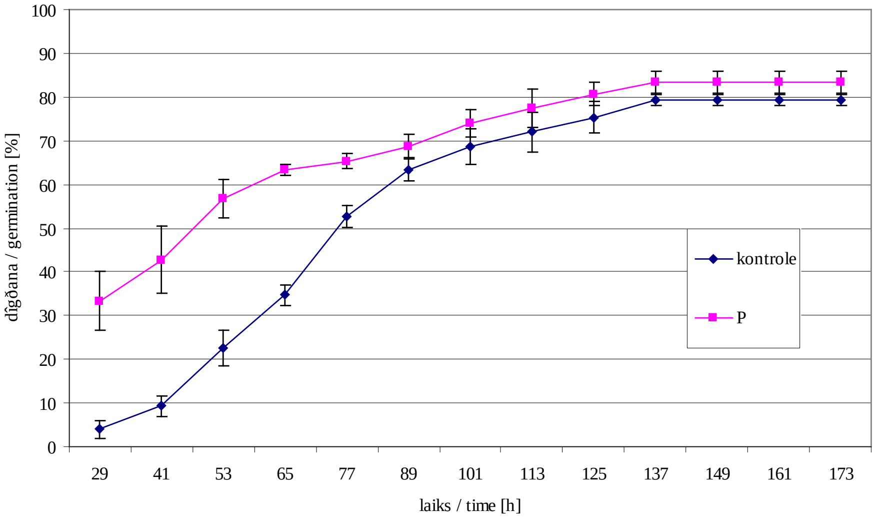
4.attēls. **Rapša šķirnes „Mozart" sēklu apstrādes ar fosforu ietekme uz hlorofila a+b daudzumu dīgļlapās**
Fig. 4. **The total amount of chlorophyls a+b in flax cotyledons from the phosphorus treated rape „Mozart" seeds**



5.attēls. **Rapša šķirnes „Mozart" sēklu apstrādes ar fosforu ietekme uz karotinoīdu daudzumu dīgļlapās**
Fig. 5. **The total amount of carotenoid in flax cotyledons from the phosphorus treated rape „Mozart" seeds**

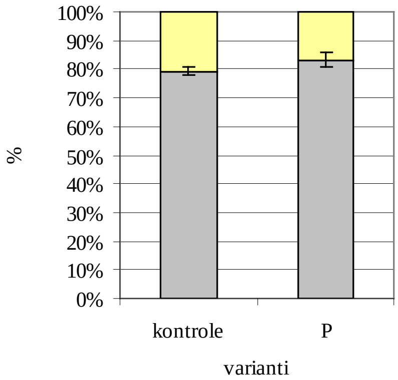
Sēklu apstrādes ar fosforu pēcietekme uz nākamās paaudzes sēklu dīgšanu. Otrajā paaudzē sēklām (2003. gada sēklu raža, kas iegūta audzējot augus no ar fosforu apstrādātām sēklām) ir ievērojami intensīvāka dīgšana, nekā kontroles varianta sēklām. Vislielākās atšķirības starp variantiem ir sēklu dīgšanas sākumā (6.attēls).

ISBN 9984 – 779 – 06 – 8

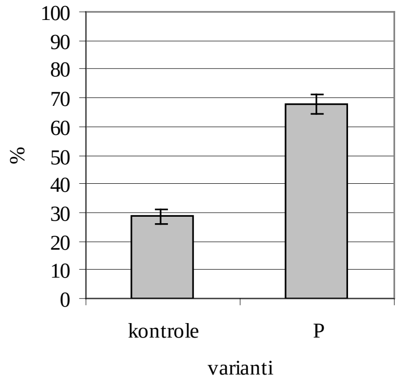


6.attēls. **Rapša šķirnes „Mozart" 2. paaudzes sēklu dīgšana**
Fig. 6. **Germination of the second generation rape „Mozart" seeds**

Ar fosforu apstrādāto sēklu dīgtspēja otrajā paaudzē ir tikai nedaudz lielāka par kontroles varianta sēklu dīgtspēju, bet sēklu dīgšanas enerģija ir par 39 % lielāka nekā kontroles varianta sēklām (7., 8.attēls).



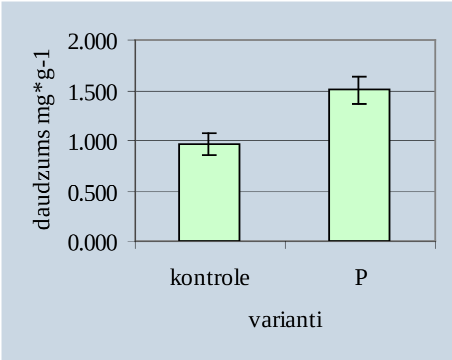
7.attēls. **Rapša šķirnes „Mozart" 2.paaudzes sēklu dīgtspēja**
Fig. 7. **Germination viability of the second generation rape „Mozart" seeds**



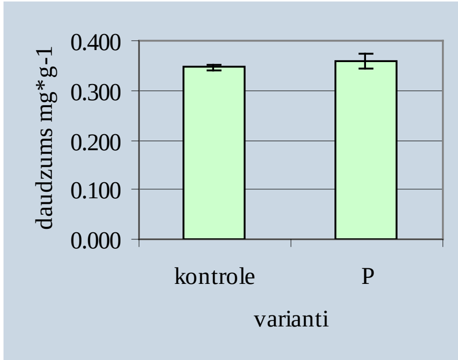
8.attēls. **Rapša šķirnes „Mozart" 2.paaudzes sēklu dīgšanas enerģija**
Fig. 8. **Germination vigour of the second generation rape „Mozart" seeds**

Lauksaimniecības zinātņu speciālisti norāda, ka paaugstināta dīgšanas enerģija, audzējot augus nelabvēlīgos vides apstākļos, var būtiski ietekmēt sēklu dīgšanu [2, 13], nodrošinot strauju augu augšanu agrajās attīstības stadijās, vienādu un izlīdzinātu attīstību ontoģenēzē. Tā rezultātā augi spēj daudz efektīvāk izmantot savu ražas potenciālu.
Apkopojot izmēģinājuma rezultātus par fosfora varianta 2.paaudzes sēklu dīgšanu, ir redzama fosfora apstrādes pozitīvā pēcietekme uz nākamās paaudzes sēklām.
Zaļo plastīdu pigmentu daudzums otrās paaudzes rapša dīgļlapās ir lielāks nekā kontroles variantam (9., 10.attēls).

ISBN 9984 – 779 – 06 – 8



9.attēls. **Sēklu apstrādes ar fosforu pēcietekme uz hlorofila a+b daudzumu rapša šķirnes „Mozart" dīgļlapās**
Fig. 9. **The total amount of chlorophyls a+b in flax cotyledons from the second generation rape „Mozart" seeds**



10.attēls. **Sēklu apstrādes ar fosforu pēcietekme uz karotinoīdu daudzumu rapša šķirnes „Mozart" dīgļlapās**
Fig. 10. **The total amount of carotenoid in flax cotyledons from the second generation rape „Mozart" seeds**

Kopējais hlorofila daudzums par 50 %, karotinoīdu daudzums par 2.9 % pārsniedz kontroles variantu, bet karotinoīdiem atšķirības ir kļūdu robežās.
Apkopojot izmēģinājuma rezultātus - sēklu apstrādei ar fosforu ir pozitīva ietekme uz zaļo plastīdu pigmentu biosintēzi arī nākamajā paaudzē.
Rapša sēklu ražas analīze. Lauka izmēģinājumos, rapša šķirni „Mozart" nodrošinot ar dažādu slāpekļa, fosfora un kālija mēslojumu, labāk aug un attīstās augi, kuru izaudzēšanai izmantotas ar fosforu apstrādātas sēklas. Iegūto ražas datu analīze liecina, ka variantos, kur lietotas ar fosforu apstrādātas sēklas, iegūta par 3-70 % lielāka sēklu raža, salīdzinot ar kontroli. Lielākā šķirnes „Mozart" sēklu raža – 4.22 t ha $^{-1}$ iegūta no augiem, kuru audzēšanai izmantotas ar fosforu apstrādātas sēklas un lietojot minerālmēslojumu N 120 (N_{45} 18:9:9 250 kg ha $^{-1}$ + N_{75}-220 kg ha $^{-1}$ amonija nitrāts + KCl). Fosfora ietekmē eļļas saturs rapša sēklās ir paaugstinājies par 0.2 līdz 1.3 %.

1. tabula / Table 1

Rapša šķirnes „Mozart" sēklu raža 2003. gadā (Latgales Lauksaimniecības zinātnes centrs)
The yield of rape „Mozart" in 2003 (in Scientific centre of agriculture of Latgale)

Mēslojuma varianti / Variants of fertilizer	Raža / Yield		Eļļas saturs sēklās Oil content in rape seeds
	t ha^{-1}	%	%
1. kontrole – bez mēslojuma (control – without fertilizer)	2.37	100	46.0
2. kontrole (control) + P sēklas (phosphorus treated seeds (iSeeds^{TM}))	2.43	103	47.3
3. N_{120} (N_{90} 18:9:9 – 500 kg ha^{-1} + N_{30} – 88 kg ha^{-1} amonija nitrāts (amonium nitrate)	3.04	128	46.2
4. N_{120} (N_{90} 18:9:9 – 500 kg ha^{-1} + N_{30} – 88 kg ha^{-1} amonija nitrāts (amonium nitrate) + P sēklas (phosphorus treated seeds)	3.33	143	47.3
5. N_{120} (N_{45} 18:9:9 – 250 kg ha^{-1} + N_{75} – 220 kg ha^{-1} amonija nitrāts (amonium nitrate) + KCl)	3.84	162	46.9
6. N_{120} (N_{45} 18:9:9 – 250 kg ha^{-1} + N_{75} – 220 kg ha^{-1} amonija nitrāts (amonium nitrate) + KCl) + P sēklas (phosphorus treated seeds)	4.22	170	47.0
	$\gamma_{0.05}$=0.20		

Literatūrā ir norādes [22], ka rapša sēklās esošie proteīni ir bagāti ar neaizvietojamām aminoskābēm (lizīnu, metionīnu, cisteīnu), sēklas satur arī nepiesātinātas taukskābes (oleīnskābi, linolskābi, linolēnskābi), kas ir nepieciešamas dzīvnieku augšanai un labvēlīgi ietekmē to produktivitāti kā arī ir vērtīgs uzturlīdzeklis cilvēkiem. Tāpēc sēklu apstrādes ar fosforu ietekme

ISBN 9984 – 779 – 06 – 8

uz rapša šķirnes „Mozart" sēklu ražu kā arī eļļas saturu sēklās uzskatāma par nozīmīgu. Izmēģinājumu rezultātu noviržu ticamības aprēķini pierāda, ka iegūtie rapša sēklu ražas pieaugumi visos variantos ir būtiski, izņemot 2. variantu – ar fosforu apstrādātas sēklas bez mēslojuma.

Tā kā fosforam ir būtiska loma visos augā notiekošajos fizioloģiski bioķīmiskajos procesos [18; 13; 6; 22; 4], arī mūsu pētījumos iegūtie rezultāti apstiprina fosfora būtiskumu. Fosfora izmantošana sēklu apstrādē nodrošinājusi labāku tā uzņemšanu un iesaistīšanu rapša metabolisma procesos, par ko liecina sēklu ražas un eļļas satura pieaugums sēklās augiem, kuri izaudzēti no ar fosforu apstrādātajām sēklām.

Secinājumi

1. Ar fosforu apstrādāto vasaras rapša šķirnes „Mozart" sēklu dīgšanas raksturojums ir šāds:
   - pēc apstrādes ar fosforu palielinās sēklu dīgšana;
   - dīgtspējas un dīgšanas enerģijas izmaiņas nav būtiskas;
   - fosfora ietekmē kopējais hlorofila daudzums dīgļlapās palielinās;
2. Rapša sēklu raža, kas iegūta, izmantojot ar fosforu apstrādātas sēklas un lietojot dažādu slāpekļa, fosfora un kālija minerālmēslojumu, ir palielinājusies par 3-70 %, bet eļļas saturs sēklās – par 0,2 –1.3 %;
3. Sēklu apstrāde ar fosforu pozitīvi ietekmē nākamās paaudzes sēklu fizioloģisko darbību:
   - palielinās sēklu dīgšana, dīgtspēja un dīgšanas enerģija;
   - lielāks ir zaļo plastīdu pigmentu daudzums dīgļlapās;
4. Ar fosforu apstrādāto rapša sēklu izmantošana ir efektīva: palielinās sēklu fizioloģiskā aktivitāte un sēklu raža, tiek uzlabota fosfora izmantošana un notiek vides saudzēšana.

Summary

The experience within the last years demonstrate that rape (*Brassica napus* var. *napus*) is suitable for growing in Latvian climate, however, investigations regarding its sorts and growing technologies are rather insufficient.

Rape is grown in relatively low temperatures and it requires considerably less warmth than other oil plants in their growth. The demand for rape increases simultaneously with widening usage possibilities of the plant. Rape seeds are important and valuable oil source. Rape is qualitative forage full of proteins. Besides that, it is used as green-fertiliser and as nectar plant. In Latvia rape oil usage has been started in bio fuel production.

It is important starting from the seeds" germination up to their maturity. The plants use the phosphorus that is in the seeds rapidly; later they absorb it from the environment. In most cases the phosphorus that is found in the soil is difficult to use by the plants, as it creates insoluble compounds. In order to have a great yield, the necessity for phosphorus is ensured by using mineral nutrition. However, in the season about 80% from phosphorus-fertiliser used for the plants become unavailable. In order to decrease the expenses for mineral nutrition as well as to avoid pollution, the seeds treated with phosphorus powdered nutrition are introduced instead. The nutrition is fixed to the seeds with the help of binding agent. The patent for this treatment method (iSeed^{TM}) belongs to Finnish company *"Kemira Grow How"* but the patent for the binding agent belongs to *"Kemira Grow How"* and *" Fortum Oil and Gas"*.

Rape „Mozart" was used in vegetation and field tests (in 2002 and 2003). It is highly productive, medium summer 00 sort with excellent quality indicators and specifically high oil contents. The „Mozart" is rather resistant to different plant diseases. It shows high lodging consistence.

Vegetation tests were carried out in the Department of Plant Physiology, The faculty of Biology, the University of Latvia but the field-tests in the Science Centre of Agriculture of Latgale.

During the tests the phosphorus treated seeds were used as well as the ones originating from the plants that were grown from the seeds treated with phosphorus. This helped to determine whether the phosphorus treatment is visible also during the next generation.

ISBN 9984 – 779 – 06 – 8

During the vegetation tests the seeds were germinated at + 20°C in the Petri dish. The length of experiment depended on the germination speed. Germination of the seeds was set up every 3 hours. The number of repetitions – 5. The number of seeds in every repetition – 100. As soon as seed lobes appeared, the Petri dish was displayed in light in order to state pigments of green plastids. We investigated germination dynamics, germination power and energy of rape seeds.

The field tests were organised according to the method of random blocks with 4 repetitions. The total field space was 2 m × 10 m = 20 m^2. The total space of the test was 1259 m^2. The soil – humus podsol gley soil. The contents of organic substances in the soil – 38 g kg^{-1}, pH_{KCl} - 7,3, P_2O_5 - 85 mg kg^{-1}, K_2O_5 - 63 mg kg^{-1}. Pre-plant - bare fallow. Basic fertiliser - *"Kemira Grow How"* complex mineral nutrition 18:9:9, plant-feeder – ammonium nitrate (dosage according to methodology). The field tests demonstrated the yield of rape seeds. Rape was cropped according to the seed ripening phase by seed combine harvester *Sampo-130*. The total oil contents in the seeds was determined by *Infratex 1241* in the laboratory of Rēzeknes Dzirnavnieks.

The results show that when the seeds are treated with phosphorus their physiological activity increases as well as the amount of chlorophyll in the seed lobes.

The field tests demonstrate that when the rape „Mozart" was fertilised with different nitrogen, phosphorus and kalium fertiliser, the plants germ and grow better if the seeds were treated with phosphorus. The yield analyses testify that the yield of the rape seeds increased by 3 - 70 %, when the seeds were treated with phosphorus and nitrogen, phosphorus and kalium fertiliser comparing to the control test. The greatest yield of the rape seeds „Mozart" - 4,22 t ha^{-1} was obtained from the plants that were grown from the phosphorus treated seeds and using mineral nutrition N 120 (N_{45} 18:9:9 -250 kg ha^{-1} + N_{75} - 220 kg ha^{-1} amonija nitrāts + KCl). The phosphorus has influenced the contents of oil in the rape seeds; it has increased by 0.2 to 1.3%.

Treatment with phosphorus also influences physiological activity of the seeds in the next generation: germination speed, germination power and energy increases, the amount of pigments of green plastids in seed lobes is greater.

As phosphorus plays an essential role in all physiologically biochemical processes of the plant, the results of the tests confirm the importance of phosphorus. Phosphorus usage in the seed treatment has ensured its better absorption and involvement in the rape metabolism processes. It demonstrates increase in the yield of seeds and oil contents in the seeds of the plants that were grown from the phosphorus treated seeds.

The usage of phosphorus treated rape seeds is effective: physiological activity of the seeds increases as well as the yield of the seeds. Besides phosphorus usage is improved and accordingly, it contributes to better nature protection.

Literatūra

1. Gudriniece E., Stramkale V., Seržane R., Strēle M., Ļebedevs A., Leitens R. (2000) Latvijā audzēto augu eļļu pētījumi. RTU zinātniskie raksti – Mežzinātne un lietišķā ķīmija, 101-105 lpp.
2. Ruža E. (2001) Rapsis un ripsis /Augkopība: rokasgrāmata, Jelgava 185-199 lpp.
3. Borovko L., Žvarta A. (2002) Productivity and quality of spring rape varieties under condition of Vidzeme area. – Int. sci. conf. "Safe and economical agricultural technologies", Priekuļi, 25.-26.07.2002., pp. 21-24.
4. Oļukalns A., Ruža E. (2003) Vasaras rapsis. – Rīga, 1-23 lpp.
5. Stramkale V. (2003) Dažādu rapša un ripša šķirņu salīdzināšana un audzēšanas tehnoloģijas piemērotība Austrumlatvijas reģionam/Lauka izmēģinājumi un demonstrējumi 2002, Ozolnieki, LLKC, 56 lpp.
6. Marschner H. (1999) Mineral Nutrition of Higher Plants. - Academic Press, 889 p.
7. Gilroy S., Jones D. L. (2000) Through from to function: root hair development and nutrient uptake. Trends in Plant Science, 5 (2), pp. 56-60.
8. Abel S., Ticconi C. A., Delatorre C. A. (2002) Phosphate sensing in higher plants. Physiologia Plantarum, 115, pp. 1-8.
9. Vance C. P. (2001) Update on the state of nitrogen and phosphorus nitrogen. Symbiotic nitrogen fixation and phosphorus acquisition. Plant nutrition in a world of declining renewable resource. Plant Physiology, 137, pp. 390-397.
10. Gravalos E., Garcia A., Cuerda G. C. (2000) Seminis Vegetable – seeds monograph. - Inst. for regional Development, Spain, 26 p.

ISBN 9984 – 779 – 06 – 8

11. Rebafka F.-P., Bationo A., Marschner H. (1993) Phosphorus seed coating increases phosphorus uptake, early growth and yield of pearl millet (*Pennisettum glaucum* R. Br.) grown on an acid sandy soil in Niger, West Africa. Fert. Res. 35: 151-160
12. Ros C., Bell R. W., White P. F. (2000) Phosphorous seed coating and soaking for improving seedling growth of *Pryza sativa* (rice) cv. IR66. Seed Sci. Technol. 28: 391-401
13. Hartmann T. H., Kester E. D., Davies T. F., Geneve L. R. (2002) Plant propagation. - Prentice Hall, 880 p.
14. Ruža A. (2001) Sēklas materiāls /Augkopība: rokasgrāmata, Jelgava 279-283 lpp.
15. Vikmane M. (2002) Laboratorijas darbi augu fizioloģijā.- LU Bioloģijas fakultāte, 85 lpp.
16. Davies P.J. (1995) The plant hormone concept: concentration, sensitivity and transport/ In: Plant hormones: Physiology, Biochemistry and Molecular Biology, 2nd edition – Kluwer Academic Publ. - Dordrecht, Boston, London, pp. 13-38.
17. Horvath D. P., ChaoW. S., Anderson J. V. (2002) Molecular analysis of signals controlling dormancy and growth in underground adventitious buds of leafy spurge. J. Plant Physiol., 128, pp.1438-1446.
18. Ткачук Е. С., Кузьменко Л. М., Нижко В. Ф., Гуральчук Ж. З., Кармадонов Ю. К. (1991) Регуляция минерального питания и продуктивность растений, Киев, Наук. думка, 172 с.

19. Мокроносов А. Т. (1981) Онтогенетический аспект фотосинтеза. - Москва, 196. с.
20 Brenner M. L., Cheikh N. (1995) The role of hormones in photosyntate partitioning and seed filling /In: Plant Hormones - Physiology, Biochemistry and Molecular Biology, 2nd edition - Kluwer Academic Publ. - Dordrecht, Boston, London, pp. 649 – 656.
21. Malkin R., Niyogi K. (2000) Photosynthesis /In: Biochemistry and Molecular Biology of Plants, Rockwille MD, pp. 575-577.
22. Strēle M., Gudriniece E., Seržane R. (1999) Rapšu eļļas ražošana un izmantošana. Ražība, Nr. 4, 1-3 lpp.

ISBN 9984 – 779 – 06 – 8

EKOLOĢISKI DROŠAS MIEŽU AUDZĒŠANAS TEHNOLOĢIJAS BIOLOĢISKAJĀ LAUKSAIMNIECĪBĀ
ECOLOGICALLY SAFE GROWING TECHNOLOGIES FOR SPRING BARLEY ON ORGANIC FARMING

AGRITA ŠVARTA, JĀNIS VIGOVSKIS

Latvijas Lauksaimniecības Universitātes aģentūra "Zemkopības Zinātniskais institūts"
Tālr.: + 371 8353634, *e-pasts*: svarta@inbox.lv

Abstract. *Field trials were carried out on organic farming fields at the Research Institute of Agriculture of the Latvia University of Agriculture (LUA). The content of nitrates in soil, the influence of previous plants (red clover, winter rue, bare fallow, fallow and green manure), use of stable manure (60 t ha^{-1} or without) and harrowing (without harrowing, before shooting, at the stage of clustering, before shooting and at the stage of clustering) on the yield and weediness of spring barley „Sencis" were tested during 2003-2004. The content of nitrates in soil was 8-79 mg kg$^{-1.}$ Previous plants and stable manure influenced barley grain yields. Harrowing increased the yields of barley only after winter rye for green manure by using stable manure, but the time of harrowing had no influence on the yield of barley. The quality of grain was satisfactory. 1000 thousand weight was medium – 33.5–38.4 g, medium was also volume weight – 609.0–633.5 g. The content of total protein was satisfactory to good – 9.6 – 11.7 %.*

Keywords: *nitrates, organic farming, quality, spring barley, yields.*

Ievads

Bioloģiskā lauksaimniecība Latvijā vēl ir salīdzinoši jauns ražošanas virziens. 2003.gada beigās Latvijā bija 550 sertificētas saimniecības, kas nodarbojās ar bioloģisko lauksaimniecību. Bioloģiski apstrādātā zemes platība bija 24 422 ha un sasniedza 1% no visas lauksaimniecībā izmantojamās zemes [1].

Bioloģiskajā lauksaimniecībā ir vairākas nopietnas problēmas: ļoti sarežģīta ir augu barības vielu, it sevišķi slāpekļa, nodrošināšana un nezāļu ierobežošana. Ja konvencionālajā lauksaimniecībā šīs problēmas risina ar minerālmēslu un dažādu augu aizsardzības līdzekļu lietošanu, tad bioloģiskajā lauksaimniecībā tos izmantot nevar. Ir jāmeklē kultūraugu audzēšanas tehnoloģijas, kuras nodrošina augstu un kvalitatīvu ražu ieguvi, bet tai pašā laikā nenodara kaitējumu apkārtējai videi un cilvēkam.

Bioloģiskajā lauksaimniecībā augu barības vielu nodrošināšanu un nezāļu ierobežošanu galvenokārt veic ar augu seku. Latvijā veikti daudzi pētījumi par dažādu priekšaugu ietekmi gan uz vasaras miežu augšanu un attīstību, gan nezāļu ierobežošanu, piem., A. Lejiņa izmēģinājumi Skrīveru augu seku stacionārā [2]. Pierādīts, ka priekšaugs ietekmē sējumu nezāļainību vairāk nekā graudaugu īpatsvars augsekā [3]. Ierobežot nezāles iespējams izmantojot zināšanas par augu allelopātiskajā īpašībām. Zināms, ka ziemas rudzi izdala vielas (piem., hidroksiamilskābes), kas aizkavē nezāļu dīgšanu un attīstību. [4].

Slāpeklis ir viens no galvenajiem ražas veidojošajiem elementiem. Bioloģiskajās augu sekās ieteicams iekļaut tauriņziežus. Latvijas apstākļos ar gumiņbaktēriju palīdzību no gaisa piesaistītā slāpekļa daudzums 40 t ha^{-1} lielai tauriņziežu masai sasniedz 150-180 kg ha^{-1} tīra skābekļa. Bez tam tauriņzieži ar labi attīstīto sakņu sistēmu uzņem augsnes dziļākajos slāņos izskalotās augu barības vielas un pēc šo augu masas iestrādes augsnē uzņemtās barības vielas kļūst pieejamas pārējiem kultūraugiem ar seklāku sakņu sistēmu. [5].

Efektīvs slāpekļa mēslojums ir kūtsmēsli, bet pārmērīgi augstu devu lietošana, nepareiza glabāšana piesārņo ūdeņus, pieaug nitrātu saturs produkcijā. Eiropas Savienībā pieņemta Nitrātu Direktīva (1991/676/EEC), kuras mērķis ir novērst ūdeņu piesārņojumu ar lauksaimnieciskās izcelsmes nitrātiem. Programmas īstenošanai plānoti vairāki pasākumi, t.sk., augu maiņas ieviešana, kas ļaus pilnīgāk izmantot augsnes potenciālo auglību, minimālās veģetācijas uzturēšana "zaļajās platībās" rudens-ziemas periodā, nodrošinot augsnes erozijas un augu barības

ISBN 9984 – 779 – 06 – 8

elementu izskalošanās ierobežošanu. Katrā saimniecībā slāpekļa mēslojuma daudzums, ieskaitot dzīvnieku atstātos mēslus, nedrīkst pārsniegt 210 kg slāpekļa uz hektāra. [6].
Pētījuma mērķis: izveidot videi nekaitīgu miežu audzēšanas tehnoloģiju augstu un kvalitatīvu graudu ražu ieguvei.

Pētījuma objekti un metodes

Pētījums veikts Latvijas Lauksaimniecības Universitātes aģentūrā "Zemkopības Zinātniskais institūts" Skrīveros laika posmā no 2003. līdz 2004.gadam.
Iekārtots trīsfaktoru lauka izmēģinājums, kur *faktors A – priekšaugi* (sarkanais āboliņš sēklai, ziemas rudzi, melnā papuve, papuve + zaļmēslojums,), *faktors B - nezāļu ierobežošanas iespējas* (bez ecēšanas, ecēšana pirms sadīgšanas (EC 7), ecēšana cerošanas fāzē (EC 23), ecēšana pirms sadīgšanas un cerošanas fāzē (EC 7 un EC 23)), *faktors C –mēslojuma lietošana* (bez kūtsmēsliem un kūtsmēsli – 60 t ha^{-1}).
Lauka izmēģinājums iekārtots velēnu podzolētās smilšmāla augsnēs. Augsnes pH_{KCl} - 6,75, organisko vielu saturs 32.5 mg kg^{-1}, P_2O_5 – 162 mg kg^{-1}, K_2O – 158 mg kg^{-1}, $N_{kop.}$– 1.1 g kg^{-1}.
Pētījumu objekts – vasaras miežu šķirne „Sencis".
Pirms sējas graudi kodināti ar lapu koku pelniem (1,5 kg pelnu un 1,5 l ūdens uz 100 kg graudu). Izsējas norma 500 dīgstošas sēklas uz m^{-2}. Sēja veikta 19. maijā (2003.) un 30. aprīlī (2004.). Izmēģinājums iekārtots 4 atkārtojumos, lauciņi izvietoti randomizēti, lauciņa platība 42 m^{-2} un uzskaites platība – 26,18 m^{-2}. Raža novākta 11. augustā (2003) un 10. augustā (2004).
Nitrātu satura noteikšanai augsnē ņemti paraugi no 0-20 cm dziļumā divos atkārtojumos miežu dīgšanas (EC 11), cerošanas (EC 28) un vārpošanas fāzē (EC 54). Nitrātu saturs noteikts ar jonizācijas metodi.
Miežu graudu raža noteikta pie standartmitruma 14 %. Noteikti graudu kvalitatīvie rādītāji: kopproteīna saturs, 1000 graudu masa, tilpumsvars
Laukā ar priekšaugu: *papuve+ zaļmēslojums* augsnē iestrādāta ziemas rudzu zaļmasa. Zaļmasas daudzums 2003. gadā – 17 t ha^{-1}, bet 2004. gadā – 15 t ha^{-1}. Tā kā kūtsmēsli ir plaši lietots mēslošanas līdzeklis, izmēģinājumā iekļauts variants ar kūtsmēsliem - kūtsmēsli 60 t ha^{-1}. Izmēģinājumā iestrādāti labi sadalījušies kūtsmēsli no bioloģiski sertificētas govju fermas. Kūstmēsli vienmērīgi izkliedēti uz izmēģinājuma lauciņa pavasarī un tūlīt iearti augsnē. Gan kūtsmēslu, gan ziemas rudzu zaļmasas sausnes ķīmiskais sastāvs attēlots 1. tabulā.

1.tabula

Ziemas rudzu zaļmasas un kūtsmēslu ķīmiskais sastāvs sausnē

Rādītāji	Ziemas rudzu zaļmasa		Kūtsmēsli	
	2003	2004	2003	2004
Sausne, g kg^{-1}	178.3	169.0	169.7	387.7
P_2O_5, g kg^{-1}	6.5	6.0	8.8	6.4
K_2O, g kg^{-1}	30.2	25.4	18.3	9.7
N kop, g kg^{-1}	28.7	27.7	37.7	23.8
Nitrāti, mg kg^{-1}	1358.10	720.00	611.07	1203.78

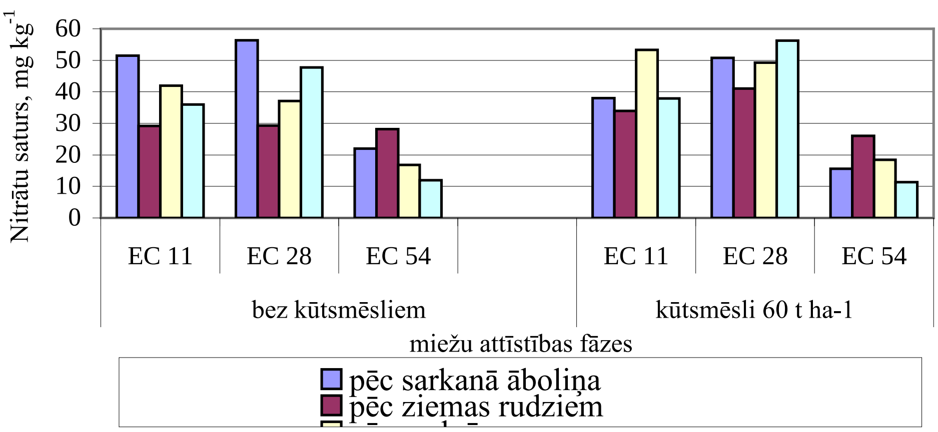
Meteoroloģisko apstākļu ziņā pētījumu gadi bija atšķirīgi. 2003.gads bija labvēlīgs vasaras miežu attīstībai. Aprīlis bija auksts un lietains, kā rezultātā aizkavējās miežu sēja (19.05.). Maijā gaiss iesila pamazām, naktīs gaisa temperatūra pieturējās zem 10 grādiem, augsnes virskārtā naktī bieži bija salnas. Mieži ātri sadīga un saceroja. Jūnija vidējā gaisa temperatūra bija 0,7 grādus zemāka par normu, savukārt nokrišņu daudzums – 75 % no normas. Savukārt 2004.gada aprīlī bija vidēji 1,7 grādus siltāks par normu. Lai gan vidēji maija temperatūra bija tuvu normai, pa dekādēm tā ļoti atšķīrās. Maija 2. dekādes temperatūra bija 3,1 grādu, savukārt trešā dekāde jau 3,6 grādus zem normas. Šai laikā gaisā un uz augsnes bieži bija salnas. Visaukstākajās naktīs mēneša vidū vietām salnu intensitāte sasniedza -5...-6 grādus. Maijā nokrišņu daudzums kopumā bija 80 % no normas. Jūnijs bija 1,3 grādus vēsāks par normu. Mēneša sākumā naktīs

ISBN 9984 – 779 – 06 – 8

gaisā vēl bija salnas līdz -1 grādam. Jūnijā nokrišņu daudzums par 52% pārsniedza normu. Vislielākais nokrišņu daudzums – 223% no normas - bija mēneša trešajā dekādē, bet diennakts nokrišņu daudzums 27.jūnijā Skrīveros sasniedza 62% no mēneša nokrišņu normas. Jūlija vidējā gaisa temperatūra un nokrišņu daudzums bija ļoti tuvu normai. Augusta vidējā gaisa temperatūra bija 1,7 grādus augstāka par normu. Vissiltākais laiks bija 1. dekādē, kas izrādījās siltākā dekāde ne vien šī gada augustā, bet arī visā šī gada vasarā. Mieži labi auga un attīstījās, kā rezultātā nodrošināja labu graudu ražu.
Datu matemātiskajai apstrāde veikta ar Microsoft Excel datorprogrammu, izmantojot divfaktoru dispersijas analīzi.

Rezultāti

Augi slāpekli galvenokārt uzņem nitrātu veidā. Lauka izmēģinājumā pētīts nitrātu saturs augsnē dažādās augu attīstības fāzēs.
Nitrātu saturs augsnē bija robežās no 8-79 mg kg^{-1} (vidēji 2003.-2004.gadā) un pa miežu attīstības fāzēm atšķīrās (1.att.). Nitrātu saturu augsnē visās miežu attīstības fāzēs būtiski ietekmēja priekšaugs. Dīgšanas laikā (EC 11) nelietojot kūtsmēslus nitrātu saturs augsnē būtiski augstāks miežiem pēc sarkanā āboliņa, bet lietojot kūtsmēslus - pēc melnās papuves. Priekšaugu ietekmes faktora īpatsvars 32 % (η^2_A). Cerošanas fāzē (EC 28) nitrātu saturs augsnē svārstās no 29-56 mg kg^{-1}. Nelietojot kūtsmēslus būtiski augstāks nitrātu saturs augsnē bija miežiem, ko audzēja pēc sarkanā āboliņa un ziemas rudziem zaļmēslojumam. Savukārt lietojot kūtsmēslus nitrātu saturs būtiski zemāks bija tikai pēc ziemas rudziem. Miežu vārpošanas fāzē (EC 54) nitrātu saturs zemāks kā pārējās miežu attīstības fāzēs – tikai 11-26 mg kg^{-1}. Priekšaugu ietekmes īpatsvars bija 38 % (η^2_A). Viszemākais nitrātu saturs konstatēts miežiem pēc ziemas rudziem zaļmēslojumam.



1.attēls. **Nitrātu saturs augsnē miežu dīgšanas (EC 11), cerošanas (EC 28), vārpošanas (EC 54) fāzē atkarībā no priekšauga un kūtsmēslu lietošanas, mg kg^{-1} vidēji 2002. - 2003.g.**

Atkarībā no izmēģinājuma variantiem vasaras miežu graudu ražas bija 1.56 - 3,85 t ha^{-1} (2.tabula).

ISBN 9984 – 779 – 06 – 8

2. tabula

Vasaras miežu „Sencis” graudu ražas atkarībā no priekšauga, kūtsmēslu lietošanas un ecēšanas laika, vidēji 2002. - 2003.gadā

Priekšaugi **(faktors A)**	**Ecēšanas laiks (faktors B)**	**Kūtsmēsli (faktors C)**	
		Bez kūtsmēsliem	**60 t ha^{-1}**
1. sarkanais āboliņš	1. bez	2.93	3.45
	2. EC 7	2.87	3.29
	3. EC 23	2.84	3.22
	4. EC 7 un EC 23	2.98	3.37
	$\gamma_{0,05}$ = 1.70 t ha^{-1}, $\gamma_{0,05}$B =0.49 t ha^{-1}, $\gamma_{0,05}$C = 0.35 t ha^{-1}		
2. ziemas rudzi	1. bez	2.00	2.82
	2. EC 7	1.91	2.94
	3. EC 23	1.83	2.78
	4. EC 7 un EC 23	1.85	2.76
	$\gamma_{0,05}$ = 0.50 t ha^{-1}, $\gamma_{0,05}$B =0.36 t ha^{-1}, $\gamma_{0,05}$C = 0.25 t ha^{-1}		
3. melnā papuve	1. bez	3.01	3.46
	2. EC 7	2.89	3.41
	3. EC 23	2.96	3.46
	4. EC 7 un EC 23	3.02	3.51
	$\gamma_{0,05}$ = 0.30 t ha^{-1}, $\gamma_{0,05}$B =0.21 t ha^{-1}, $\gamma_{0,05}$C = 0.15 t ha^{-1}		
4. papuve un zaļmēslojums	1. bez	2.85	3.01
	2. EC 7	2.97	3.35
	3. EC 23	2.79	3.19
	4. EC 7 un EC 23	2.76	3.02
	$\gamma_{0,05}$ = 0.47 t ha^{-1}, $\gamma_{0,05}$B =0.34 t ha^{-1}, $\gamma_{0,05}$C = 0.24 t ha^{-1}		

Izmēģinājuma rezultāti uzskatāmi pierāda kūtsmēslu ietekmi uz vasaras miežu graudu ražu (p-vērtība < 0,0001). Graudu ražas pieauga par 0.47–0.99 t ha^{-1} 20003. gadā, bet 20004.gadā - par 0.33-0.87 t ha^{-1}. Lielāko ražas pieaugums vidēji 0.92 t ha^{-1} bija novērojums miežiem, ko audzēja pēc ziemas rudziem.

Priekšaugu ietekme bija būtiska (p-vērtība < 0.0001) un tā atšķīrās pa gadiem (p-vērtība < 0.0001).

Augstākās ražas 2003.gadā tika konstatētas audzējot miežus pēc melnās papuves un pēc papuves + zaļmēslojums gan ar kūtsmēsliem, gan bez tiem.

Savukārt 2004.gadā būtiski augstākas ražas audzējot miežus pēc melnās papuves un sarkanā āboliņa abos variantos - ar un bez kūtsmēsliem.

Ecēšana ietekmēja graudu ražas būtiski vienīgi 2003.gadā kad tos audzēja pēc papuves + zaļmēslojums, tomēr ecēšanas laikam arī šajā variantā nebija būtiskas nozīmes. 2004.gadā ecēšanas ietekme uz graudu ražu nebija būtiska. 2004.gads bija bagāts ar nokrišņiem, tāpēc mieži attīstījās ātri, veidoja biezu aplapojumu un labi nomāca nezāles.

Graudu kvalitatīvie rādītāji parādīti 3. tabulā.

Tūkstots graudu masa (TGM) vidēji 2003.-2004.gadā svārstījās no 33.5-38.4 g un bija atarīga no priekšauga un kūtsmēsliem. Būtiski augstāka TGM konstatēta variantos, kur miežus audzēja pēc sarkanā āboliņa un ziemas rudziem gan lietojot kūtsmēslus, gan audzējot miežus bez tiem. Kūtsmēslu ietekme uz TGM bija būtiska (p-vērtība = 0.0004 < 0.05), savukārt kūtsmēslu ietekmes īpatsvars bija 33,6 % ($\square^2_C$).

ISBN 9984 – 779 – 06 – 8

3.tabula

Vasaras miežu „Sencis” graudu kvalitātes raksturojums (vidēji 2003. - 2004.gados)

Priekšaugs (faktors A)	kūtsmēsli (faktors C)	1000 graudu masa, g	Tilpummasa, g l^{-1}	Kopproteīns, %
1. Sarkanais āboliņš	Bez kūtsmēsliem	34.76	622.63	10.
	60 t ha^{-1}	35.64	632.44	10.5
2. ziemas rudzi	Bez kūtsmēsliem	34.42	623.31	9.6
	60 t ha^{-1}	35.82	628.44	9.8
3. Melnā papuve	Bez kūtsmēsliem	34.40	619.31	11.1
	60 t ha^{-1}	35.96	623.56	11.1
4. papuve+ zaļmēslojums	Bez kūtsmēsliem	34.48	617.62	11.0
	60 t ha^{-1}	34.90	619.81	11.4
		$\gamma_{0.05}$= 1.42 g; $\gamma_{0.05}$ A= 1.00 g, $\gamma_{0.05}$ C= 0.71 g; $\gamma_{0.05}$ AC= 1.41 g	$\gamma_{0.05}$= 9.50 g l^{-1}; $\gamma_{0.05}$ A= 6.72 g l^{-1}; $\gamma_{0.05}$ C= 4.75 g l^{-1}; $\gamma_{0.05}$ AC= 9.50 g l^{-1}	$\gamma_{0.05}$= 1.16 %; $\gamma_{0.05}$ A= 0.83 %; $\gamma_{0.05}$ C= 0.58 %; $\gamma_{0.05}$ AC= 1.17 %

Tilpummasa variēja no 612.5-650.0 g l^{-1}. Analizējot 2003. un 2004.gada vidējos rādītājus, tilpummasu būtiski ietekmēja gan priekšaugs (p-vērtība = 0.03 < 0.05), gan kūtsmēslu lietošana (p-vērtība =0.04 < 0.05). Priekšauga ietekmes īpatsvars bija 12.2 % ($\square^2_A$), bet kūtsmēslu lietošanas - 7.1 % ($\square^2_C$). Būtiski augstāku tilpummasu konstatēja variantos: sarkanā āboliņa un ziemas rudziem gan lietojot kūtsmēslus, audzējot miežus bez tiem.

Šķirne „Sencis” ir alus miežu šķirne, kam raksturīgs zems proteīna saturs. Vidējais kopproteīna saturs graudos (3. tabula) bija 9.6-11.4 % un tas bija atbilstošs šķirnei, To būtiski ietekmēja priekšaugs (p-vērtība = 0.0038 < 0.05), pie kam priekšauga ietekmes īpatsvars bija 76.4 %. Būtiski augstāks kopproteīna saturs graudos novērojams miežiem, kurus audzēja pēc melnās papuves un papuves + zaļmēslojumam, kopproteīna saturs pārsniedz 11 %. Zems proteīna saturs graudos novērots miežiem audzējot pēc ziemas rudziem (kopproteīna saturs 9.6-9.8 %). Kūtsmēslu lietošana un ecēšanas laiks būtiski neietekmēja kopproteīna saturu graudos.

Izmēģinājumi turpinās un, veicot trešā gada lauka izmēģinājumus, atsevišķi rādītāji var mainīties.

Secinājumi

1. Miežu graudu ražas izmēģinājumā bija 1.56 - 3,85 t ha^{-1}. Ražas lielumu būtiski ietekmēja kūtsmēslu lietošana. kūtsmēslu lietošana paaugstināja miežu graudu ražas vidēji par 0.92 t ha^{-1}.
2. Ecēšana būtiski ietekmēja graudu ražas vienīgi 2003. gadā, pie kam ecēšanas laikam nebija būtiskas nozīmes.
3. Kopproteīna saturu graudos, 1000 graudu masu un tilpummasu būtiski ietekmēja priekšaugs. Augstākā 1000 graudu masa, tilpumsvars un kopproteīna saturs tika novērots miežiem, ko audzēja pēc sarkanā āboliņa un ziemas rudziem gan lietojot kūtsmēslus, gan audzējot tos bez kūtsmēsliem.
4. Nitrātu saturs augsnē bija 8-79 mg kg^{-1} un galvenokārt bija atkarīgs no priekšauga un miežu attīstības fāzes. Augstākais nitrātu saturs augsnē tika novērots miežu cerošanas un stiebrošanas fāzē. Vārpošanas fāzē slāpekļa saturs augsnē samazinās un visus brīvos slāpekļa savienojumus patērē kultūraugi ražas veidošanai.

ISBN 9984 – 779 – 06 – 8

Summary

Field trials were carried out on organic farming fields at the Research Institute of Agriculture of the Latvia University of Agriculture (LUA). The content of nitrates in soil, the influence of previous plants (red clover, winter rye, bare fallow, fallow + green manure), use of stable manure (60 t ha^{-1} or without) and harrowing (without harrowing, before shooting, at the stage of clustering, before shooting and at the stage of clustering) on the yield and weedness of spring barley „Sencis" were tested during 2003-2004.

The aim of field trial is to work out environmentally friendly growing technologies for spring barley.

The field trials were carried out on turf podsolic soil: pH_{KCl} – 6.75, P_2O_5 – 16.2 g kg^{-1}, K_2O – 15.8 g kg^{-1}, organic matter content – 32.5 g kg^{-1}, N_{total} – 1.1 g kg^{-1}. The object of research: spring barley „Sencis". Seed rate was 500 germinating seeds per m^{-2}. Before sowing, grains were treated with 1.5 kg of ashes of foliage trees and 1.5 l of water per 100 kg of grain. Sowing date was 19.05.2003. and 30.04.2004. The number of replications was four, random plot layout, the plot size - 42 m^{-2} and testing plot size– 26.18 m^{-2}. The harvest was in 11.08.2003. and 10.08.2004.

After previous plant fallow + green manure, 15 t ha^{-1} (2004) and 17 t ha^{-1} (2003) of biomass of winter rye were cultivated. In the trial, variants with stable manure were included (doses of 60 t ha^{-1}).

The content of nitrates in soil at the growing stages: before shooting (EC 11), at the stage of tillering (EC 28) and at the stage of earing (EC 54) was determinated.

Crude protein content was determinate by Kjeldahl method.

ANOVA (two factor with replication) was used for data analysis.

Results. The content of nitrates in the soil at the different growth stages of barley was 8-79 mg kg^{-1}. The previous plant influenced the content of nitrates at the all growing stages. At the stage of germination (EC 11) in variants without stable manure the highest content of nitrates was obtained after red clover, but in variants with stable manure – after bare fallow. At the stage of clustering (EC 28) the content of nitrates was 29-56 mg kg^{-1}. In variants without stable manure the highest content of nitrates was obtained after red clover and fallow + green manure. In variants with stable manure the lowest content was determinated after winter rye and the content of nitrates was significantly low. At the stage of earing (EC 54) the content of nitrates in soil was low – only 11-26 mg kg^{-1}. The lowest content of nitrates was in sowings after fallow + green manure.

Depending on the variants, the yields in the field trial varied from 1.56 - 3,85 t ha^{-1}.

The data demonstrate the influence of stable manure on spring barley – the influence was significant. Grain yields have increased by 0.47–0.99 t ha^{-1} (2003) and 0.33-0.87 t ha^{-1} (2004) on average. Use of stable manure for barley after winter rye provided the highest yield increase - by 0.92 t ha^{-1} on average during 2003-2004.

The influence of previous plants on the spring barley was significant and differed during years.

In 2003 after different previous plants the highest yields were obtained after fallow + green manure and after bare fallow in both variants, with stable manure and without it. In 2004 the highest yields were obtained after red clover and bare fallow in both variants, with stable manure and without it.

Harrowing increased the grain yields significantly only after winter rye for green manure with stable manure, whereas time of harrowing had no significant influence on the grain yield in 2003. In 2004 the influence of harrowing was not significant. Excess precipitation and warm weather in most part of the vegetation period favoured fast development of barley and suppression of weeds.

Depending on the variants, the thousand grain weight (TGW) varied from 33.5-38.4 g and was medium during the 2003-2004. The highest TGW was obtained after red clover and winter rye in both variants, with stable manure and without it. The influence of the using of stable manure on

ISBN 9984 – 779 – 06 – 8

the TGW was significant during 2003-2004. The specific weight of influence of the use of stable manure was 33.6 % (η^2_C).

Depending on the variants, the grain volume weight varied from 612.5-650.0 g l^{-1}. The influence of previous plants and the use of stable manure on the spring barley were significant during 2003-2004. The highest volume weight was obtained after red clover and winter rye in both variants, with stable manure and without it. The use of stable manure increased volume weight by 6.65 g on average. The specific weight of influence of previous plants on the volume weight was 12.2 % (η^2_A), but specific weight of stable manure – 7.1 % (η^2_C).

The crude protein varied from 9.6-11.7 % and was satisfactory to good for variety „Sencis" (malting barley) in 2003. The influence of previous plants (η^2_A = 94 %) on the crude protein were significant.

Literatūra

1. Zemkopības Ministrijas Lauksaimniecības 2003.gada ziņojums. www.zm.gov.lv.
2. Lejiņš A., Lejiņa B. Pētījumi par augmaiņu un nezāļu apkarošanu ziemas rudzos un miežos augseku stacionārā Skrīveros no 1997.-2000. // Agronomijas vēstis. - 2002. - Nr.4. – 102.-106.lpp.
3. Žekoniene V.Влияние структуры посевов на распространение сорняков в посевах зерновых. // Weed Control in Baltic region: Proceedings of international conference, Jelgava, Latvia, 1997. – P - 125-127.
4. Prezepiorkowski T., Gorski S.F. (1994). Influence of rye (Secale cereale) plant residues on germination and growth of three triazine-resistant and susceptible weeds. Weed Technology 8, 744-747.
5. Praktiskā bioloģiskā lauksaimniecība Latvijā. I-III / sast. M. Vaivare. – Rīga: McĀbols, 2002. - 10-85.lpp.
6. Nitrātu Direktīva, 1991/676/EC

ISBN 9984 – 779 – 06 – 8

VIDES KVALITĀTE UN AIZSARDZĪBA

ENVIRONMENT QUALITY AND PROTECTION

ISBN 9984 – 779 – 06 – 8

EVALUATION OF LANDSCAPE ECOLOGICAL POLARIZATION AND ITS APPLICATION FOR STRATEGICAL TERRITORIAL PLANNING

AINAVAS EKOLOĢISKĀS POLARIZĀCIJAS NOVĒRTĒŠANA UN TĀS PIELIETOŠANA TERITORIJAS STRATĒĢISKAJĀ PLĀNOŠANĀ

MARGARITA JANKAUSKAITĖ, DARIJUS VETEIKIS

Vilnius University, Faculty of Natural Sciences, M. K. Čiurlionio 21,
LT-03101, Vilnius, Lithuania
Phone: + 370 2104709, *e-mail*: jankauskaitė@geo.lt

Abstract. *To avoid antagonism in system nature-economy-society the concept of state territory management has to be based on the principles of sustainable and balanced development. The strategy of economy development should follow not only the criteria of economical effectiveness, but also the indexes of ecological stability of the territory.*

The extent of ecological polarization (measure of landscape stability) is conditioned by the combination of (1) landscape geochemical sensitivity and (2) technogeochemical pressure defined in respective territorial units. With respect to self-cleaning features of landscapes 7 levels of geosystem sensitivity were distinguished and mapped in Lithuania territory. The largest part of the territory is occupied by averagely and more than averagely sensitive geosystems, the least area is taken by relatively insensitive and extremely sensitive geosystems. The technogeochemical pressure was evaluated through the detailed analysis of landscape technomorphological structure. Using the GIS data bases, in the technotopes distinguished the technogeochemical pressure was evaluated according to the area of industrial and built-up territories, agricultural lands, road net density (adjusted by traffic intensity), and dosmestic pollution (assessed according to the population density). Each of the agents was given different weight coefficients in regard to its pollution emissions. The layer superposition of the geosystem sensitivity and technogeochemical pressure gave the emergence of cartoscheme revealing the distribution of areas with different ecological polarization, divided into 5 tension levels. In order to distinguish the priority territories of land management and optimization the polarization area net and the natural frame of Lithuania were superposed.

Knowledge of the ecological polarization areas allows the rendering of recommendations to economy units for their economical activity organization that should be developed considering the means of landscape ecological stability maintenance like increase of forest percentage, formation of geochemical barriers, proper distribution of land use.

Keywords: *ecological polarization, landscape geochemical sensitivity, technogeochemical pressure, territorial planning.*

Introduction

In the contemporary conditions of the intense use of natural resources and technogenic pollution the security of landscape ecological stability is especially important, because landscape is a complex whole of inter-systemic links the functioning of which determine the sustainability of man's living environment.

In order to motivate the strategy of environment protection and rational use, it is important to evaluate not only the actual extent of anthropogenic load but also natural-ecological landscape potential (geopotential), that is determined by the landscape genetic possibilities to resist the technogenic load without noticeable changes [1-3]. There are many theories explaining this mechanism of landscape stability and self-cleaning, based on reversible negative links, stopping the chain impulse conduction reactions by biogeoceonosis species composition, microorganisms activity, hydrothermal factors [4-9] and the other indexes ensuring the landscape stability [9-11]. According to some scientists [12, 13], the highest self-cleaning ability is the mark to the landscape territorial complexes that are characterized by the high intensity of matter circulation, that strongly barrier or buffer the fluxes of pollutants or have dominance of dispersive fluxes. The territories that accumulate pollutants, have weak barriers and slow biogeochemical circulation are described by weak self-cleaning ability. These are the territories of low ecological stability, sensitive to anthropogenic activity.

ISBN 9984 – 779 – 06 – 8

The purpose of this work was to evaluate the ecological stability of Lithuanian territory by distinguishing the areas of different ecological polarization, based on the ratio of landscape technogeochemical pressure and sensitivity to chemical pollution.

Materials and methods

Ecological polarization in landscape systems was estimated in three stages: (1) evaluated the sensitivity of landscape systems to chemical impact, (2) determined the territorial distribution of technogeochemical pressure, and (3) based on the result of the first two stages the classes of ecological polarization in landscape systems distinguished and their distribution mapped. Bellow is shortly presented methodology of all the stages.

Geosystem sensitivity to chemical impact. Evaluation of landscape resistance, based on the concept of geosystemic links, is very complicated. Therefore, for the environmental purposes in order to standardize the use of natural resources, it is enough to evaluate the partial index, i.e., the sensitivity (vulnerability), that is understood as a short-term geosystem reaction to the outer impact, estimated by the possible relative speed of structure degradation.

The determination of landscape system sensitivity to chemical impact was performed on the grounds of the regularities of the heavy metals and organic pollutants migration [14], evaluating (in grades) the potential geosystems possibilities to neutralize or in a relatively short time to remove the toxic substances. Two different models were offered for evaluation of sensitivity to chemical impact:

1. Landscape system sensitivity to soil pollution. In the process of this evaluation the soil genetic type was taken as the main factor: the least sensitive are gleysols, the most sensitive – arenosols. The sensitivity of soil in respect of granulo-metric composition rises in range from rough sand to clay. According to relief influence, the least sensitive are geosystems that disperse the pollutants – elevations, the most sensitive – concentrating pollutants – hollows, etc. Besides that, factors of geochemical background, ground water depth, its mineralization, annual precipitation, and soil temperature were taken into account.
2. Landscape system sensitivity to the pollution of ground water. In regard to granulo-metric composition influence to the ground water pollution, the sensitivity grades rise in the range from clays to sands (the lighter is the soil the higher is the sensitivity to ground water pollution). The evaluation grades in regard to soil genetic type distribute in the same range as in the evaluation of sensitivity to the soil pollution (the most sensitive are the least geochemically active soils). In respect to the ground water depth, the higher is the level of water, the higher is the sensitivity grades. The other evaluation factors were the intensity of run-off, ground water mineralization.

Combination of the above mentioned evaluations gave the evaluation of integrated landscape system sensitivity to chemical impact. It was corrected additionally (±30%) by coefficients considering the impact of local factors (stabilizing factor – forests, destabilizing factors – long-term industrial air pollution) [14]. As a result, with respect to self-cleaning features of landscapes, 7 levels of geosystem sensitivity were distinguished and mapped in Lithuania territory.

Evaluation of technogeochemical pressure. Technogeochemical pressure in landscape is caused by emissions from industry and power production, agriculture, transport, pollution of domestic waste. In order to evaluate the ecological polarization in landscape systems, it is important to know the territorial distribution of the mentioned pollution sources. To determine directly the actual pollution of each industrial plant, agricultural field or settlement is impossible at this time due to the shortage or imprecision of the data. Statistical data given in reports only for administrative districts and large cities is of insufficient preciseness to analyse the territorial distribution of pollution. Therefore the method was offered allowing to qualitatively evaluate the potential pollution in landscape using the term of so called technogeochemical pressure. In order to evaluate the strength of technogeochemical pressure the earlier published [15] methods was adapted. The technogeochemical pressure was evaluated in grades considering the total pressure

ISBN 9984 – 779 – 06 – 8

being made by the mentioned pollution sources (industry and power supply, agriculture, transport, and domestic waste). Every pollution source was given (by expert analysis) the different maximum evaluation in grades, reflecting the relative weight of respective pollution source in technogeochemical pressure (to compare: the industry and power supply got maximum 40 grades evaluation range, agriculture – 30, transport – 20, domestic waste – 10).

Technogeochemical pressure from industry & power production and agriculture was evaluated according to their occupied part (in %) in the territory. Transport's technogeochemical pressure was evaluated according to the density of the main infrastructure elements (roads and railroads) also taking into account the type and category of these elements, because these determine the extent of pollution along the infrastructure lines. For evaluation of the technogeochemical pressure created by domestic waste the population density indirectly showed the extent of pollution. The main principle of evaluation was: the higher is the pollution source relative index (percentage, density), the higher meaning of technogeochemical pressure it was given in a respective territory. Finally the sum of all the pollution source evaluations made up the integrated technogeochemical pressure evaluation in the territory. The calculation of the mentioned relative dimensions was enabled by operations and analysis using various GIS data bases (©CORINE Land Cover Lithuania data base, European Commision, Phare Programme, 1998; Topographical information LTDBK50000-V ©State survey of land managing and geodesy, 1996; GDB200 ©GIS-CENTRAS, 1993-1999).

In order to do the analysis of the territorial distribution of technogeochemical pressure the specific system of territorial units – technotopes (relatively independent territorial units of landscape technogenic structure, characterized by specific techogenization type and landuse features) – was chosen. In the whole territory of Lithuania nearly 2000 technotopes were distinguished [16]. In the mentioned technotopes the relative measures of each pollution source were calculated, converted to grades and finally summed up. The technogeochemical pressure evaluation grades were classified into 5 levels from very low to very high technogeochemical pressure.

Distinguishing of ecological polarization classes. The above described information layers (sensitivity to chemical impact and technogeochemical pressure) were superposed using the GIS software and too many ($5 \times 7 = 35$) polarization classes were extracted. To simplify this complicated polarization assessment, the polarization classification matrix was created allowing to reduce the 35 polarization variants into 5 classes from very low to very high polarization (Table 1).

Results and discussion

The main three groups of results were obtained out the above methodology application. As mentioned, the landscape systems sensitivity to chemical impact of Lithuanian territory was determined. According to the landscape potential for self-cleaning 7 levels of geosystem sensitivity were distinguished and the map of their distribution in Lithuanian territory created (by M. Jankauskaitė). The largest area of extremely sensitive landscapes distinguished in Vilnius-Kaunas belt. Here, as in all the Eastern and South-eastern Lithuania the luvisols soils are dominating with a light mechanical composition, not having large buffer capacity. Long-term and very intensive atmospheric pollution in this zone have changed the background of soils with low geochemical activity. Much smaller areas of extremely sensitive geosystems are in the middle valley of the Venta river (light luvisols and the long-term impact of Mažeikiai oil-refinement plant). Extremely sensitive territories are also in Seashore zone and the region of Saugai-Priekulė (sand with the lowest geochemical activity and influence of Klaipėda city).

ISBN 9984 – 779 – 06 – 8

Table 1.

Distinguishing the classes of ecological polarization according to the combination of geosystem sensitivity (categories 1 to 7 see fig. 1 caption) and technogeochemical pressure degree (categories 1 to 5 see fig. 2 caption): i – very low, ii – low, iii – medium, iv – high, v – very high

Sensitivity of geosystems	*Technogeochemical pressure*				
	1	2	3	4	5
1	*i*	*i*	*i*	*i*	*ii*
2	*i*	*i*	*ii*	*ii*	*ii*
3	*i*	*ii*	*ii*	*iii*	*iii*
4	*i*	*ii*	*iii*	*iv*	*iv*
5	*ii*	*ii*	*iii*	*iv*	*v*
6	*ii*	*iii*	*iv*	*v*	*v*
7	*ii*	*iii*	*v*	*v*	*v*

The results show that territorially the largest part (two thirds of Lithuania territory) is taken by averagely sensitive (35%) and more than averagely sensitive (32%) geosystems. Not so common is the level of less than averagely sensitive (16%), little sensitive (8%) and very sensitive (6%) geosystems. Extremes (relatively insensitive and extremely sensitive geosystems) ocupy small part of Lithuanian territory (1% each) (Fig. 1).

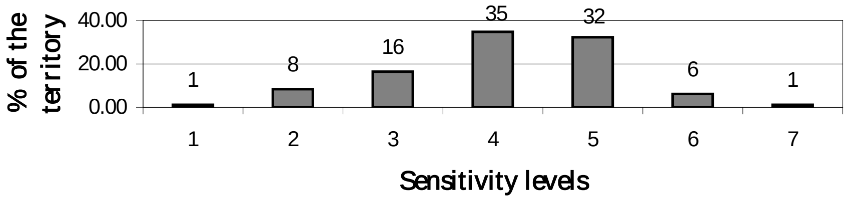


Fig. 1. **Percentage distribution of geosystems of different geochemical sensitivity in the territory of Lithuania: 1 – relatively insensitive, 2 – little sensitive, 3 – less than averagely sensitive, 4 – averagely sensitive, 5 – more than averagely sensitive, 6 – very sensitive, 7 – extremely sensitive**

In regard to technogeochemical pressure the highest grades belong to the technotopes with the largest part of industrial territories (technotopes comprising Vilnius, Kaunas, Klaipėda, and other large cities, some large industry and power plants). Such territories take up about 1% of Lithuanian area. High evaluation was given to agricultural technotopes (especially in Middle Lithuania plain), they are the most frequent (taking up 37% of the territory). The lowest grades were obtained for technotopes in relatively natural Southeast sandy plain and other woody territories (26% of the territory). Medium technogeochemical pressure values are applied to Žemaičių and Aukštaičių elevations, as they are averagely agriculturally cultivated (taking up 26%). Areas with low technogeochemical pressure occupy about 11% of Lithuanian territory (Fig. 2). These data show that Lithuanian landscape under the conditions of intensive exploitation experiences rather remarkable chemical load.

The third group of results reveals the distribution of the potential ecological polarization in landscape. The mapped distribution of 5 level ecological polarization areas shows a very spotty situation in this regard (Fig. 3). With growing landscape ecological polarization its stability diminishes due to the changes of the features upholding the landscape inter-systemic self-regulation potential and because of inability to keep the functioning equilibrium. Therefore the map of ecological polarization also shows the areas of unequal landscape stability.

ISBN 9984 – 779 – 06 – 8

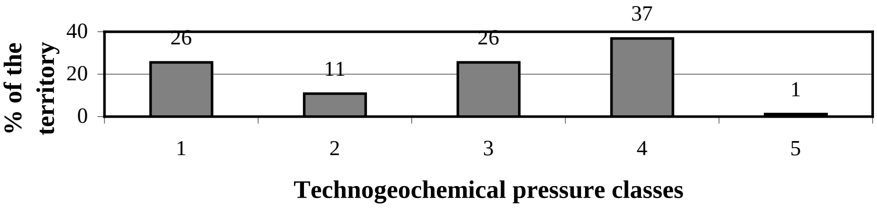


Fig. 2. **Percentage distribution of areas with different technogeochemical pressure in the territory of Lithuania: 1 – very low, 2 – low, 3 – medium, 4 – high, 5 – very high**

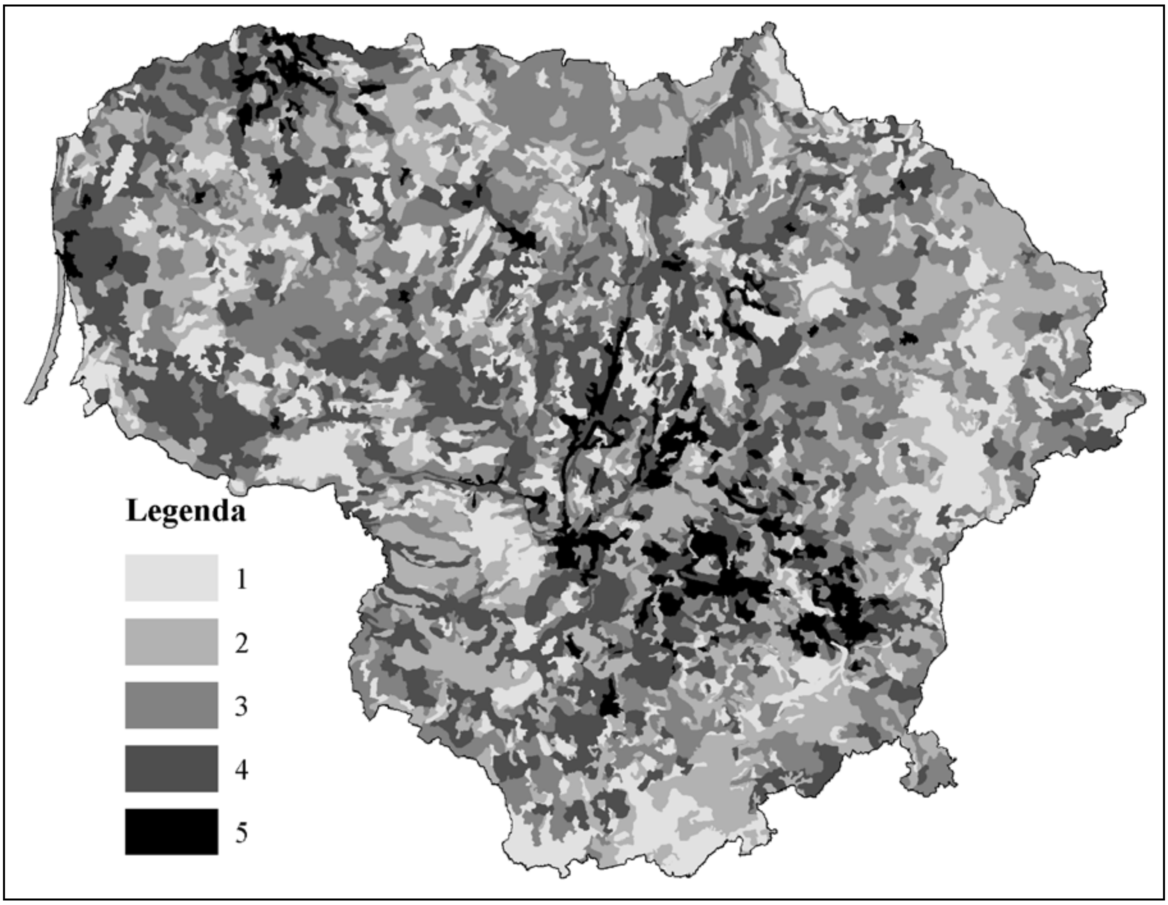


Fig. 3. **Distribution of ecological polarization in the Lithuanian landscape systems. Ecological tensions: 1 – very low, 2 – low, 3 – medium, 4 – high, 5 – very high**

The areas of the highest ecological polarization, though occupying 4% of Lithuanian territory, are more or less scattered across the whole country. The highest concentration of such a polarization spots is located in the triangle of Vilnius-Kaunas-Kėdainiai cities. This is the area of the most sensitive geosystems and highest, longest-lasting technogenization. The causes of such a situation are the proximity of the largest two cities (Vilnius and Kaunas), the arterial road connecting them, large industrial and power enterprises. In North-western Lithuania the area of very high ecological polarization, determined by extremely sensitive geosystems experiencing high technogeochemical pressure, covers the city of Mažeikiai and its surroundings (some parts of the Venta valley, oil refinement plant and railroad territories).

ISBN 9984 – 779 – 06 – 8

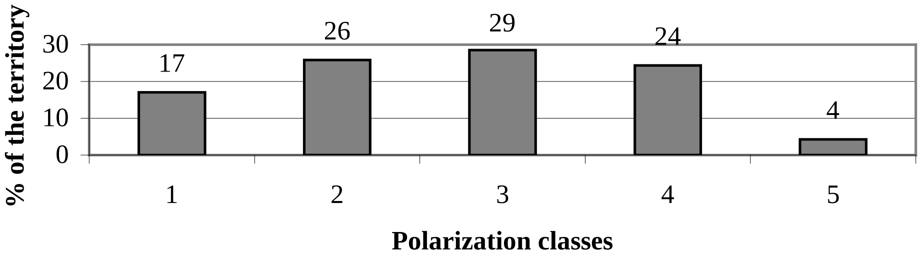
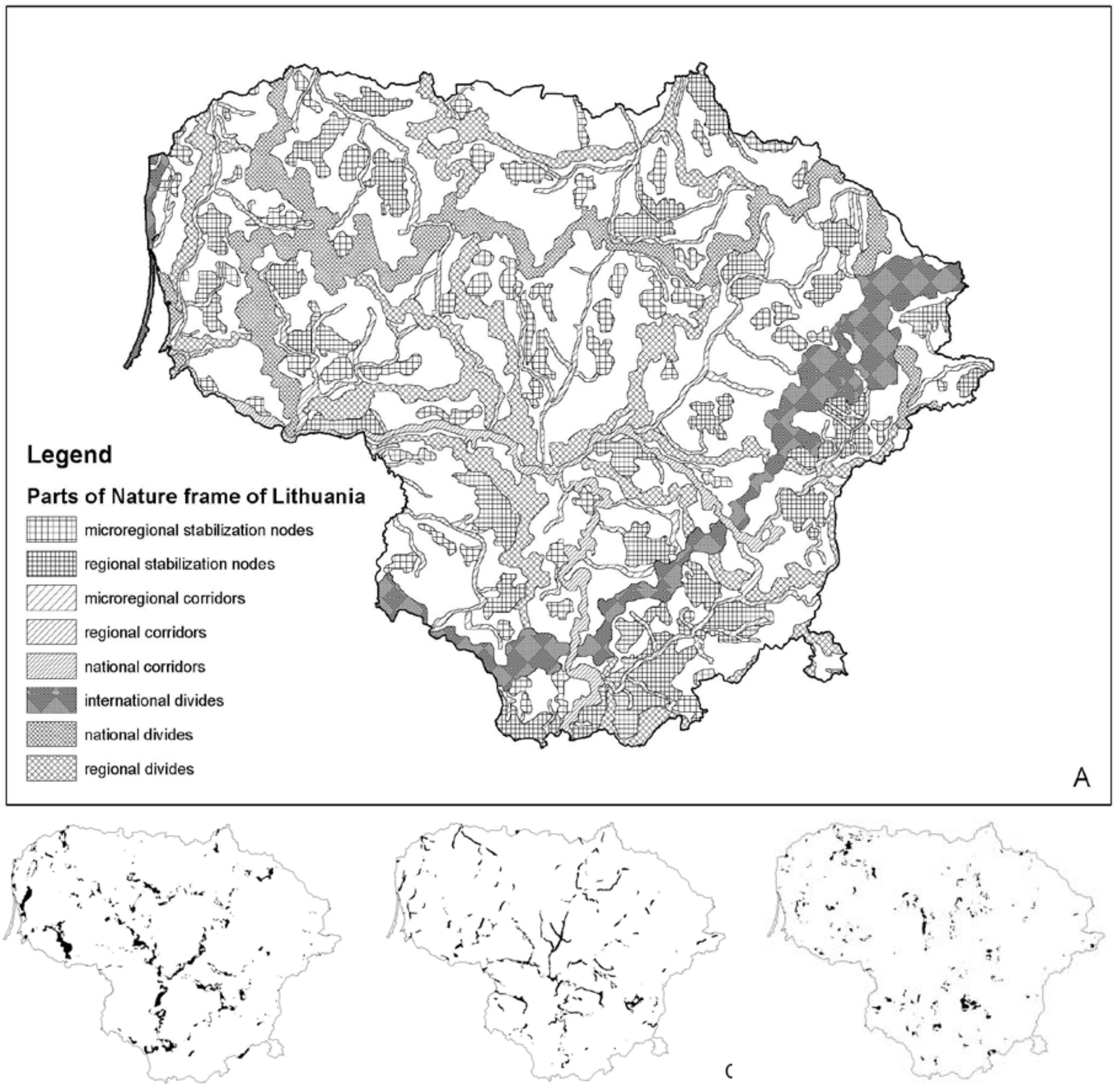


Fig. 4. **Percental distribution of ecological polarization classes in the Lithuanian territory. Class names see in Fig. 3 caption**



B C D

Fig. 5. **Nature frame of Lithuania (A) [17] and its parts that fall into the areas of high and very high polarization: B – geoecological divides, C – geoecological corridors, D – nodes of geoecological stabilization.**

Besides the mentioned large areas, there are several smaller spots with very high ecological polarization worthy to mention: Klaipėda sea port, established on very sensitive seashore geosystems, Radviliškis town with railroad node and Panevėžys city creating very high technogeochemical pressure for sensitive geosystems, etc. Percentage of polarization classes distribution in Lithuanian territory is given in Fig. 4. Each of low, medium and high polarization

ISBN 9984 – 779 – 06 – 8

classes occupy about one fourth of Lithuanian territory. Areas with very high polarization take up 4%, very low – 17% of Lithuanian territory.

Discussion may rise regarding the practical application of the research carried out. To prove the applicability of the results, the overlay operation was performed with the polarization map and Nature Frame scheme (included into the National Plan of Lithuania [17]). The Nature Frame of Lithuania (already acknowledged legally) distinguished according to the general geoecological principles, consists of geoecological divides (functioning as entering windows of circulating matter), migration corridors, and nodes of geoecological stabilization [18], most of them ranged from microregional to international level (Fig. 5, A). The Nature Frame covers about 51% of Lithuanian territory (divides occupy 24%, corridors – 10%, stabilization nodes - 17%). The overlay operation with ecological polarization map revealed that some of these territories fall into the areas of high and very high polarization (Fig. 5, B-D). Such territories (taking up 10% of Lithuanian area and about 20% of Nature Frame) become the priority tasks for territorial planning and landscape optimisation.

Knowledge of the ecological polarization areas allows the rendering of recommendations to economy units for their economical activity organization that should be developed considering the means of landscape ecological stability maintenance like increase of forest percentage, formation of geochemical barriers, proper distribution of land use. Besides that, the research results obtained can be interpreted in many other ways (like entropy, ecological planning, etc.) therefore they can be applied for the further analysis of landscape systems in Lithuanian territory.

Conclusions

1. In order to optimise the landscape destabilized by the contemporary intensive landuse, it is important to evaluate the sensitivity of landscape systems, their technogeochemical load, and by the ratio of the both to distinguish the problematical areas of potential ecological polarization. These areas should be associated with the primary installation of environment protection means. By application of methods evaluating the geosystems sensitivity and technogeochemical pressure, using the cartographic, statistical and field research data as well as GIS technologies, some important results were obtained: the cartographic models of landscape systems sensitivity to chemical impact and technogeochemical pressure in landscape technotopes; and finally, the overlay of the last mentioned two cartographic models enabled creating the landscape ecological polarization map of Lithuania.
2. The territory of Lithuania in regard to geosystem sensitivity to chemical impact is rather contrasting, having the dominance of averagely and more than averagely sensitive geosystems. Relativly insensitive and extremely sensitive geosystems cover a little part of Lithuania (each for about 1%). The most sensitive are the Baltic highlands, especially in the belt of Vilnius-Kaunas, characterized by intensive and long-term pollution, weakenning the natural landscape self-cleaning features. Besides that, the rather large area of very sensitive geosystems is located in North-western part of Lithuania (around Mažeikiai city).
3. Due to the broad agricultural areas in Lithuania the largest part of the country is occupied by the technotopes with high technogeochemical pressure sharing its part with less frequent technotopes experiencing low and medium technogeochemical pressure. Areas of very high technogeochemical pressure mostly are related with intensive industrial and residential built up and cover only about 1% of the territory.
4. Various combinations of geochemical sensitivity and technogeochemical pressure allowed to distinguish large variety of ecological polarization types, that were classified into 5 main classes and mapped. The cartographic view shows a relatively high polarization of Lithuanian landscape. The highest polarization is characteristic to the triangle area of cities Vilnius-Kaunas-Kėdainiai and the region of Mažeikiai city. The areas of the lowest ecological polarization, i.e. the areas of the most stable landscape, are determined in the

ISBN 9984 – 779 – 06 – 8

largest forested territories (South, East, South-western Lithuania). Areas of very high ecological polarization occupy about 4% of Lithuanian territory.

5. The example of the applications of presented results can be the overlay of the polarization and Lithuanian Nature Frame maps. It was estimated that about 20% of the Nature Frame territories fall into the areas of high and very high ecological polarization. These territories should become the priority tasks of territorial planning and landscape optimisation. Besides that, the research results obtained can be interpreted in many other ways (like entropy, ecological planning, etc.) therefore they can be applied for the further analysis of landscape systems in Lithuanian territory.

References

1. Звонкова Т. В. Географическое обоснование экологических экспертиз. - Москва: Издательство Московского университета, 1985. - 208 с.
2. Устойчивость геосистем. - Москва: Наука, 1983. - 88 с.
3. Ландшафты. Нагрузки. Нормы. - Москва: Наука, 1990. - 156 с.
4. Арманд Д. Л. Наука о ландшафте. - Москва: Мысль, 1975. - 287 с.
5. Арманд А. Д. Самоорганизация и саморегулирование географических систем. - Москва: Наука, 1988. - 259 с.
6. Демек Я. Теория систем и изучение ландшафта. - Москва: Прогресс, 1977. - 223 с.
7. Сочава В. Б. Введение в учение о геосистемах. - Новосибирск: Наука, 1978. - 319 с.
8. Naveh Z., Liebermann A. S. Landscape ecology. Theory and Application. - New York: Springer- Verl., 1990. - 356 p.
9. Ланге О. Целое и развитие в свете кибернэтики // Исследования по общей теории систем. - Москва: Наука, 1969. - с. 181-251.
10. Pauliukevičius G., Grabauskienė I. Methods forecasting the resistance of geosystems to human impact // Structural, dynamical and functional properties of the Lithuanian landscape. - Vilnius: Mokslas, 1993. - p. 149-171.
11. Pauliukevičius G., Kenstavičius J. Ekologiniai miškų teritorinio išdėstymo pagrindai. - Vilnius: Geografijos institutas, Vilniaus universitetas, 1995. - 179 p.
12. Глазовская М. А. Геохимия природных и техногенных ландшафтов СССР. - Москва: Высшая школа, 1988. - 327 с.
13. Экогеохимия городских дандшафтов. - Москва: Наука, 1995. - 330 с.
14. Jankauskaitė M. Geosistemų jautrumo cheminiam poveikiui nustatymas // Geografija - 1993, t. 29, p. 78-84.
15. Jankauskaitė M. Kraštovaizdžio cheminės apkrovos šaltiniai ir vertinimo problemos // Geografijos metraštis - 1998, t. 31, p. 284-293.
16. Veteikis D. Technogeninė kraštovaizdžio morfostruktūra (Lietuvos teritorijos pavyzdžiu). // Daktaro disertacijos santrauka - Vilnius: Vilniaus universitetas, 2003. - 32 p.
17. National Plan of Lithuania, 2003. Vilnius.
18. Kavaliauskas P. Methodological fundamentals of land management – Vilnius: Academia, 1992. – 148 p.

ISBN 9984 – 779 – 06 – 8

PILSĒTVIDES AINAVAS KVALITĀTE UN TO IETEKMĒJOŠIE FAKTORI LATGALĒ

URBAN LANDSCAPE QUALITY AND FACTORS THAT HAVE INFLUENCE ON LANDSCAPE QUALITY IN LATGALE REGION

IVARS MATISOVS

Rēzeknes Augstskola, Inženieru fakultāte, Atbrīvošanas aleja 76,
Rēzekne, LV-4600, Latvija
Tālr.: + 371 4625145, *e-pasts*: ivars@dau.lv

Abstract. *The paper deals with urban landscape individualities in the cities and towns of Latgale region. Also show facilities and methods of integrated assessment of urban landscape quality. Article provides information about specifics of urban landscape and factors, that have influence on landscape quality. The paper presents the results of Daugavpils and Rēzekne urban landscape quality complex assessment, that have been realised in 2003-2005. This results don't establish significant disparities between quality of urban landscape among Daugavpils and Rēzekne. This method of urban landscape assessment makes possible to get believeable and precise information about landscapes quality.*

Keywords: *landscape, urban landscape, factors of landscape quality, assessment of landscape quality.*

Ievads

Ainava ir formāla izpausme attiecībām, kas eksistē dotajā laika periodā starp indivīdu vai sabiedrību un topogrāfiski noteiktu teritoriju, kas laika gaitā radusies dabas un cilvēka faktora vai abu darbības kombinācijas rezultātā [1]. Ainava tiek uzskatīta par ekonomiskai attīstībai labvēlīgu resursu un par dzīves vides kvalitātes rādītāju. Ainava ir visur- gan pilsētās un laukos, degradētās vai koptās teritorijās, sevišķi skaistās vai ikdienišķās vietās. Cilvēka darbība var veicināt nelabvēlīgas pārmaiņas ainavās un tas uzliek indivīdiem un sabiedrībai īpašas tiesības un pienākumus saglabāt un mērķtiecīgi plānot ainavas. [2]

Pilsēta ir mūsdienu ainavas neatņemama sastāvdaļa, kura atrodas sarežģītās telpiskās un funkcionālās attiecībās ar apkārtnē esošajiem objektiem un procesiem. Pilsētvidei raksturīgs blīvs vēstures uzslāņojums un īpatnēja vietas atmosfēra, investīciju viļņiem izpaužoties kā savdabīgiem pilsētvides ģeoloģiskajiem nogulumiem.

Pilsētvides ainavas kvalitāte ir viens no svarīgākajiem pilsētu kā mākslīgu ekosistēmu raksturojošajiem vides parametriem. Tas ir komplekss rādītājs, jo sevī integrē gan pilsētas dabiskās pamatnes (reljefs, ūdeņi, klimats, veģetācija), gan antropogēnas izcelsmes (ielu tīkls, ēkas un citi artefakti) elementus. Tādējādi pilsētvides ainavas kvalitātes novērtējumā jāņem vērā visplašāko ainavu raksturojošo parametru un uztveres aspektu kopumu. Pie tam nebūt netiek noliegts ainavas novērtējuma subjektīvais faktors, jo "ģeogrāfija nav tikai precīza zinātne ar universāliem likumiem, bet arī vietu individuālo tēlu atrašanas, apraksta un interpretācijas māksla" [3].

Pilsētas attīstību nosaka vesels komplekss visdaudzveidīgāko dabas faktoru, starp kuriem par nozīmīgākajiem uzskatāmi ģeogrāfiskais stāvoklis, hidroģeoloģiskie apstākļi, klimats, reljefa īpatnības un veģetācija [4]. Tādējādi pilsētas ainavas analīzē vienmēr jāņem vērā pilsētas ārējā vide jeb dabiskais fons, kas ļauj objektīvi novērtēt pilsētas ekosistēmā un līdz ar to arī ainaviskajā telpā notiekošās izmaiņas.

Pilsētvides ainavas veidošanās un transformācijas process ir nepārtraukts telpā un laikā, līdz ar to likumsakarīgi mainās arī ainavas estētiskā un ekoloģiskā kvalitāte. Īpaši strauji tas notiek pilsētu ekonomiskā uzplaukuma vai arī dažādu nelabvēlīgu faktoru izraisītā pilsētu panīkuma periodos, kad būtiski mainās pilsētu ekonomiskais potenciāls un sociāli demogrāfiskā situācija. Šajos laika periodos notiek ievērojamas izmaiņas arī pilsētu vizuālajā veidolā, kas ir ainaviskās telpas dominējošais elements.

ISBN 9984 – 779 – 06 – 8

Strukturālas pārmaiņas tautsaimniecībā un pieaugošā iedzīvotāju mobilitāte ir izmainījušas pilsētu attīstības perspektīvas. Uz jaunām zināšanām balstītās aktivitātes ir koncentrētas dažos lielos pilsētu centros, bet lieli reģioni, to vidū arī Latgale, ar mazāk konkurētspējīgiem pilsētu centriem atpaliek savā attīstībā. Šajos apvidos ir nepieciešams nostiprināt pilsētu funkcijas, lai aizkavētu migrāciju starp reģioniem, jo tā vēl vairāk samazinātu šo teritoriju funkcionalitāti un apgrūtinātu pakalpojumu sniegšanu pienācīgā līmenī [5]. Viens no dzīves vides kvalitātes būtiskākajiem komponentiem ir pievilcīga ainava, kas lielā mērā ietekmē dzīves vietas izvēli.
Pēc kardinālo politiski sociālo izmaiņu izsauktās ekonomiskās krīzes, kas mūsu valstī bija vērojama 20.gadsimtu noslēdzošajā desmitgadē, pēdējos gados arī Latgales pilsētās vērojama lēna, bet noturīga ekonomiskā augšupeja. Līdz ar to atsācies pilsētvides ainavas transformācijas process, kas, domājams, sevišķi pastiprināsies līdz ar Latvijas pievienošanos Eiropas Savienībai un globalizācijas tendenču straujāku ienākšanu mūsu dzīves telpā.
Līdz šim Latvijas ainavu pētnieku uzmanība galvenokārt bijusi pievērsta lauku vides ainavas izpētei un raksturojumam. Toties pilsētvides ainavas komplekss novērtējums, vismaz Latgales reģionā, līdz šim nav veikts, tāpēc likumsakarīgi izvirzās jautājums par pilsētvides ainavas kvalitātes novērtējuma nepieciešamību. 2003.- 2005.gadā tika veikts pirmais mēģinājums kompleksi novērtēt Latgales pilsētvides ainavas kvalitāti, kā izmēģinājumu poligonu izmantojot novada lielpilsētas Rēzekni un Daugavpili.
Līdzšinējā ainavu zinātnes un ainavu plānošanas praksē vismazāk tikusi apzināta un vērā ņemta ainavas uztvere tajā dzīvojošo cilvēku apziņā- īpaši vietas pārzināšana, izpratne, izjūta, iztēle un vērtējums [6], bet tieši cilvēkiem, kuri ilgstoši dzīvo pilsētvidē un kuru uztvere speciāli orientēta uz pilsētas emocionāli estētisko apguvi, piemīt maksimāli plaša apkārtējās ainavas uztveres kapacitāte [7].
Arvien biežāk ainavu faktors un ainavu telpa nonāk sabiedrības un indivīda, kā arī attīstības plānotāju interešu sfērā. Tādējādi ainava kļūst par valsts politikas objektu. Attīstības plānošanā ainava iegūst īpašu nozīmi kā savdabīgs vietu un reģionu attīstības resurss un priekšnosacījums, jo katrai ainavai piemīt īpatnējas iespējas, ko nosaka dabas apstākļi un procesi, līdzšinējā izmantošana, saimnieciskās darbības radītās slodzes un to ietekmes. Nevajadzētu arī aizmirst, ka ainava kalpo par pamatu cilvēku identitātes saglabāšanai un veidošanai [8].
Jāatzīmē, ka ainavas estētiskais novērtējums ir daudz plašāks nekā vizuālais novērtējums, jo tas bez ainavas vizuālās uztveres aspektiem ietver arī citas izjūtas. Iekšējā ainavā papildus vizuālajam aspektam jāizmanto novērotāja citas sajūtas: smarža, skaņa, drošības sajūta [9]. Ainavas estētisko novērtējumu ietekmē arī paša novērotāja etniskā piederība, izglītības līmenis, profesija, sociālais stāvoklis, vecums un citas individuālās īpatnības [10]. Tiek uzskatīts, ka novērtējot ainavas estētisko kvalitāti, noteikti jāņem vērā tās ciešā saikne ar apvidus ekoloģiskajām īpatnībām. Tādējādi, ainavas estētiku iespējams pētīt tikai ar kompleksu ekoloģiski estētisko pieeju [11].
Ainavas novērtēšana - vērtības piešķiršana atsevišķai ainavai, tās tipam vai elementam atkarībā no specifiskiem kritērijiem [1]. Tie var būt ainavas vizuāli estētiskā kvalitāte, kultūrvēsturiskā nozīmība, ainavas kā ekosistēmas kvalitāte iedzīvotāju veselīga un droša dzīvesveida nodrošināšanai. Pasaulē tiek pielietotas daudzveidīgas ainavas kvalitātes novērtēšanas metodes, pie tam pielietojamie normatīvi ir visai atšķirīgi, ko ietekmē gan ģeogrāfiskās vides īpatnības, gan pētījuma mērķis. Tādējādi ainavas kvalitātes pētījumu metodes ir lielākā vai mazākā mērā lokalizētas un ir pielietojamas tikai noteiktu ainavapvalka tipu izpētei.
Pilsētvides ainavas uzdevums ir gan optimāli atbilst tai izvirzītajām sociāli ekonomiskajām un ekoloģiskajām funkcijām, gan arī būt apveltītai ar estētiskajām kvalitātēm. Jāpiebilst, ka ainavu estētiskais novērtējums ir tikpat sarežģīts jautājums kā ainavu klasifikācija.

Materiāli un metodes

Latgales pilsētvides ainavas izpētē priekšroka tika dota vizuāli estētiskajai pieejai, galveno uzmanību veltot ainavas vizuālajam veidolam, viegli saskatāmām un novērtējamām pazīmēm. Šī ir saistoša un viegli izprotama pieeja, tomēr tajā ir spēcīgs subjektīvisma faktors. Tomēr,

ISBN 9984 – 779 – 06 – 8

iesaistot ainavas novērtēšanas procesā ievērojamu skaitu dalībnieku un veicot ainavas novērtēšanu daudzos subjektīvi izvēlētos skatpunktos, pie tam ainavu vērtējot atšķirīgos gadalaikos un meteoroloģiskajos apstākļos, var pieņemt, ka ir iegūti pietiekami objektīvi ainavas kvalitātes vērtējumi dažādos pilsētas rajonos un visā pilsētā kopumā.
Ainavas kvalitātes novērtēšanai Latgales novada pilsētās tika izmantota raksta autora modificēta subjektīvā ainavas uztveres kontroljautājumu anketa (skat. 1.tab.), kuru paredzēts izmantot skatu punktos, novērtējot attiecīgo vizuālo ainavu un atzīmējot ar to saistītās asociācijas. No skatu punkta tika vērtēta ainavas elementu optimālā daudzveidība un harmonija gan no kvantitatīvā, gan no kvalitatīvā viedokļa. Praktiski netika izmantots panorāmas ainavas vērojums no kāda augsti pacelta, īpaša skatpunkta, bet gan uztverta tā saucamā pilsētas iekšējā ainava, kurā iesaistīts pats vērotājs.

1.tabula

Ainavas kvalitātes kompleksa novērtējuma tabula
[1, ar autora modifikācijām un papildinājumiem]

Ainavas parametrs	Novērtējums (punkti)			
	1	2	3	4
Mērogs	Tuvs	Mazs	Liels	Plašs
Daudzveidība	Vienveidīga	Vienkārša	Dažāda	Kompleksa
Harmonija	Haotiska	Nesaskanīga	Balansēta	Harmoniska
Kustība	Trakojoša	Neesoša	Dzīva	Mierīga
Krāsa	Vienkrāsaina	Neizteikta	Spilgta	Krāsaina
Smarža	Nepatīkama	Uzmācoša	Neitrāla	Patīkama
Skaņa	Uzbāzīga	Traucējoša	Klusa	Patīkama
Iespaids	Nomācošs	Nepievilcīgs	Pievilcīgs	Skaists
Izjūtas	Draudošas	Nedrošas	Drošas	Patīkamas
Izteiksmīgums	Garlaicīgs	Neuzkrītošs	Interesants	Aizraujošs
Unikalitāte	Parasta	Neparasta	Reta	Unikāla

Ainavas kvalitāte tika novērtēta pēc 11 parametriem (skat. 1.tab.). Katrs no tiem tika vērtēts pēc 4 ballu skalas, tādējādi ainavas kvalitātes vērtējums teorētiski varēja atrasties 11- 44 punktu intervālā. Iegūtie rezultāti atradās robežās no 15 līdz 41 punktam. Statistiski apstrādājot iegūtos datus, radās iespēja izdalīt 5 ainavas kvalitātes pakāpes: ļoti augsta (36-41), augsta (31-35), vidēja (26-30), zema (21-25) un ļoti zema (15-20).
Ainavas kvalitātes vērtējums katrā skatpunktā tika noteikts, saskaitot iegūtos punktus. Savukārt pilsētas rajona ainavas kvalitātes vidējo vērtējumu iegūst, katra skatpunkta punktu summu izdalot ar skatpunktu skaitu. Papildus tika veikts arī pilsētvides kvalitātes subjektīvs ekoloģiskais novērtējums pēc 5 ballu skalas gan katrā skatpunktā atsevišķi, gan pilsētas rajonā kopumā. Tika ņemta vērā vides sakoptība, piesārņojuma pakāpe ar sadzīves vai rūpnieciskajiem atkritumiem, gaisa un ūdens kvalitāte. Ekoloģiskās kvalitātes novērtējuma pakāpes: izcila, laba, vidēja, slikta, katastrofāla.
Ainavas novērtēšanas gaitā tika izmantoti izdevniecības "Jāņa sēta" Daugavpils pilsētas plāns (mērogs 1 : 25 000) un Rēzeknes pilsētas plāns (mērogs 1 : 15 000). Lai raksturotu Latgales pilsētu ainavas kvalitāti un to ietekmējošos faktorus, tika izmantots plašs pilsētvides dažādus aspektus raksturojošs statistisko datu klāsts, kas pārsvarā balstās uz LR Centrālās statistikas pārvaldes apkopoto informāciju.
Ainavas kvalitātes novērtējuma procesā tika iesaistīti Daugavpils Universitātes un Rēzeknes Augstskolas studenti, kuri 3 gadu laikā dažādos gadalaikos veica abu Latgales novada lielpilsētu pilsētvides ainavas kvalitātes kompleksu novērtējumu. Novērtējumu atsevišķos pilsētas rajonos kopīgi veica 2 - 3 cilvēku lielas grupas, uz vietas saskaņojot individuālos subjektīvos viedokļus. Iesaistot studentus - topošos vides speciālistus - pilsētas ainavas kvalitātes novērtēšanas procesā, vienlaikus tiek sasniegti vairāki mērķi:

ISBN 9984 – 779 – 06 – 8

1) iegūts liels informācijas apjoms par pilsētvides ainavas kvalitāti un tās teritoriālo diferenciāciju;
2) ainavas novērtējumā iesaistīti paši pilsētnieki, tiem piedāvājot iespēju attīstīt sapratni par ainavas kvalitātes jautājumiem un iedziļināties atbilstošajā problemātikā. Tas perspektīvā varētu sekmēt arī pilsētvides ainavas kvalitātes uzlabošanos.

Pilsētvides ainava tika fiksētas fotoattēlos. Tādējādi, veicot atkārtotu ainavu inventarizāciju, radīsies iespēja izsekot ainavu dinamikas procesam. Tas ir sevišķi aktuāli mūsdienās, jo līdz ar ekonomisko attīstību atsākusies strauja tradicionālās pilsētvides ainavas transformācija. Tas sevišķi attiecināms uz lielpilsētām, kas ir īpaši labvēlīga vide investīciju piesaistei.

Rezultāti un to izvērtējums

Latgales kultūrvēsturiskajā novadā atrodas 13 pilsētas, kas ievērojami atšķiras pēc to ģeogrāfiskā stāvokļa un dabas vides apstākļiem, aizņemtās teritorijas un telpiskās struktūras, vēsturiskās attīstības gaitas, iedzīvotāju etniskā un konfesionālā sastāva, demoģeogrāfiskajiem un sociāli ekonomiskajiem rādītājiem un attīstības tendencēm. Tādējādi būtiski atšķiras arī pilsētu ainaviskais veidols, kā arī ainavas estētiskā un ekoloģiskā kvalitāte.

No dabas faktoriem par spēcīgāko uzskatāmas pilsētas teritorijas un tās apkaimes ģeomorfoloģiskās un hidrogrāfiskās īpatnības. Arī vēsturiski pilsētas radušās un izaugušas cilvēku dzīvei un darbībai vislabvēlīgākajās vietās. Tās var būt saistītas gan ar izdevīgo fiziski ģeogrāfisko stāvokli, piemēram, Daugavpilij, Krāslavai un Līvāniem attīstoties tiešā nozīmīgā Daugavas ūdensceļa tuvumā, gan ar transporta tīkla veidošanos, pilsētām attīstoties svarīgu tranzīta ceļu krustpunktos, piemēram, Daugavpils, Rēzeknes un Ludzas gadījumā. Dzelzceļa līniju izbūve ir bijusi vitāli svarīga Kārsavas, Zilupes un Viļānu attīstībā, toties Preiļi, Dagda, Balvi, Viļaka un Varakļāni izauguši kā vietējas nozīmes tirdzniecības un amatniecības centri blīvi apdzīvotos lauku areālos. Latgales pilsētu ainava veidojusies ilgstošā vēstures procesā, pakāpeniski uzkrājoties pārmaiņām ainavu telpā. Šī procesa līdzsvarotību izjauc krasas politisko, ekonomisko un sociālo apstākļu pārmaiņas. Jāpiebilst, ka 20.gadsimta sākumā Latgalē bija tikai 3 pilsētas- Daugavpils, Rēzekne un Ludza. Pēc Latvijas neatkarības pasludināšanas pilsētas tiesības tika piešķirtas vairākiem Latgales miestiem [12]. Būtiskas izmaiņas Latgales pilsētu iedzīvotāju etniskajā sastāvā un arī ainaviskajā veidolā atstāja Otrais pasaules karš.

2.tabula

Latgales pilsētu ainavas kvalitāti ietekmējošie dabas un antropogēnie faktori

Pilsēta	Paugurains reljefs	Daugava	Vidēji liela upe	Ezers	Pils, parks, pilsdrupas, cietoksnis	Dzelzceļš	Ievērojama industriālā apbūve
Daugavpils		X		X	X	X	X
Rēzekne	X		X	X	X	X	X
Ludza	X			X	X	X	X
Krāslava	X	X		X	X		
Līvāni		X	X	X		X	X
Balvi				X	X		
Preiļi					X		X
Viļāni			X			X	
Varakļāni					X		
Kārsava						X	
Zilupe			X			X	
Viļaka				X	X		
Dagda	X			X			

Šodienas ainavu raksturu lielā mērā nosaka tie apstākļi, kas pastāvēja padomju varas gados un noteica cilvēka darbības ietekmju veidus. Padomju gados ievērojami augušas Latgales pilsētas- gan iedzīvotāju skaita ziņā, gan teritoriāli. Ap lielākajām pilsētām izveidojušās ietekmes zonas, kurās notiek izteikta lauku vides urbanizācija.

ISBN 9984 – 779 – 06 – 8

Latgales pilsētās vēl joprojām pastāv no padomju laika mantotās un tā laika ietekmētās sociālās situācijas. Kaut arī sabiedrība ir sociāli diferencēta un kļūst arvien diferencētāka, tomēr ģeogrāfiskajā telpā tā vēl ir maz organizēta. Tomēr pēdējos gados sociālo situāciju maiņa sāk ietekmēt arī pilsētu fizisko struktūru un ainavisko telpu, īpaši lielākajās pilsētās. Mazpilsētās, kur sociālo grupu dažādība ir daudz ierobežotāka un sabiedrība nav tik elastīga, šis process ir mazāk vērojams [13].

Pēdējo 15 gadu laikā būtiski nav mainījies dažāda tipa un stāvainības māju īpatsvars Latgales pilsētu ainavas telpiskajā veidolā. Latgales pilsētu ainavas telpiskajā veidolā dominē individuālās mājas, kuru īpatsvars svārstās robežās no 49 % Kārsavā līdz 85 % Līvānos, pie tam abās novada lielpilsētās Daugavpilī un Rēzeknē individuālo ēku īpatsvars ir identisks - 78 %. Tās pārsvarā ir vienstāva, retāk divstāvu ēkas. Savukārt 5 un vairāk stāvu māju īpatsvars Latgales pilsētas ir neliels - tikai Daugavpilī un Rēzeknē tas sasniedz 6 %, pārejos rajonu centros atrodas robežās no 1,4 līdz 4,7 %, bet mazpilsētās nepārsniedz 1 % [14].

3.tabula

Latgales pilsētu teritoriālā struktūra (procentos) un ielu tīkls [15]

Pilsēta	Apbūvētās zemes	Zaļā zona un meži	Lauk-saimn. zemes	Ūdeņi	Citas zemes	Ielu tīkla blīvums (km/km^2)
Balvi	61,5	12,2	23,5	2,0	0,8	6,0
Viļaka	31,2	5,8	37,7	25,3	-	3,0
Ludza	50,7	23,0	11,5	10,6	4,2	5,8
Kārsava	49,9	6,8	34,0	0,8	8,5	5,7
Zilupe	19,1	42,1	28,6	0,7	9,5	5,4
Krāslava	52,2	21,0	21,8	5,0	-	5,8
Dagda	43,1	9,9	44,8	2,2	-	7,7
Preiļi	38,2	14,1	17,4	0,4	29,9	5,6
Līvāni	58,1	33,5	5,0	0,7	2,7	6,0
Viļāni	67,4	18,7	12,4	1,5	-	7,9
Varakļāni	50,7	9,8	39,3	0,2	-	4,9

Kā jebkuras vietas, arī pilsētas tēla ideja ir plašāka par tradicionālo dabas morfoloģisko ainavas traktējumu, jo tajā būtiska loma ir arī kultūrvēsturiskajam un vizuāli estētiskajam aspektiem, starp kuriem minami vēstures uzslāņojums, vietas "atmosfēra", konfesionāli etniskā savdabība. Etnosociālās vides ietekme sevišķi spilgti izpaužas Latgales pilsētu individuālās apbūves rajonos, vizuāli iezīmējot pilsētnieku estētiskos priekšstatus un tradīcijas, kas izpaužas ēku arhitektūrā un krāsojumā, būvkonstrukciju materiālu pielietojuma īpatnībās, pagalmu un tuvākās apkārtnes sakoptībā.

Vēl joprojām pilsētvides ainavu degradējošs elements ir tā arī līdz galam neuzbūvēto un ekspluatācijā nenodoto daudzstāvu dzīvojamo namu silueti. Arī ekspluatējamās ēkas pašas par sevi ir nolietojušās, tām ir nepieciešama rekonstrukcija, bet iedzīvotāju līdzekļi to neatļauj. Tāpēc daudzdzīvokļu namu renovācijas darbi Latgales pilsētās praktiski vēl nav sākušies, toties pēdējos gados daudzviet ir uzsākta salīdzinoši aktīva individuālo privāto ēku renovācija, kas bieži vien ir saistīta ar namu īpašnieku nomaiņu. Pie tam katrs īpašnieks celtniecības, pārbūves vai apdares darbus veic pēc savas gaumes, saprašanas un materiālajām iespējām. Parasti tas noved pie pilsētvides ainaviskās savdabības zaudēšanas, diemžēl, dažkārt arī pie ainavas degradācijas. Savukārt piepilsētu izplešanās tendence rada aizvien pieaugošu spiedienu uz vērtīgām ainavām.

Ainavas kvalitāte līdz 2005.gada pavasarim tikusi novērtēta 315 skatpunktos Rēzeknē un 86 skatpunktos Daugavpilī. Ainavas kvalitātes novērtēšana ir uzsākta arī Krāslavā un Preiļos. Rēzeknē visaugstāko novērtējumu guvusi ainava pilsētas Dienvidu rajonā (skat. 4.tab.), kam

ISBN 9984 – 779 – 06 – 8

raksturīgs paugurains reljefs ar daudziem veiksmīgiem skatpunktiem, kas paver iespēju iegūt panorāmisku pilsētvides ainavu, tādējādi būtiski paaugstinot ainavas vizuāli estētiskā novērtējuma līmeni.
Viszemāk tikusi novērtēta ainava pilsētas Ziemeļu rajonā, kam raksturīga padomju laika industriālā apbūve un liels daudzdzīvokļu dzīvojamo namu masīvs. Ziemeļu rajons atrodas atstatu no pilsētas centra un ainaviski veido bezpersonisku padomju laika standartarhitektūras paraugu, kam ar pilsētas tradicionālo veidolu nav nekāda sakara. Diemžēl zemu ainavas kvalitātes novērtējumu guvusi arī Kovšu ezera apkārtne, kas potenciāli varētu būt nozīmīga rekreācijas zona. Tāpat nesakopti un ainaviski nepievilcīgi ir Rēzeknes upes krasti.

4.tabula

Rēzeknes pilsētvides ainavas kvalitātes novērtējums 2003. - 2005.gadā

Pilsētas rajons	Novērtējuma punktu skaits	Vidējā ainavas kvalitāte (punkti)	Subjektīvais vides kvalitātes vērtējums (balles)
Pilsētas centrālā daļa	89	27,8	3,0
Dienvidu rajons	65	30,3	3,6
Vipinga	34	29,7	3,4
Jupatovka	36	27,8	3,0
Ziemeļu rajona dzīvojamā zona	31	26,4	3,1
Ziemeļu rajona rūpnieciskā zona	29	25,0	2,6
Makarovka	15	28,0	3,4
Kovšu ezera apkārtne	16	25,8	3,5
Rēzeknes pilsēta kopumā	315	28,0	3,2

Rēzeknes pilsētas ekonomiskās attīstības stratēģijā 2001.- 2010.gadam ir ietverts nodoms izstrādāt pilsētas labiekārtošanas un apzaļumošanas programmu. Stratēģijā uzsvērts, ka pilsētvides ainavu un pilsētas infrastruktūras fizisko izskatu lielā mērā vēl joprojām nosaka iepriekšējās sistēmas mantojums. Liela daļa telpiskās (fiziskās) pilsētvides ir nolietotā stāvoklī un nav humanizēta. Līdzekļi pilsētas labiekārtošanai tiek piešķirti pēc atlikuma principa un pilsētas labiekārtošana ir nesaraujami saistīta ar ekonomiskās attīstības perspektīvām un sociālās situācijas attīstību [16].
Rēzeknes ainavas ekoloģiskais vērtējums (3,2 balles) ir praktiski identisks ar novērtējumu Daugavpilī. Lai gan rūpnieciskās ražošanas apjoms un transporta kustības intensitāte Rēzeknē ir ievērojami zemāka nekā Daugavpilī, tomēr negatīvo antropogēno iedarbību uz Rēzeknes pilsētvidi pastiprina vairāki faktori, starp kuriem minami:

- pilsētas atrašanās samērā noslēgtā reljefa pazeminājumā, kas apgrūtina piesārņojošo vielu izkliedi apkārtējā telpā un termālās inversijas apstākļos rada smoga iespējamību,
- blīva apbūve (pēc iedzīvotāju blīvuma Rēzekne ir 2.vietā valstī pēc Rīgas),
- pilsētas siltumapgādē līdz šim pārsvarā tika izmantots mazuts ar lielu sēra saturu,
- individuālo māju apkure, bieži vien ar zemas kvalitātes kurināmo, rada ievērojamu lokāla mēroga piesārņojumu.
- ievērojamu mežu masīvu trūkums Rēzeknes apkaimē.

Tā kā Rēzekne ir salīdzinoši blīvi apbūvēta, ir iesniegti priekšlikumi piegulošo pagastu pašvaldībām par pilsētas teritorijas paplašināšanu līdz apvedceļiem, jo tieši neapbūvētās pilsētas teritorijas robežojas ar pagastu teritorijām un to attīstība ir jāskata kompleksi detālplānojumu izstrādes procesā [16].

ISBN 9984 – 779 – 06 – 8

Jāatzīmē, ka Daugavpils ainavas kvalitāte (vidējais rādītājs - 27,6 punkti) kopumā būtiski neatšķiras no attiecīgā Rēzeknes rādītāja. Tāpat kā Rēzeknē, arī Daugavpilī pastāv visai ievērojamas atšķirības starp atsevišķiem pilsētas rajoniem.
Tādējādi konstatēts, ka Latgales novada lielpilsētu ainavai piemīt vidēji augsta estētiskā kvalitāte. Turpinot iesāktos pētījumus, paredzēts iegūt daudz plašāku informāciju tieši par atsevišķu Daugavpils pilsētas rajonu ainavas kvalitāti, kā arī paplašināt ainavas kvalitātes pētījumu ģeogrāfisko areālu, ietverot arī citas Latgales reģiona pilsētas.

Secinājumi

1. Ainava ir viens no svarīgākajiem jebkuru teritoriju raksturojošajiem elementiem, kurš atspoguļo ilgstoša attīstības procesa rezultātu telpā dotajā laika momentā. Tādējādi var apgalvot, ka ainava ir sociuma kolektīvās iztēles noturīgs atspoguļojums ārējā fiziskajā vidē.
2. Pilsētvides ainava ir nozīmīga kultūrainavas sastāvdaļa, kurai ir būtiska nozīme vietas tēla veidošanā un identitātes nostiprināšanā, tā var kļūt arī par ekonomisko attīstību stimulējošu faktoru. Ainavas kā nozīmīgas kultūrvēsturiskā mantojuma sastāvdaļas saglabāšana un aizsardzība veicina arī novadam piemītošā rakstura un identitātes saglabāšanu, kā arī nodrošina pilsētas kā pievilcīga tūrisma objekta vērtību.
3. Pilsētvides ainavas kvalitātes kompleksa novērojuma rezultātā netika konstatētas būtiskas atšķirības starp abu Latgales lielpilsētu pilsētvides ainavas kvalitatīvajiem rādītājiem. Tomēr jāatzīmē, ka Rēzeknes pilsētas ainavas kvalitātes vērtējums (vidēji 28,0 punkti) ir nedaudz augstāks nekā Daugavpilī (vidēji 27,6 punkti). Tādējādi pilsētvides ainavas kvalitāte Latgales lielpilsētās kopumā uzskatāma par viduvēju, pastāvot ievērojamām atšķirībām starp atsevišķiem pilsētu rajoniem. Pilsētu ainavas kvalitāti būtiski pazemina ievērojamais industriālās apbūves īpatsvars un transporta, īpaši dzelzceļa, nelabvēlīgā ietekme uz vidi.
4. Prognozējot tālāku pilsētvides ainavas attīstību, iezīmējušās būtiskas atšķirības starp atsevišķām Latgales novada pilsētām. Piemēram, Daugavpilī vērojama daudz intensīvāka ekonomiskā rosība nekā Rēzeknē, kas rod izpausmi arī pilsētu vizuālajā ainaviskajā veidolā. Daugavpilij raksturīgs dinamisks pilsētvides transformācijas process, ko veicina ievērojams investīciju pieplūdums.
5. Ainavas kvalitātes novērtējumu veica nosacīti viendabīgs novērotāju kopums- augstskolu studenti ar līdzīgu specializācijas virzienu- vides zinātni. Tomēr tika pamanītas atšķirības ainavas kvalitātes novērtējumā starp cilvēkiem, kuri veica savas dzimtās pilsētas ainavas izpēti, un tiem cilvēkiem, kuri dotajā pilsētā dzīvo tikai salīdzinoši neilgu laiku. Acīmredzot, pastāv psiholoģiskas atšķirības pazīstamas un nepazīstamas vides ainavas uztverē.
6. Ainavas novērtēšanas procesā izmantotā metode ļauj gūt samērā precīzu un objektīvu informāciju par pilsētvides ainavisko kvalitāti. Turpinot uzsāktos pētījumus, paplašinot izpētes areālu un pielietojot daudzveidīgas ainavas izpētes metodes, var iegūt rezultātus, kam būtu praktiska nozīme pilsētu attīstības plānošanas procesā, tādējādi veicinot dzīves kvalitātes paaugstināšanos un nodrošinot pilsētu ilgtspējīgu attīstību.
7. Svarīga problēma ir pilsētas un to aptverošās lauku teritorijas mijiedarbība un faktisko robežu definēšana nepārtrauktās ainaviskās telpas kontekstā. Apkārtējās lauku teritorijas iegūst no šo pilsētu attīstības, tomēr vienlaikus tās ir pakļautas sadrumstalošanas riskam, pilsētu teritoriālajai izaugsmei iespiežoties dabas un kultūrainavās, kā rezultātā zūd šo teritoriju lauku identitāte. Lai to novērstu, ir jāveic integrēta pilsētu un lauku teritoriju plānošana. Cerams, ka mūsu valstī realizējamā administratīvi teritoriālā reforma, kas paredz novadu izveidi pārsvarā ap pilsētu kā novada centru, palīdzēs realizēt arī pilsētu un lauku sabalansētu attīstību.

ISBN 9984 – 779 – 06 – 8

Pateicības

Autors izsaka pateicību Daugavpils Universitātes akadēmiskā bakalaura studiju programmas „Vides zinātne" un Rēzeknes Augstskolas profesionālā bakalaura studiju programmas „Vides inženieris" studentiem par aktīvo līdzdalību pilsētvides ainavas kvalitātes kompleksa novērtējuma procesā.

Summary

The paper deals with urban landscape individualities in the cities and towns of Latgale region. Also show facilities of integrated assessment of urban landscape quality. Article provides literary overview about specifics of urban landscape and factors, that have influence on landscape quality. Complex character of urban landscape stressed equally impressive factors that includes visual aesthetic, ecological and cultural historical aspects.

Until now, investigations of Latvian landscape deal with rural landscape characteristics, and only in comperatively few areas, but integrated assessment of urban landscape, at least in Latgale region, wasn't realized.

This paper presents the results of Daugavpils and Rēzekne urban landscape quality complex assessment, that have been realised in 2003 - 2005. By continuing investigations, widening research area and using another methods, we can get new results, which have practical importance on process of urban development planning. Also, it is necessary to begin integrated assessment of urban landscape in another cities and towns of Latgale region.

This results don't establish significant disparities between quality of urban landscape among Daugavpils and Rēzekne. On the other hand, urban landscape quality in Rēzekne (on average 28,0 points) is a little bit higher than in Daugavpils (on average 27,6 points). Hence we can conclude, that urban landscape quality in the cities of Latgale region is almost normal, but ecological condition on subjective valuation is quite normal.

Compratively higher quality of urban landscape in Daugavpils comes by outlying territories with remarkable proportion of green and blue areas but the lowest landscape quality is in Soviet times block housing estates.

In turn, in Rēzekne higher quality of urban landscape is in southern part of the city, where individual buildings and green areas dominates. Industrial territories and transport corridors, especially railways, gives unfriendly influence on urban landscape quality.

This method of urban landscape assessment makes possible to get believeable and precise information about landscapes quality. Another methods of investigations can be used: including of new participants, investigations in different seasons etc. Therefore, we can get more objective results of landscapes quality assessment.

Literatūra

1. Ietekmes uz vidi novērtējums. Apakšnodaļa „Ainavu vērtējums" (aut. Nikodemus O.)- Rīga: IVN Valsts birojs, 2002.
2. European Landscape Convention.- Council of Europe, 2000.
3. Bunkše E.V. Sirēnu balsis: ģeogrāfija kā cilvēcīga erudīcija.- Rīga: Norden, 1998.
4. Голубчиков С., Гутников В. Экология крупного города.- Москва Пасъва, 2001.
5. VASAB 2010+. Telpiskās attīstības rīcības programma: vīzija un stratēģijas ap Baltijas jūru 2010.- Vismāra, 2001.
6. Krauklis Ā. Ģeogrāfiskās ainavas daba, uztvere un apsaimniekošana. // Zeme.Daba.Cilvēks. LU 57.zinātniskā konference. Referātu tēzes. Rīga: Latvijas Universitāte, 1999.- 81.-82.lpp.
7. Яргина З. Эстетика города.- Москва: Стройиздат, 1991.
8. Melluma A. Ainava kā attīstības resurss: Kurzemes piemērs. Ģeogrāfiski raksti. X sējums.- Rīga: Latvijas Ģeogrāfijas biedrība, 2002.- 5.-15.lpp.
9. Bells S., Nikodemus O. Rokasgrāmata meža ainavas plānošanai un dizainam.- Rīga: Valsts Meža dienests, LTS International Ltd., 2000.
10. Николаев В.А. Ландшафтоведение: Эстетика и дизайн.- Москва: Аспект Пресс, 2003.
11. Экология и эстетика ландшафта.- Вильнюс: Минтис, 1975.
12. Turlajs J., Milliņš G. Latvijas apdzīvotās vietas.- Rīga: Jāņa sēta, 1998.

ISBN 9984 – 779 – 06 – 8

13. Šķiņķis P., Stankeviča V. Latvijas pilsētu sociāli ģeogrāfiskās atšķirības. Ģeogrāfiski raksti. VII sējums.- Rīga: Latvijas Ģeogrāfijas biedrība, 1999.- 94.-115.lpp.
14. Melluma A. Materiāli pilsētu klasifikācijai no reģionālās attīstības viedokļa. – Rīga: LR VARAM, 1994.
15. Latvijas rajonu pilsētas un pagasti. Statistisko datu krājums.- Rīga: LR VSK, Latvijas statistikas institūts, 1998.
16. Rēzeknes pilsētas ekonomiskās attīstības stratēģija.- Rēzeknes pilsētas dome, 2003.

ISBN 9984 – 779 – 06 – 8

DABAS LIEGUMA „LIELUPES PALIEŅU PĻAVAS" NOVĒRTĒJUMS
THE EVALUATION OF THE RESTRICTED NATURE RESERVE „LIELUPE FLOOD-PLAIN MEADOWS"

INGA STRAUPE, ALEKSANDRS ADAMOVIČS

Latvijas Lauksaimniecības universitāte, Lielā iela 2, Jelgava, LV-3001,
e-pasts: inga.straupe@llu.lv, aleksandrs.adamovics@llu.lv

DINA ROMĀNOVA

Latvijas universitāte, Kronvalda bulvāris 4, Rīga, LV-1586

Abstract. *The restricted nature reserve „Lielupe flood-plain meadows" was formed to maintain the natural meadows on the banks of the river Lielupe in the territory of Jelgava town. The varied complex of plant communities are located in meadows of Pilssala, on the Lielupe's right and left bank and thus the nesting of rare and protected meadow and waterbirds as well as important rest area for migrating birds is determined there. The restricted nature reserve is proposed as Natura 2000 place, too. There are the medium moist, moist and wet meadows in the reserve that are the habitats of EU Habitats directive. The biological value of the Lielupe flood plain meadows are currently being endangered by overgrowing and eutrophication. To provide meadows management for maintaining botanical and ornithological values, the inventory of natural meadows was done and proposals for management were developed.*

Keywords: *vegetation, restricted nature reserve, flood-plain meadows, plant communities, management.*

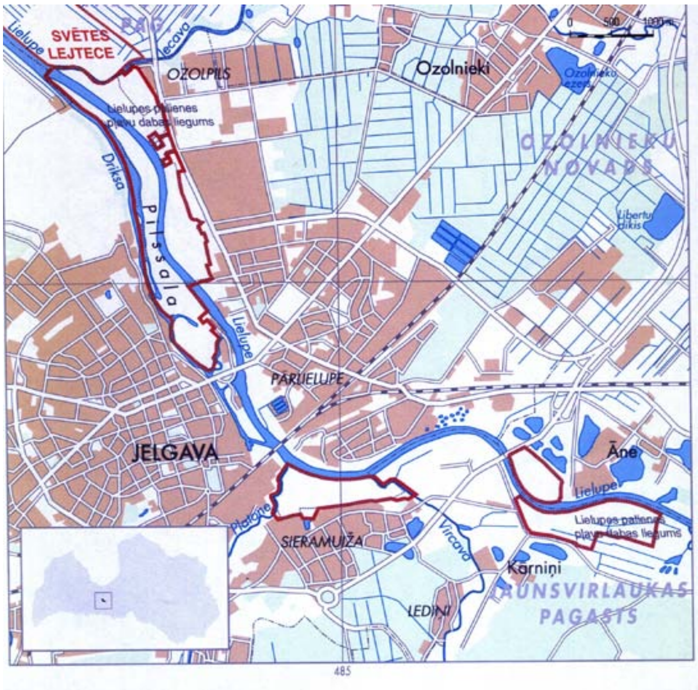
Ievads

Dabas liegums „Lielupes palieņu pļavas" izveidots 1999.gadā, lai saglabātu antropogēni mazizmainītas dabiskas pļavas Lielupes palienē. Kopš 20.gadsimta 80 gadiem teritorijā notiek regulāras caurceļojošo putnu uzskaites pavasarī un ligzdojošo putnu novērojumi, tāpēc vietējās nozīmes ornitoloģiskā lieguma statuss teritorijas daļai (162 ha platībā) piešķirts jau 1991.gadā. Tajās konstatēts vairāk kā 135 putnu sugas. Regulāri tajās dzīvo un barojas 70-80 sugu putni. Pļavas ir nozīmīga ligzdošanas vieta tādām putnu sugām kā griezei *Crex crex* (L.) - 30-50 pāri, ormanītim *Porzana porzana* (L.) – 10 pāri, gugatnim *Philomachus pugnax* (L.) – 5 pāri, melnajam zīriņam *Chlidonias niger* (L.) – 10 pāri, brūnajai čakstei *Lanius collurio* L. – 3-30 pāri, melnai puskuitalai *Limosa limosa* (L.) - 5-15 pāri [4]. Lieguma teritorijā iekļautas divas papildus teritorijas (135 ha) augšpus Jelgavas pilsētas (1.attēls) [11].

Dabas lieguma „Lielupes palieņu pļavas" pamatteritoriju (257 ha) veido trīs savstarpēji nodalītas pļavu teritorijas Lielupes krastos Jelgavas pilsētā: Pilssala (4,5 km garu salu no Jelgavas pils atdala Lielupes atteka Driksa, Lielupes labā krasta pļavas starp Robežu ielu un Iecavas upes ieteku un Lielupes kreisā krasta pļavas starp Vircavas un Platones upes ieteku (1.attēls) [3].

Dabas liegums „Lielupes palieņu pļavas" atrodas Latvijas centrālajā daļā, Zemgales līdzenumā. Pateicoties savdabīgajam Zemgales līdzenuma novietojumam (amfiteātra veida nolaidenums), visi ūdeņi tek Jelgavas virzienā [5]. Vidējais nokrišņu daudzums Jelgavas apkārtnē gadā ir 600 – 650 mm, kas ir par apmēram 100 mm mazāks nekā vidēji valstī [10]. Veģetācijas periods ir garāks nekā pārējās republikas daļās un ilgst vidēji 200 dienas [5]. Šajā teritorijā pavasaris iestājas agrāk nekā citos Latvijas rajonos, jo augsnes pilnīgi atkūst jau aprīļa sākumā. Arī vasaras Jelgavas apkārtnē ir siltākas [12].

ISBN 9984 – 779 – 06 – 8



1.attēls. **Dabas lieguma „Lielupes palieņu pļavas" teritorijas**

Jelgavas apkārtnes augšņu pamatā atrodas augšdevona ieži, uz kuriem kvartāra nogulumu segas biezums mainās no 10 – 20 m [5]. Lielupes palienes pļavās biežas applūšanas rezultātā veidojas tādas reljefa formas kā noskalojumi un dažādi sanesumi [18]. Augsnes virsējos slāņus veido Lielupes aluviālie nogulumi, kuru biezums mainās no dažiem centimetriem līdz vairākiem metriem. Šie nogulumi sastāv no smilts, grants un aleirīta [12]. Tā kā Lielupes palienes pļavas joprojām regulāri applūst, tad mainās arī to aluviālā nogulumu slāņa biezums. Galvenokārt pļavās konstatētas auglīgās aluviālās augsnes, kas veidojās no palu ūdeņu sanestā materiāla [5]. Lielupes palienē dominē graudainās palienes augsnes, kas veidojas no organisko vielu bagātiem mālainiem sanesumiem. Organisko vielu daudzums var sasniegt 4 – 6,5 % [12, 18]. Zemākajās un mitrākajās pļavās uzkrājusies kūdra [4]. Plūdi pavasaros un vasarās un paaugstinātais gruntsūdens līmenis pļavās būtiski ietekmē lieguma abiotiskos un biotiskos apstākļus [5]. Galvenie biotopi Lielupes palieņu pļavās ir: pļavas un ganības (56,9 %) un mitrāji – ūdensteces (18,7 %), applūstošas krastmalas (17,6 %) [16].

Pētījuma mērķis bija inventarizēt dabas liegumu „Lielupes palieņu pļavas" un konstatēt botāniski vērtīgās pļavas, raksturot un novērtēt tās, kā arī ieteikt nepieciešamo apsaimniekošanu. Lai realizētu Eiropas Savienības finansētu projektu „Latvijas palieņu pļavu atjaunošana ES prioritāro sugu un biotopu aizsardzībai" (Latvijas Dabas fonds, 2004. - 2008.g.), kura mērķis ir atjaunot arī aizaugošās Lielupes palieņu pļavu teritorijas un nodrošināt ilgstošu palieņu pļavu apsaimniekošanu, lai saglabātu apdraudētās augu un dzīvnieku sugas un biotopus, ir īpaši nozīmīgs un aktuāls lieguma pļavu novērtējums.

Materiāli un metodes

Latvijas Dabas fonda projekta *Pļavu inventarizācija Latvijā* (2001. – 2002.gads) ietvaros apsekotas botāniski vērtīgās pļavas dabas lieguma "Lielupes palienes pļavas" pamatteritorijā. Par katru apsekoto bioloģiski vērtīgo pļavas nogabalu izpildīta anketa un dati ievadīti Latvijas dabas fonda datu bāzē [2, 13]. Pļavas raksturojuma lapā ietvertas koku, krūmu un lakstaugu sugas un to segums, informācija par pļavas apsaimniekošanu un apdraudošie faktori. Pļavu klasifikācijā izmantots Latvijas biotopu klasifikators [6, 8]. Lieguma teritorijā esošie zālāji aptver trīs pļavu tipus – mēreni mitras, mitras un slapjas pļavas.

ISBN 9984 – 779 – 06 – 8

Rezultāti un to izvērtējums

Mēreni mitrās pļavās raksturīgi vidēji bagāti mitruma apstākļi visu veģetācijas periodu. Te dominē augu sugas, kas pielāgojušās augšanai samērā bagātās augsnēs. Šajās pļavās zelmenis ir vairākos stāvos [9, 21]. Mēreni mitrām pļavām izdala sekojošus apakštipus: vilkakūlas pļavas, atmatu pļavas un īstās pļavas [8]. Pēc Brauna – Blankē fitosocioloģiskās klasifikācijas mēreni mitras pļavas pieskaitāmas pie klases Molinio – Arrhenatheretea [14]. Kopumā Lielupes palienes pļavās sastopami 11 mēreni mitro pļavu tipi visās trīs lieguma pamatteritorijās.

Vilkakūlas** Nardus **pļavas Latvijas teritorijā sastopamas samērā reti, nelielās platībās [9, 22]. Vilkakūlas pļavas ir veidojušās nabadzīgās skābās augsnēs un tajās ir ļoti dažādi mitruma apstākļi, kā rezultātā veidojas ļoti atšķirīgs sugu sastāvs. Pļavām raksturīgs zems vai vidēji augsts zelmenis. Vilkakūlas pļavās dominē mēreni mitru vietu augi, piemēram, bālganais grīslis *Carex pallescens* L., aitu auzene *Festuca ovina* L., stāvā vilkakūla *Nardus stricta* L., mazā mauraga *Pilosella officinarum* F.W.Schultz et Sch.Bip. Tās izmanto ganīšanai (Latvijas biotopu klasifikators, 2001). Ja vilkakūlas pļavas regulāri tiek ganītas vai arī pļautas, tad te veidojas sugām bagātīgs augājs [9]. Šīs ir vienīgās no mēreni mitrām pļavām, kuras pēc Brauna – Blankē fitosocioloģiskās klasifikācijas ir iedalāmas citā klasē – Calluni-Ulicetea [14]. Vilkakūlas pļavas ir Eiropas Savienības prioritārs aizsargājams biotops - sugām bagātas vilkakūlas pļavas smilšainās augsnēs (kods 6230) [9].

Atmatu pļavas Latvijā sastopamas reti. Tās galvenokārt veidojās upju ielejās vidēji bagātās smilts un mālsmilts augsnēs ar neitrālu vai vāji skābu reakciju. Šīm pļavām ir raksturīgs blīvs un vidēji augsts zelmenis. Tajās ir daudz sugu, kam lapas sakārtotas rozetē vai veidojas ložņājoši un guloši stublāji [8]. Šajās pļavās dominē vidēji augstas graudzāles – parastā smaržzāle *Anthoxanthum odoratum* L., parastā smilga *Agrostis tenuis* Sibth., sarkanā auzene *Festuca rubra* L. Šīm pļavām ir raksturīgas arī tādas sugas kā parastais vizulis *Briza media* L., rudens vēlpiene *Leontodon autumnalis* L., mazā zilgalvīte *Prunella vulgaris* L., ložņu āboliņš *Trifolium repens* L.u.c. Šīs pļavas ir Eiropas Savienībā prioritārs aizsargājams biotops - sugām bagātas atmatu pļavas (kods 6270) [9].

Īstās pļavas Latvijā sastopamas samērā bieži. Tās ir mēreni mitras pļavas, sastopamas labi aerētās un ļoti auglīgās augsnēs, sastopamas uz upju ieleju terasēm, kā arī reti un īslaicīgi applūstošās palienēs. Tām raksturīgs samērā augsts un blīvs zelmenis vairākos stāvos. Īstajās pļavās biežāk sastopamas vidēji augstās graudzāles – augstā dižauza *Arrhenatherum elatius* (L.) J. et C. Presl., bezakotu zaķauza *Bromopsis inermis* (Leyss.) Holub, pļavas auzene *Festuca pratensis* Huds., pūkainā pļavauzīte *Helictotrichon pubescens* (Huds.) Pilg., pļavas timotiņš *Phleum pratense* L., parastā kamolzāle *Dactylis glomerata* L. u.c. Te ir arī liela divdīgļlapju daudzveidība. Tās tiek izmantotas siena ieguvei. No īstajām pļavām visbiežāk lieguma teritorijā sastopamas pūkainās pļavauzītes *Helictotrichon pubescens* pļavas. Īstās pļavas ir Eiropas Savienībā aizsargājams biotops - mēreni mitras pļavas (kods 6510) [9].

Mitras pļavas pēc augsnes īpašībām iedala ļoti auglīgās palieņu pļavās, pļavās un ganībās ar auglīgu un mēreni auglīgu augsni, mēreni auglīgās pļavās [8, 22]. Pēc Brauna – Blankē fitosocioloģiskās klasifikācijas šīs pļavas pieskaitāmas Molinio – Arrhenatheretea klasē [14]. Lielupes palienes pļavās pārstāvēti 11 mitro pļavu tipi. No tiem lielākā daļa atrodas Lielupes labā krasta teritorijā.

Ļoti auglīgas palieņu pļavas ir reti sastopamas un veidojas upju palienēs, kur ir labi aerētas, neitrālas augsnes [8]. Lielupes palieņu pļavās tās pārstāvētas ar **pļavas lapsastes** *Alopecurus pratensis* **pļavām**. Pļavas lapsastes pļavas sastopamas reti, nelielās platībās un uz neitrālām aluviālajām augsnēm [22]. Tas ir izskaidrojams ar to, ka to pastāvēšanai nav nodrošināti pietiekami labvēlīgi apstākļi (lielākai daļai Latvijas upju pēc platības ir mazas palienes terases). Lapsastes pļavās aug apmēram 30 augu sugas, no tām dominējošā ir pļavas lapsaste *Alopecurus pratensis* L., raksturīgās sugas ir bezakotu zaķauza, purva skarene *Poa palustris* L., garlapu veronika *Veronica longifolia* L., pļavas ķērsa *Cardamine pratensis* L., ložņu vārpata *Elytrigia repens* (L.) Nevski, pļavas guntiņa *Lychnis flos-cuculi* L., baltā madara *Galium album* Mill., lielā

ISBN 9984 – 779 – 06 – 8

nātre *Urtica dioica* L. u.c. [8, 22]. Šīs pļavas iekļautas Eiropas Savienības aizsargājamo biotopu sarakstā - mēreni mitras pļavas (kods 6510) un upju palieņu pļavas (kods 6450) [9].

Pļavas un ganības auglīgās un mēreni auglīgās augsnēs sastopamas visā Latvijas teritorijā, lielākās platības veidojot upju, t.sk. Lielupes krastos. Šīs pļavas veidojas mitrās un periodiski pārmitrās vietās [8]. Auglīgās un mēreni auglīgās augsnēs aug dažādas divdīgļlapju sugas, kur parasti ir vairākas dominējošās sugas, piemēram, parastā vīgrieze *Filipendula ulmaria* (L.) Maxim., pļavas bitene *Geum rivale* L., dažādlapu dadzis *Cirsium heterophyllum* (L.) Hill u.c. Bieži vien šajās pļavās var sastapt retas augu sugas. Lielupes palienes pļavās sastopamas ciņu grīšļa, pļavas bitenes un parastās vīgriezes pļavas. Tās sastopamas palienēs [22]. **Ciņu grīšļa pļavas** sastopamas bieži. Te dominē ciņu grīslis *Carex cespitosa* L. Šajās pļavās sastopamas arī tādas sugas kā meža zirdzene *Angelica sylvestris* L., purva purene *Caltha palustris* L., purva cietpiene *Crepis paludosa* (L.) Moench., purva kosa *Equisetum palustre* L., purva madara *Galium palustre* L. u.c. **Pļavas bitenes pļavās** dominē dažādas divdīgļlapju sugas – meža zirdzene, dažādlapu dadzis, purva cietpiene, ziemeļu madara *Galium boreale* L., pļavas bitene, zeltainā gundega *Ranunculus auricomus* L., kodīgā gundega *Ranunculus acris* L. u.c. **Parastās vīgriezes pļavām** raksturīgs ir tas, ka te veidojas parastās vīgriezes tīraudzes ilgstošas neapsaimniekošanas rezultātā. Pļavas un ganības auglīgās un mēreni auglīgās augsnēs ir starptautiski aizsargājami biotopi - eitrofas augsto lakstaugu audzes (kods 6430) un un upju palieņu pļavas (kods 6450) [9].

Slapjas pļavas Latvijas teritorijā ir maz izplatītas [22]. Tās atrodamas tādās vietās, kur gandrīz visu gadu virs augsnes ir ūdens – reljefa pazeminājumos vai palienēs [8].

Augsto grīšļu pļavas veidojas upju palienēs uz slapjām kūdras augsnēm. Latvijā tās sastopamas bieži, nelielās platībās. Zelmenis ir augsts. Pēc Brauna – Blankē fitosocioloģiskās klasifikācijas šīs pļavas iedala Phragmiti – Magnocaricetea klasē [14]. Lielupes palienes pļavās ir sastopamas augsto grīšļu pļavas – uz Pilssalas un Lielupes labajā krastā, apmēram 0,5 km no Ozolpils. Tās pārstāvētas kā slaidā grīšļa, divrindu grīšļa un parastā miežubrāļa pļavas.

Slaidā grīšļa pļavas Latvijas teritorijā sastopamas bieži. Tajās dominē slaidais grīslis *Carex acuta* L. Šīs pļavas veidojas upju krastos, visbiežāk šaurā joslā, nelielās platībās. Slaidā grīšļa pļavās ir slikta augsnes aerācija bagātīgo mitruma apstākļu dēļ. Šīs pļavas tiek izmantotas ganīšanai [8]. Slaidā grīšļa pļavas pieskaitāmas pie ES aizsargājamiem biotopiem - upju palieņu pļavas (kods 6450).

Divrindu grīšļa pļavas, salīdzinot ar citām grīšļu pļavās, sastopamas retāk. Tās veidojas slapjās vietās upju palienēs [8]. Dominē divrindu grīslis *Carex disticha* Huds. Kurzemē un Vidzemē divrindu grīšļa pļavas praktiski nav sastopamas [22].

Miežubrāļa pļavas arī veidojas upju palienēs. Šīs pļavas visbiežāk veido šauru joslu gar upes vai ezera krastu. Te dominējošā suga ir miežubrālis *Phalaroides arundinacea* (L.) Rauschert. Miežubrāļa pļavas izmanto pļaušanai un ganīšanai [8].

Lielupes palienes pļavas pakļautas būtiskai antropogēnai iedarbībai. Pļavu teritorijas, kas atrodas uz Pilssalas un Lielupes labā krastā, plaši izmanto rekreācijas vajadzībām. Gar Lielupes krastu visās lieguma teritorijās notiek intensīva makšķerēšana. Tās rezultātā pļavās veidojas taku tīkls un palielinās arī piesārņojums ar sadzīves atkritumiem [4]. Šo faktoru ietekmē mainās pļavu sugu sastāvs. Tomēr visbūtiskāk Lielupes palienes pļavu augu sabiedrības ietekmē tādi faktori kā aizaugšana, neregulāra pļaušana un maza ganīšanas intensitāte.

Pēdējos gados Eiropā ir strauji palielinājusies zinātniskā un politiskā interese par mitrajām pļavām, kas galvenokārt ir saistīta ar bioloģiskās daudzveidības saglabāšanu starptautiskā līmenī [19, 20]. Lai saglabātu pļavās esošo bioloģisko daudzveidību, nepieciešami atbilstoši apsaimniekošanas pasākumi. Eiropā efektīva pļavu saglabāšana balstās uz veģetācijas apsaimniekošanu (pļavu ganīšanu vai pļaušanu), ierobežotu mēslojuma lietošanu un hidroloģisko kontroli, jo ūdens līmenim pļavās ir liela nozīme dažādu augu sabiedrību veidošanā. Neapsaimniekotās pļavās samazinās bioloģiskā vērtība, jo te, pēc dažādu Eiropas zinātnieku pētījumiem, par dominējošajām sugām kļūst spēcīgi konkurējošas sugas, tādas kā augstā dižauza, parastais miežubrālis, skābenes *Rumex sp.* L., lielā nātre [20].

ISBN 9984 – 779 – 06 – 8

Daudzviet Eiropā ir izstrādātas dažādas pļavu apsaimniekošanas shēmas, kas nosaka apsaimniekošanas atbilstošu pielietojumu, piemēram, finansiāls atbalsts zemju īpašniekiem un pļavu apsaimniekotājiem, lai nodrošinātu sekmīgu pļavu apsaimniekošanu, piemēram, ganīšanu [20].

Latvijas Bioloģiskās daudzveidības nacionālās programmas uzdevums ir veicināt dabas resursu ilgtspējīgu izmantošanu, vienlaikus aizsargājot dabu. Lai nodrošinātu zālāju ilgtspējīgu izmantošanu un aizsardzību, sniegti sekojoši risinājumi: saglabāt pļavu platības; apturēt dabisko pļavu un ganību aizaugšanu; saglabāt raksturīgās augu un dzīvnieku sabiedrības dabiskajās pļavās [1, 19]. Lai novērstu turpmāku pļavu platību samazināšanos un atjaunotu bioloģisko daudzveidību tajās, nepieciešams veikt atbilstošu apsaimniekošanas pasākumus [20]. Pļavu apsaimniekošanas metodes jāizvēlas, ņemot vērā pļavas pašreizējo un vēsturisko apsaimniekošanu, kā arī pļavas tipu [8]..

Galvenās pļavu apsaimniekošanas metodes ir ganīšana un pļaušana. Ganīšana ir pakāpenisks veģetācijas novākšanas veids, savukārt, pļaušana ir pēkšņs veģetācijas aizvākšanas veids [21]. Katrā pļavā ir svarīgi saglabāt vienu apsaimniekošanas veidu, lai veidotos augu sugas ar noteiktu izturību pret pļaušanas režīmu vai noganīšanu [15].

Ganot pļavā lopus, tajā izplatās pret ganīšanu izturīgi augi (zemie lakstaugi, cerveidīgie augi). Atkarībā no ganīto mājlopu veida, rodas savdabīga zelmeņa struktūra un augu sugu izvietojums [15]. Zelmeņa struktūra ir svarīga bezmugurkaulnieku faunai, kā arī uz zemes ligzdojošiem putniem [21]. Izvēloties ganīšanu kā apsaimniekošanas veidu, svarīgi izvēlēties piemērotāko mājlopu veidu – aitas, kazas, liellopus vai zirgus.

Par apsaimniekošanas veidu izvēloties pļaušanu, pļavās veidojas viena augstuma zelmenis ar vienveidīgu augu sastāvu. Bezmugurkaulnieku fauna šajā gadījumā ir daudz nabadzīgāka [21]. Pļaušanu vislabāk pielietot tad, kad jāsamazina nevēlamo dominējošo sugu daudzumu, piemēram, dižo ūdenszāli *Glyceria maxima* (Hartm.) Holmb., ciņusmilgu *Deschampsia cespitosa* (L.) P.Beauv. Pļaujot pļavas, ir jāievēro pareizs pļaušanas veids, kas ļauj dzīvniekiem izglābties no pļaušanas tehnikas [15]. Mēreni mitrām un mitrām pļavām bagātās augsnēs svarīga ir regulāra pļaušana. Mēreni mitrās nabadzīgu augteņu pļavās vislabākā ir ganīšana, jo tad te veidojas īss zelmenis ar sugām, kuras pielāgojušās ganīšanai [7]. Pļaušanas ietekmē slapjās pļavās veidojas liela sugu daudzveidība [7]. Dažādu pļavu tipu piemērotākie apsaimniekošanas veidi ir apkopoti 1.tabulā.

1.tabula

Pļavu apsaimniekošanas veidi

Pļavas tips	**Pļaušana**		**Ganīšana**	
	laiks	augstums	laiks	mājlopi
Mēreni mitras	jūlijs	5-10 cm	jūnijs-septembris	jebkuri, atkarībā no floristiskā sastāva
Slapjas	Pielieto, ja teritorija ir neliela		ne ātrāk par jūniju	liellopi, zirgi

Laikā no 2004. - 2008.gadam Latvijas dabas fonds realizē projektu „Latvijas palieņu pļavu atjaunošana ES prioritāro sugu un biotopu aizsardzībai", kura mērķis ir atjaunot bioloģiski vissvarīgākās un pašlaik aizaugošās palieņu pļavu teritorijas (16 vietās Latvijā, t.sk. arī Lielupes palienes pļavas), kā arī nodrošināt ilgstošu palieņu pļavu apsaimniekošanu, lai saglabātu apdraudētās sugas (piemēram, griezi, ķikutu) un biotopus (upju palieņu pļavas, sugām bagātās vilkakūlas pļavas u.c.). Projekta ietvaros notiks zinātniski pamatotu dabas aizsardzības plānu izstrāde teritorijām, palieņu pļavu atjaunošana lielākajā daļā aizaugušo teritoriju. Pļavās paredzētas dažādas metodes, kas iekļauj krūmu novākšanu, krūmu sakņu sistēmas izpostīšanu, ierobežotus hidrotehniskos darbus, kontrolētu dedzināšanu, pirmreizējo pļaušanu, eksperimentālo ganīšanu. Lai izvēlētos piemērotāko metodi katrai teritorijai, notiks informācijas apmaiņa par palieņu pļavu apsaimniekošanas metodēm. Privāto zemju īpašniekiem, kuru īpašumi koncentrējas Lielupes labā krasta teritorijā, būs iespēja sagatavot pieteikumus agro-vides

ISBN 9984 – 779 – 06 – 8

atbalstam, lai nodrošinātu atjaunoto palieņu pļavu nākotnes apsaimniekošanu. Projekta rezultātā tiks sagatavota pļavu praktiskās apsaimniekošanas rokasgrāmata.

Secinājumi

1. Dabas liegums „Lielupes palieņu pļavas" izveidots, lai saglabātu daudzveidīgas dabiskas pļavas Lielupes upes palienē, kurās barojas un ligzdo reti un aizsargājami pļavu un ūdensputni (konstatētas 135 putnu sugas).
2. Galvenie biotopi liegumā ir: pļavas un ganības (56,9 %) un mitrāji – ūdensteces (18,7 %), applūstošas krastmalas (17,6 %).
3. Lieguma teritorijā esošie zālāji aptver trīs pļavu tipus – mēreni mitras, mitras un slapjas pļavas. Pēc Brauna – Blankē fitosocioloģiskās klasifikācijas pļavas pieskaitāmas pie klases *Molinio – Arrhenatheretea, Calluni-Ulicetea un Phragmiti – Magnocaricetea.*
4. Pļavu inventarizācijā konstatētās dabiskās pļavas atbilst Eiropas Savienības prioritāriem aizsargājamiem biotopiem: sugām bagātas vilkakūlas pļavas smilšainās augsnēs (kods 6230) un sugām bagātas atmatu pļavas (kods 6270) un aizsargājamiem biotopiem: upju palieņu pļavas (kods 6450), eitrofas augsto lakstaugu audzes (kods 6430) un mēreni mitras pļavas (kods 6510).
5. Lielupes palienes pļavas pakļautas būtiskai antropogēnai iedarbībai, galvenokārt, rekreācijai. Visbūtiskāk tomēr Lielupes palienes pļavu augu sabiedrības ietekmē tādi faktori kā aizaugšana, neregulāra pļaušana un maza ganīšanas intensitāte.
6. Regulāra pļaušana ir nepieciešamā apsaimniekošana mēreni mitrām, mitrām pļavām bagātās augsnēs un slapjām pļavām.
7. Ganīšana ir vispiemērotākā apsaimniekošana mēreni mitrās nabadzīgu augteņu pļavās.
8. Laikā no 2004. - 2008.gadam Latvijas Dabas fonds realizē projektu „Latvijas palieņu pļavu atjaunošana ES prioritāro sugu un biotopu aizsardzībai", kura mērķis ir atjaunot bioloģiski vissvarīgākās un pašlaik aizaugošās palieņu pļavu teritorijas t.sk. arī Lielupes palienes pļavas, kā arī nodrošināt ilgstošu zinātniski pamatotu palieņu pļavu apsaimniekošanu, lai saglabātu apdraudētās sugas un biotopus.

Summary

The restricted nature reserve "Lielupe flood-plain meadows" was formed in 1999 to maintain the natural meadows on the banks of the river Lielupe in the territory of Jelgava town (now the area of reserve has reached 392 ha). The varied complexes of plant communities are located in meadows of Pilssala, on the Lielupe's right and left bank and thus the nesting of rare and protected meadow and water birds as well as important rest area for migrating birds are determined there (about 135 species of birds are recognized there). Regularly 70 – 80 bird species live and feed there. The main habitats in the restricted nature reserve "Lielupe flood-plain meadows" are meadows (56,9 %) and wetlands – streams (18,7%), flood-plain banks (17,6%). The reserve is proposed as Natura 2000 place, too. In 2004 Latvian Fund for Nature has started to manage a new project „The restoration of Latvian floodplains for EU priority species and habitats", financed by EU. Project will continue until 2008. The project includes all the best floodplain meadows from all regions of Latvia, which hold significant nature values *inter alia* Lielupe flood-plain meadows. The aim of this project is to restore the overgrowing meadows and to provide sustainable meadows management for maintaining endangered plant and animal species Main objectives of the project are to restore biologically most important and presently abandoned floodplain areas and to ensure subsequent continuous management for the benefit of species (e.g., *Crex crex*) and habitats (e.g., Species-rich *Nardus* grasslands, Fennoscandian lowland species-rich dry to mesic grasslands). To provide management of meadows for maintaining botanical and ornithological values, the inventory of natural meadows was done in the frame of the project "The inventory of meadows in Latvia" (Latvian Fund for Nature, 2000-2002) in the main territory of the restricted nature reserve "Lielupe flood-plain meadows". The information about the plant species and their cover, the meadows management and factors that

ISBN 9984 – 779 – 06 – 8

have impact on the territory are registered. The meadows are divided according to Latvia habitats classification. There are the medium moist, moist and wet meadows in the reserve. The meadows are included in classes Molinio – Arrhenatheretea, Calluni-Ulicetea and Phragmiti – Magnocaricetea by the phytosociological classification of Braun – Blanke. The medium moist conditions during all vegetation period are characteristic for *the medium moist meadows*. The plant species adapted to grow in medium rich soils dominate there. The sward of these meadows is composed of several layers. The medium moist meadows are prior protected habitats of EU – Species rich *Nardus* grasslands on siliceous substrates (code 6230), Fennoscandian lowland species-rich dry to mesic grasslands (code 6270) and protected habitats of EU – Lowland hay meadows (code 6510). *The moist meadows* have developed on the banks of the rivers in moist rich and medium rich soils. The several plant species of dicotyledons dominate there. The moist meadows are occurring mainly on the Lielupe right bank. The moist meadows are protected habitats of EU — Lowland hay meadows (code 6510), Northern Boreal alluvial meadows (code 6450), and Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (code 6430). *The wet meadows* are very rare in the territory of Latvia. These meadows are located in lowlands or flood-plain areas that are filled with water all the year. The biological values of the Lielupe flood plain meadows are currently being endangered by anthropogenic influence - recreation and eutrophication. The negative factors of vital importance are overgrowing, irregular cutting and grazing of low intensity. The proposals for management were developed on the base of inventory of natural meadows. Regular cutting is necessary to manage the medium moist, moist meadows in rich soils and wet meadows. Grazing is the most appropriate management for the medium moist meadows in pure soils. The main actions in restoring the Lielupe flood-plain meadows are to prepare site management plan for this reserve and to conduct meadow restoration in most overgrown areas. Methods include shrub removal, destruction of shrub root system, limited hydro-technical works, controlled burning, initial mowing, experimental grazing. The obtained numerical data on target species and habitats before and after management help to identify the best methods. Others of foreseen actions are also to exchange information on floodplain meadow management methods. The production of 'best practice' management guidelines will be carried out. An important point is to assist individual landowners in preparing applications for agri-environmental support to ensure future management of restored floodplain meadows.

Literatūra

1. Bioloģiskās daudzveidības nacionālā programma. 2000. Rīga, Vides aizsardzības un reģionālās attīstības ministrija. 51 lpp.
2. Braun- Blanquet J. 1964. Pflancensociologie. Grundzuge der Vegetationskunde.- Wien, New York, Springer Verlag, 865 S.
3. Bušs K., Gavrilova Ģ., Tabaka L., Vimba E. 1984. Augu valsts. Latvijas Padomju enciklopēdija 5_2. sējums. Rīga, Galvenā enciklopēdiju redakcija. 80 – 83 lpp.
4. Dabas liegums "Lielupes palienes pļavas" – Dabas aizsardzības plāna pirmā redakcija. 2002. Rīga, SIA "Estonian, Latvian & Lithanian Environment". 29 lpp. (nepublicēts)
5. Galeniece M., Tabaka L., Birkmane K. 1958. Latvijas PSR veģetācija. Rīga, Latvijas PSR Zinātņu akadēmijas izdevniecība, 78 lpp.
6. Jermacāne S. 2004a. Latvijas dabisko zālāju klasifikācija. www.lva.gov.lv/daba/lat/biodiv/lauks_plava_klasif.htm
7. Jermacāne S. 2004b. Latvijas zālāji (pļavas un ganības). www.lva.gov.lv/daba/lat/biodiv/lauks_zalaji
8. Kabucis I. (red.) 2001. Latvijas biotopi klasifikators. Rīga, Latvijas Dabas fonds. 96 lpp.
9. Kabucis I. (red.) 2004. Biotopu rokasgrāmata: Eiropas Savienības aizsargājamie biotopi Latvijā. Rīga, Latvijas Dabas fonds. 160 lpp.
10. Latvijas PSR ģeogrāfija. 1975. Rīga, Zinātne. 671 lpp.
11. LR MK Noteikumi nr. 212 par dabas liegumiem. 1999. www.varam.gov.lv/vad/latviski/likumdosana
12. Mežals G., Skujāns R., Freivalds V. 1970. Augsnes zinātne un Latvijas PSR augsnes. Rīga, Zinātne. 523 lpp.
13. Pakalne M., Znotiņa V. 1992 . Veģetacijas klasifikācija: Brauna - Blanke metode. Riga, 34 lpp.
14. Pott R. 1995. Die Pflanzengesellschaften Deutschlands. Stuttgart, Ulmer 529 s.
15. Račinska I. 2002. Rokasgrāmata īpaši aizsargājamo dabas teritoriju dabas aizsardzības plānu izstrādātājiem. Rīga, Ulma. 96 lpp.
16. Račinskis E., Stīpniece A. 2000. Putniem starptautiski nozīmīgas vietas Latvijā. Rīga, LOB. 184 lpp.

ISBN 9984 – 779 – 06 – 8

17. Tērauds V. 1968. Dabisko pļavu un ganību uzlabošanas jautājumi. Rīga, Liesma. 182 lpp.
18. Tērauds V. 1972. Pļavas un ganības. Rīga, Zvaigzne. 306 lpp.
19. Vides nacionālā monitoringa programma – Bioloģiskās daudzveidības monitoringa daļa. 2002. Rīga, Vides aizsardzības un reģionālās attīstības ministrija. 59 lpp.
20. Wade M., Joyce C. 1998. European wet grasslands: biodiversity, management and restoration. England, John Wiley & Sons Ltd. 339 pg.
21. Znotiņa V. 2002. Pļavas. www.latvijas.daba.lv/biotopi/plavas
22. Сабардина Г.С. 1957. Луговая растительность Латвийской ССР.- Рига, Изд. АН ЛССР, 303 стр.

ISBN 9984 – 779 – 06 – 8

TENTATIVE LEVELS OF POPS IN LITHUANIAN ENVIRONMENT
EKSPERIMENTĀLI NOTEIKTIE POP LĪMEŅI LIETUVAS APKĀRTĒJĀ VIDĒ

***PER-ANDERS BERGQVIST, +VIOLETA KAUNELIENĖ, +*AURELIJA CICĖNAITĖ, +ILONA JEGOROVA, +JOLITA KATKEVIČIŪTĖ**

* Umeå University, Department of Environmental Chemistry, SE-901 87 Umeå, Sweden,
+ Kaunas University of Technology, Chemical Technology Faculty, Department of Environmental Engineering, Radvilenu st. 19, Kaunas LT - 50254, Lithuania
Phone: + 370 610 67601, *e-mail*: aurelija.cicenaite@gmail.com

Abstract. *Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. The Stockholm Convention is a global treaty to protect human health and the environment from POPs. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment. This study was done in order to evaluate tentative POPs levels in Lithuania.*
Limited amount of PAHs and PCBs were analyzed in Šiauliai air, in two biggest Lithuanian rivers – Nemunas and Neris, and in one of the biggest waste landfill in Lapes. Sampling was done using semi permeable membrane devices (SPMDs). The same procedure of sampling and analyses was used to ensure data comparability. In general, POPs pollution levels were compared with results from other studies.
Keywords: *POPs, PAHs, PCBs, SPMDs, environment, Stockholm Convention, air, water, landfill.*

Introduction

Persistent organic pollutants (POPs) is a common name of pollutants group that are semi-volatile, persistent and toxic to humans and wildlife [1, 2]. POPs remain in the environment for long periods, become widely distributed geographically, and accumulate in the fatty tissue of living organisms. This group of pollutants includes some of the most harmful chemicals such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCB), pesticides, dioxins, etc.
The Stockholm Convention is a global treaty to protect human health and the environment from POPs. POPs circulate globally and can cause damage wherever they travel. In implementing the Convention, Governments will take measures to eliminate or reduce the release of POPs into the environment [3, 4]. One of the first steps is estimation of current pollution. The aim of this study was to evaluate the tentative levels pf POPs in Lithuanian environment.
PAHs are of special interest due to their toxicity, carcinogenicity, mutagenicity and wide distribution in the environment [5]. Airborne PAH include substances which, when inhaled, are believed can cause human health effects ranging from nausea and difficulty in breathing to lung cancer [6]. Traffic, domestic heating, refuse burning, petroleum refining, coal coking, tar paper production, aluminum smelting, thermal power, and wood preservation operation using creosote are all examples of major human and industrial PAH sources [5, 7].
PCBs are the class of non-polar, non-flammable, industrial fluids with good thermal and chemical stability, and electrical insulating properties that allowed their application as dielectric fluids in transformers and capacitors, as heat-transfer and hydraulic fluids, as plasticizers in paints, and in the formulation of lubricating and cutting oils, sealants and pressure-sensitive copy paper [8, 9, 10].
Semipermeable membrane device (SPMD) is a passive sampling method commonly used as a time-integrated measure of vapour or aqueous concentrations of persistent hydrophobic chemicals, including PAHs, PCBs and pesticides [11, 12]. The SPMDs technique is based on a

ISBN 9984 – 779 – 06 – 8

simple device which accumulates the compounds in a lipid phase after passage through a diffusion membrane layer [13].

Materials and methods

SPMDs were deployed during 21 days in air and water. At each site, one sampler that included two or one standard SPMDs which were deployed on separate steel spiders inside a metal umbrella, were hung up at about 2-3 meters height or put in stainless steel canisters and left in water.

The umbrella was designed to protect the SPMDs from sunlight, rain, wind and direct particles deposition. Stainless steel canisters were used to protect SPMDs from damages during the sampling. Air was still able to pass freely under and around to the SPMDs.

Sampling sites.

Air. Four SPMDs were deployed in the Šiauliai city. Samples were taken in residential area, private houses area, and city centre, near heavy traffic, during autumn (10/09/2002 – 31/09/2002) and winter seasons (8/12/2002 – 30/12/2002). The average temperature was 7.7^{o}C, average air pressure was 749 mm Hg, average amount of rain was 1.64 mm during the sampling period (21 day).

Rivers. Two Lithuanian rivers – Neris and Nemunas were investigated. The above-mentioned sites in Neris and Nemunas rivers were chosen near various industrial factories in order to estimate their possible influence on rivers pollution with organic pollutants. Sampling time in Neris river was performed from 6/10/2000 – 17/1/2001 and from 6/10/2000 till 27/10/2003 in Nemunas river.

Landfills. *Leachate sampling.* One standard SPMDs were deployed in Lapiu landfill leachate storage reservoir and three membranes were deployed into landfills surrounding streams. The mean water temperature in reservoir and surface waters during the exposure time was about 10^{o}C.

The selected sites descriptions are presented in the Table 1.

Table 1.

Sampling sites descriptions

Air		**River**	
Place name, number of samples	**Exposure site**	**Place name, number of samples**	**Exposure site**
Šiauliai, Baltupėnų str. (S1a), (1 SPMD)	Residential area, district heating	Neris, (2 SPMDs)	Industrial area, Kaunas city centre
Šiauliai, crossroad of two main streets (S2a), (1 SPMD)	City centre, heavy traffic, < 20 m to the street.	Nemunas, (2 SPMDs)	Downstream industrial area (Kaunas city)
Šiauliai, crossroad of two main streets (S3a), (1 SPMD)	City centre, heavy traffic, < 2 m to active street.	**Landfills**	
Šiauliai, Pabalių str. 34 (S4a), (1 SPMD)	Private house area, no district heating	I M, (1 SPMD)	Leachate reservoir
Šiauliai, Medelyno secondary school (S5w) (1 SPMD)	Residential area, central heating, >300 m to a street;	I S, (1 sediments sample)	Stream, about 100 m from leachate treatment plant
Šiauliai, Medelyno kinder garden (S6w), (1 SPMD)	Residential area, central heating, >10 m to a street;	II M, II S, (1 SPMD and 1 sediments sample)	Stream, about 250 m from leachate treatment plant
Šiauliai, Pabaliu str. 34 (S4w), (1 SPMD)	Private house area, no central heating, >20 m to a street;	III M, III S, (1 SPMD and 1 sediments sample)	Marilė stream, about 300 m from landfill
Šiauliai, Zvyro 34 (S7w), (1 SPMD)	Private house area, no central heating, >50 m to a street ;	IV M, IV S, (1 SPMD and 1 sediments sample)	Marilė stream, approximately 2 km from landfill

Explanations: M – membrane, S – sediments;

ISBN 9984 – 779 – 06 – 8

Sediment sampling. The sediments samples were collected into dark glass bottles with aluminium folia under the lid to avoid contamination during transportation. After sampling the sediment samples were stored in a freezer.

Field blank. Four SPMDs as a field blanks were used at sampling sites: two for air, one for rivers and one for landfills. Standard SPMD was kept in air during deployment of membrane. Such field blank account for the contamination of the SPMDs by transportation (e.g. airborne chemicals). During analysis it was treated in the same way as deployed devices, with the exception that it wasn't exposed to water.

Before and after sampling, the SPMDs were stored at -18 ^{o}C in sealed solvent cleaned tin cans, to avoid accumulation of contaminants from the outer surface into the membrane after the sampling period was finished.

SPMDs extraction, cleanup and analyses.

All solvents used in the study were of glass-distilled quality (Burdick & Jackson, Neuulm, Germany).

In order to clean membrane surface from particles and lipids, SPMDs were washed in clean water, n-hexane and 1 M HCl. The membranes were carefully dried before dialysis. The compounds were dialyzed with cyclopentane: dichlormethane (95:5) mixture for three times. After extraction, three ^{2}H-labeled PAH standards and eight ^{13}C-labeled PCBs were added as internal standard for a cleanup. The spiked extracts were fractionated by gel permeation chromatography (GPC) technique as detailed in "ExposMeter" recommendations or Bergqvist et al. manuscript [13, 14]. Different columns were used in this investigation from those in the cited study, namely a 300 × 22.5 mm Envirosep-ABC HR-GPC column and a 75 × 22.5 mm Envirosep-ABC guard column. The GPC-fractions were followed by a silica column (10 mm i.d.). Further, samples were eluted with hexane: dichloromethane (1:1) and were evaporated by using rotary evaporator, for further evaporation - a stream of nitrogen. The known amount of ^{2}H–labeled dibenzofurane (Promochem, Kungsbacka, Sweden) was added just before instrumental analyses and used as recovery standard (RS). PAHs and PCBs were identified by GC/MS as described in "ExposMeter" recommendations or Bergqvist et al. manuscript [13, 14].

All results were corrected by using recovery values from the most structurally similar internal standard. Recoveries of PAHs and PCBs standards are reported in Table 2.

Table 2.

IS recoveries (numbers are given in percents)

Compound	S1a	S2a	S3a	S4a	S5w	S6w	S4w	S7w	I M	II M	III M	IV M	I S	II S	III S	IV S	Neris1	Neris2	Nemunas
PAH, %																			
IS-ACE	182	170	126	82	62	86	69	124	77	72	44	74	73	31	33	55	26	29	71
IS- FL	157	153	136	139	62	86	69	124	108	104	55	104	103	42	78	206	68	79	73
IS-BP	139	140	135	132	99	85	113	98	105	81	29	53	133	17	6	194	91	66	79
PCB, %																			
IS #28	97	85	9	6	54	62	57	15	107	147	50	101	93	35	86	92	87	89	85
IS #52	112	86	52	61	62	64	66	22	94	135	48	92	35	32	71	82	43	70	74
IS #101	52	49	66	41	52	60	58	61	84	154	50	101	93	36	90	94	65	41	35
IS #118	128	102	112	80	79	92	81	88	122	158	54	105	99	40	99	105	69	71	72
IS #105	91	78	74	61	73	85	78	81	117	153	53	107	125	39	99	102	69	77	79
IS #153	99	97	102	77	76	82	73	71	90	153	47	94	91	36	89	92	79	76	78
IS #138	124	101	109	82	67	82	75	74	115	135	45	87	30	34	85	87	75	73	75
IS #180	105	95	103	77	72	83	73	79	113	116	50	98	23	37	94	93	70	63	64

ISBN 9984 – 779 – 06 – 8

Sediments samples preparation. Sediments were dried in the oven for couple of days at 40°C temperature until constant weight. Then 10-20% (about 1g) of each sample was dried in the oven at 110°C until constant weight and dry weight of the samples was calculated, further, samples were placed in the oven at 500°C over the night, to determine total amount of the organic carbon (TOC) in the samples. The portion of the solution of labelled ^{13}C compounds used for the SPMD analyses as Internal Standard was added, and the sediment samples were extracted using the Soxhlet extractor with 170ml of toluene for each sample over the night. The extract was further cleaned with GPC-system and the silica gel column as described above.

Analysis. SPMD samples from landfills were prepared the same way as described above, but different instrument was used. High resolution gas chromatography (HRGC)/low resolution mass spectrometry (LRMS) - instrument system used in the analysis for landfill samples, included a non-polar capillary column (J&W DB-5, 60 m* 0.32 mm i.d., 0.25-mm film thickness Folsom, CA, USA) and a Fisons MD 800/GC 8000 operating in selected ion recording (SIR) mode. In the mass spectrometry, an auto sampler injects 1μl samples into a split less injector. In the SIR mode two most abundant ions of the native compounds and the standards are monitored. The instrument detection limit (IDL) refers to the smallest signal above background noise that an instrument can reliably detect (approximately 1 pg/injection). The analyzed compounds from the sample's chromatograms were identified by retention time. Recoveries of PAH and PCB standards are reported in Table 2.

The amounts of investigated pollutants were calculated by using "ExposMeter" recommendations and reported in *ng/m³* for air, *ng/l* for water and *ng/g* dry weight for sediments [13].

Results

ΣPAH_{16} (US EPA) and ΣPAH_{24} concentrations in landfill sediment samples varied, respectively, between 53 – 293 ng/g d.w. and 63 - 408 ng/g d.w.; in atmospheric gas phase ranged between 48 - 275 ng/m³ and 54 – 336 ng/m³; in rivers –were found between 16 - 23 ng/l and 20- 24 ng/l; and, as was mentioned above, lowest PAHs concentrations were found in landfill streams water samples, and varied between 4-12 ng/l (ΣPAH_{15}) and 5-15 ng/l (ΣPAH_{24}) (Fig. 1).

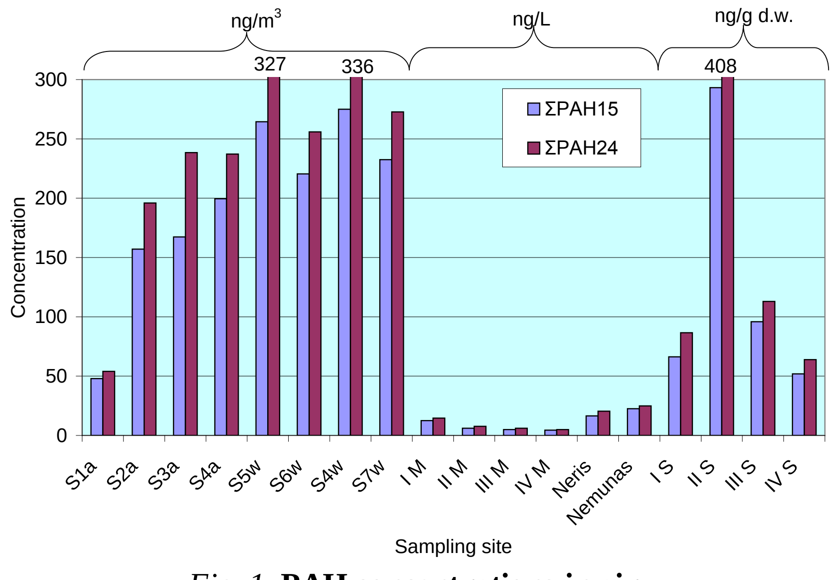


Fig. 1. **PAH concentrations in air**

PCB levels estimated are presented in Fig. 2. ΣPCB_{11} concentrations in landfill sediment samples varied between 0.81 – 117.15 ng/g d.w.; in rivers and landfill streams water samples, respectively, concentrations varied 1.02 – 1.3216 and 0.06 – 4.43 ng/l; ΣPCB_{11} concentrations in atmospheric gas phase ranged between 0.19 – 0.27 ng/m³.

ISBN 9984 – 779 – 06 – 8

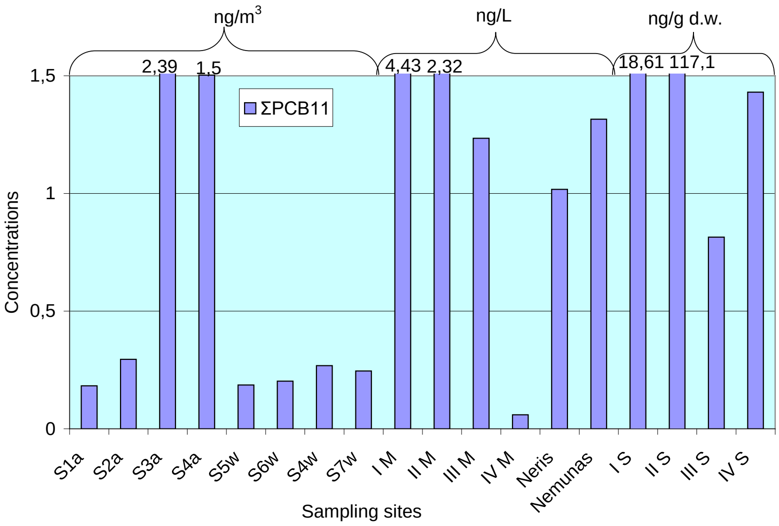
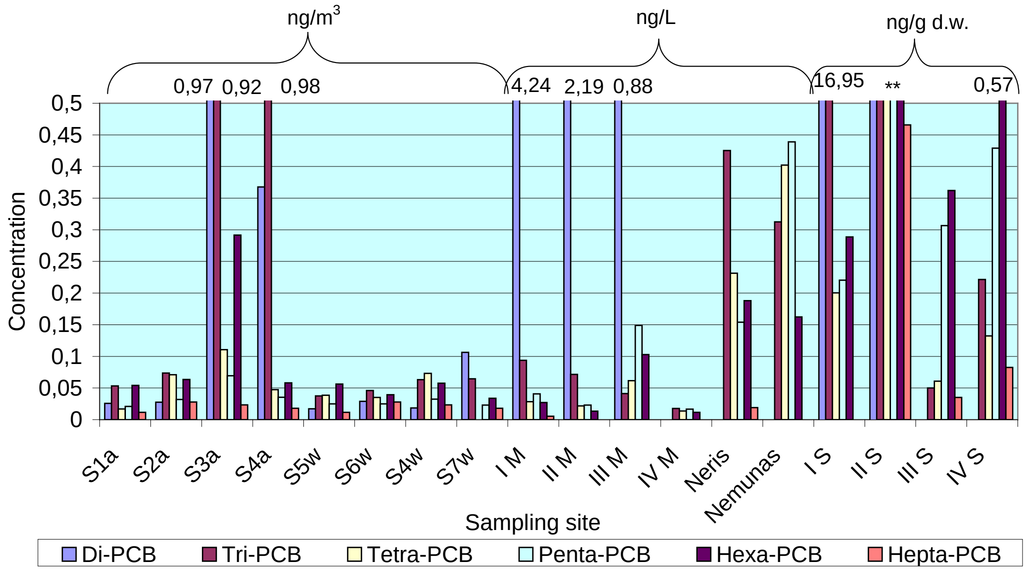


Fig. 2. **ΣPCB$_{11}$ concentrations at sampling places**



** Di-PCB 101,77; Tri-PCB 3,75; Tetra-PCB 2,07; Penta-PCB 4,59; Hexa-PCB 4,50;

Fig. 3. **Concentrations of PCBs congener groups at sampling places**

Discussion

PAHs. It is surprising that relatively low PAHs concentrations in landfill surrounding comparing with PAHs levels in Lithuanian rivers were detected. This presumably indicates that emissions of PAHs to rivers from industry are quite high.

The total sum of 15 U.S. EPA PAHs in landfill samples, showed a net decline in concentrations going further from landfill, as it could be expected.

Naphthalene is one of the most volatile PAHs and therefore easy to loose in the analysis. It could be that naphthalene calculated concentrations are too low; this should be taken into consideration. Due to the chromatographic interferences the determination of fluorine in many landfills samples was impossible. For this reason it was excluded from US EPA 16. Phenanthrene was the most abundant individual PAHs in all samples, except sediment samples. Concentrations in air samples ranged between 23 ng/m^3 and 109 ng/m^3, in river samples varied from 3.27 to 7.69 ng/l, in landfill's water samples concentrations were 0.64 – 5.81 ng/l, in sediments – from 2.86 to 34.83 ng/g d.w.

PCBs. Elevated PCBs concentrations were found in water samples close to landfill leachate treatment plant, going further from it PCBs concentrations in water samples decreases and

ISBN 9984 – 779 – 06 – 8

increases in sediments. It is known that PCBs tend to be associated with particles or with and organic carbon.
25 of 28 targeted PCB congeners were detected in Neris and Nemunas. The background site values were exceeded by most of the PCBs congener concentrations in Nemunas river and vary from 0,06 to 0,3 ng/L for each congener. In Neris concentration of PCBs#28 (0,43 ng/L) was elevated compare with the concentration of other PCB congeners such as PCB#31 (0,24 ng/L), PCB#44 (0,134 ng/L), PCB#52 (0,14 ng/L), PCB#110 (0,164 ng/L). Since the concentration of PCB #28 and #31 was found to be elevated compared to the more chlorinated congeners, it is suggested that the pollution in Neris might be recent, consist of fresh PCB and/or close to ongoing effluent. Such PCB pattern might also be influenced by the highly chlorinated PCB congeners tendency to be bound to dissolved organic matter and suspended particulate material within the water column reducing their availability for membrane uptake.
The PCBs profile of congener group concentrations in 8 sampling places (S3a, S4a, S7w, I M, II M, III M, I S, II S) are dominated by Di-PCBs, followed by Tri-PCBs, Fig. 3. Concentration of different PCB homologues decreased from PCB #15 to PCBs #180, indicating that there might be fresh pollution of PCBs source, as these PCBs (di-, tri-) are very volatile and their concentrations tend to decrease significantly in a few years. Thereby, the strong temperature dependence of vapor pressure, and the rate of evaporation from various environmental surfaces, has been shown to affect the atmospheric concentrations of PCBs congener distribution [15, 16]. Temperature dependency is generally increasing with the degree of chlorination [17].
Consequently, results indicated high Di-PCBs concentrations in landfill surrounding streams (fresh pollution source), but others PCBs congeners concentrations were relatively low compared to PCBs concentrations found in rivers (Fig. 3). Concentrations in water close to landfill (M) and in sediments (S) showed that there was a leak of PCBs from landfill (Fig. 1, 2, 3). Elevated PCBs concentrations in sediments samples could be related to PCBs association with particles or with/and organic carbon.
Significantly lower concentrations of PCBs were found in air winter samples than in air autumn samples, this appearance could be related to lower temperatures and correspondingly less volatilization (Fig. 2).

Acknowledgment

This study was funded by Swedish Institute, Umeå University and Kaunas University of Technology. Special thanks to the Department of Environmental Chemistry (Umeå University) and Department of Environmental engineering (Kaunas University of Technology).

Conclusions

In this screening study wide range of PAHs and some PCBs were analyzed from different environmental medias. The highest PAHs concentrations were found in the air, because of their evaporation. PAHs concentrations were highest close to the heavy traffic. In Šiauliai air autumn samples di-, tri- PCBs indicated fresh undiscovered PCBs pollution source. Air samples were approximately six times more polluted with analyzed PAHs and three times more polluted with analyzed PCBs in comparison with Swedish urban background sites. Results indicated that rivers are more polluted with POP's compared with stream waters close to landfills. Higher concentration of PCB#28 (0,43 ng/L), to compare with PCB#110 (0,16 ng/L), might reflect recent pollution in Neris river. In general PCB and PAH levels in Lithuanian rivers were 2-10 times higher than the corresponding values from Swedish waters. The total sum of EPA 15 PAHs showed a net decline in concentrations going further from the landfill (from 11,76 to 1,82 ng/l).

ISBN 9984 – 779 – 06 – 8

References

1. Vallack, H. W., Bakker, D.J., Brandt, I., Brorström-Lunden,E., Brouwer, A., Bull, K.R., Gough, C., Guardans, R., Holoubek, I., McCutchheon, P., Mocarelli, P., Taalman, R.D.F.,. Controling persistent organi pollutants – what next? Environmental Toxicology and Pharmacology 6 (3), 1998. p.143-175.
2. Commission of the European Communities (2003.06.12) Regulation of the European Parliament and of the Council on persistent organic pollutants and amending Directives 79/117/EEC and 96/59/EC, Brussels.
3. http://www.pops.int/. Stockholm convention on persistent organic pollutants (POPs). (Review 2004/12/22).
4. http://www.ec.gc.ca/international/multilat/stock_e.htm#sta. La Voie verte – The green Lane. Last update 2003/03/07. (Rewiev 2004/12/24)
5. Aderemi O. Ogunfowokan. Isolation and determination of polycyclic aromatic hydrocarbons in surface runoff and sediments, Water, Air, and Soil Pollution 147, 2003. p. 245-261.
6. http://www.inchem.org/documents/ehc/ehc/ehc202.htm#SubSectionNumber:7.1.1.Chemical Safety Information from Intergovernmental Organizations. (Review 2004/12/17).
7. Lohmann R., Corrigan B. P., Howsam M., Jones K. C., Ockenden W. A.. Further developments in the use of semipermeable membrane devices (SPMDs) as passive air samplers for persistent organic pollutants: field application in a spatial survey of PCDD/Fs and PAHs. Environmental science technology, 35, 2001. p. 2576-2582.
8. Syed R.Qasim, W.Chiang Sanitary landfill leachate: Generation, Control and Treatment, 1994. ISBN No. 1-56676-129-8.
9. Conell, Desley W. Basic concepts of environmental chemistry. 1997
10. Persistent Organic Pollutants. A Swedish View of an International Problem // Swedish Environmental Protection Agency.
11. Drew R. Luellen, Damian Shea. Semipermeable membrane devices accumulate conserved ratios of sterane and hopane petroleum biomarkers. Chemosphere, Vol. 53, 2003. p. 705-713.
12. J.N. Huckins, J.D. Petty, C.E. Orazio, J.A. Lebo, R.C. Clark, V.L. Gibson, W.R. Gala, K.R.Echols. Determination of uptake kinetics (sampling rates) by lipid containing semipermeable membrane devices (SPMDs) for polycyclic aromatic hydrocarbons (PAHs) in water. . Environmental science and technology. 33, 1999, 3918-3923
13. www.exposmeter.com. Exposmeter sampling technologies. (Review 2004/12/17)
14. P.A. Bergqvist, B. Strandberg, R. Ekelund, C. Rappe, A. Granmo. Temporal monitoring of organochlorine compounds in the sea water by semipermeable membranes following a flooding episode in western Europe. Environmental science and technology. 32 (24), 1998, p. 3887-3892.
15. Wania, F., Mackay, D. Global fractionation and cold condensation of low volatility organochlorine compounds in polar regions Ambio 22 (1). 1993. p.10-18.
16. Wania, f., Haugen, J.E., Lei, Y.D., Mackay, D. temperature dependence of atmospheric concentrations of semi-volatile organic compounds. Environmental science and technology. 32. 1998. p. 1013-1021.
17. Breivik, K., Alcock, R., Li, Y.F., Bailey R.E., Fiedler H., Pacyna J.M. Primary sources of selected POPs: regional and global scale emission inventories. Environmental pollution. 128. 2004. p.3-16.

ISBN 9984 – 779 – 06 – 8

INFLUENCE OF WASTE DUMP "CHROBRÓW" IN POLAND ON GROUND - AND SURFACE WATER
ATKRITUMU IZGĀZTUVES „CHROBROW" (POLIJA) IETEKME UZ GRUNTSŪDEŅIEM UN VIRSZEMES ŪDEŅIEM

AGNIESZKA GONTASZEWSKA, ANDRZEJ KRAIŃSKI

University of Zielona Góra,
ul. Z.Szafrana 2, 65-001 Zielona Góra, Poland
Phone: + 48 683282427, *e-mail*: A.Gontaszewska@ib.uz.zgora.pl

Abstract. *In paper an influence of waste dump "Chrobrów" on groundwater and tributary of the Bóbr river was described. This waste dump was installed in former gravel excavation. For first 10 years it had no leak stopper and sewage water could freely infiltrate. Geological structure of the waste dump subsoil is unfavourable because garbage are directly stored on gravels with high filtration coefficient which make migration of pollutants easy. At the moment the waste dump has a leak stopper made from bentonite composite but there are still polluted grounds underneath. In this paper was analyzed data about ground- and surface water quality from years 1994 – 2004. It was found that the quality of groundwater deteriorated, especially in years 1999 and 2002. The most worsening was noted in case of chlorides, ammonia nitrogen, sodium and potassium. Unfortunately there is no data before 1994 so there is no information about hydrogeochemical background. Increased values of all groundwater components in first period of investigation are results of exploitation in years 1984 – 1994, when waste dump had no leak stopper. But later deterioration of groundwater quality can not be explained in this way. It should be drawn a conclusion that the seal of waste dump bottom does not work correctly. It was found that there is no negative impact of waste dump on surface water what is caused by absence of hydraulic contact between river and groundwater on investigated area.*

Keywords. *Waste dump, waste water infiltration, groundwater contamination, groundwater pollutants*.

Introduction

Waste dump „Chrobrów" accumulates solid wastes from Żagań – a town in the south-west part of Poland (about 50 000 inhabitants). It is located on the south edge of Chrobrów village which is situated about 6 km east from Żagań (Fig.1.). Ca. 30 m from the north border of waste dump there is a small stream – a tributary of Bóbr river (Fig.2.).

The waste dump "Chrobrów" is located on the grounds at an exploited gravel mine, one of many in the Bóbr river surroundings. Initially, in years 1985-1994, municipal wastes were stored directly in the mine's trough. In years 1994-96 the waste dump's wall and bottom were sealed with a lining of bentonite composite. This leak stopper prevents migration of effluxes from waste dump into soil and groundwater. A drainage system (above and beneath leak stopper) was also made. Drainage waters are collected in separated reservoirs. Waters from drainage above the leak stopper are exported to waste water treatment plant and waters from drainage beneath leak stopper become totally evaporated. At the moment (2004) the whole mine troughs are completely filled and overground part of waste dump has reached assumed height. A closure and the beginning of land reclamation in years 2005-2006 is planned.

Geological structure

The described area is located in the north part of Żagań-Valley (Kotlina Żagańska). This valley was created in place where four river come together: Bóbr (main river) and its tributaries: Kwisa, Czarna and Szprotawa. The valley's bed is composed from Pleistocene and Holocene fluvial (river) deposits (Kondracki, 2001).

The geological structure of the subsoil of the waste dump is presented on three geological cross-sections (Fig.3., Fig.4., Fig.5.). Two geological complexes of deposits can be distinguished: glacial and fluvioglacial (glacial outwash). Glacial deposits are represented by glacial till. from Saale glaciation (Drenthe stage).

ISBN 9984 – 779 – 06 – 8

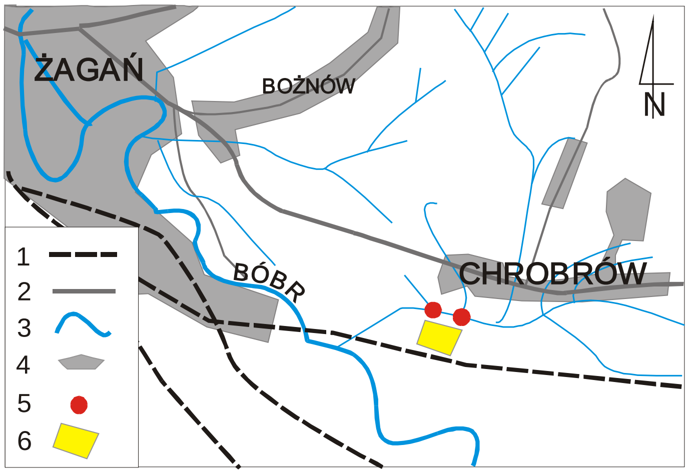


Fig. 1. **Map of environs of waste dump**

Explanations: 1 – railway trucks; 2 – roads; 3 – rivers; 4 – urban areas; 5 – points of sampling of surface water; 6 – waste dump.

The roof surface occurs irregularly, ca on 110 – 114 m a.s.l. In the south and west part of the mentioned area glacial till occur directly on the ground surface (ca 120 m a.s.l.). The glacial till of Saale glaciation is tens of meters thick [3.4]. In a lithological meaning this tills are mainly clays and sandy clays.

Fluvioglacial deposits are represented mainly by gravels, rarely by sands with different granulation with gravel admixture. In stratigraphic respect this deposits might be connected with one of the sander level of Saale glaciation (Warthe stage).

The hydrogeological conditions of the waste dump subsoil are simply. Groundwater flows into north east, in the direction of the stream (Fig.1., Fig.2.). The table of the stream water is situated above groundwater level (Fig.4.).

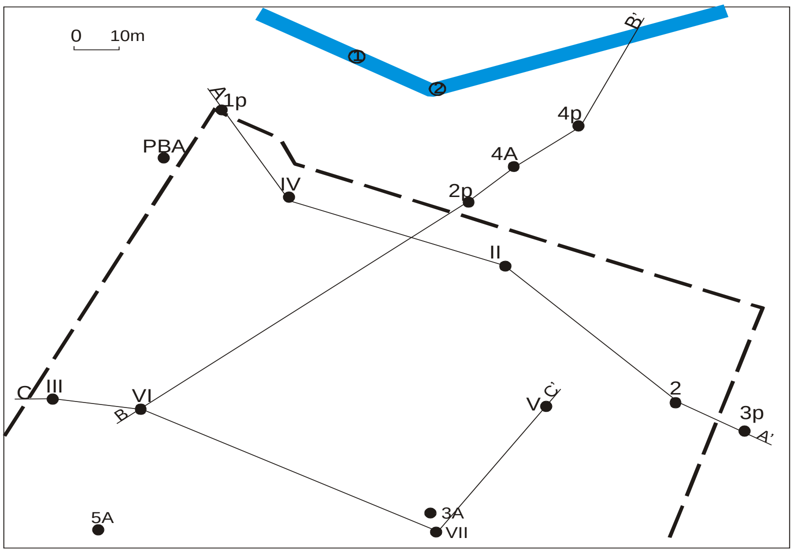


Fig. 2. **Site plan of waste dump „Chrobrów” and lines of geological cross-section.**

1p, 2p, 3p, 4p – sampling points of groundwater; 1, 2 – sampling points of surface water.

ISBN 9984 – 779 – 06 – 8

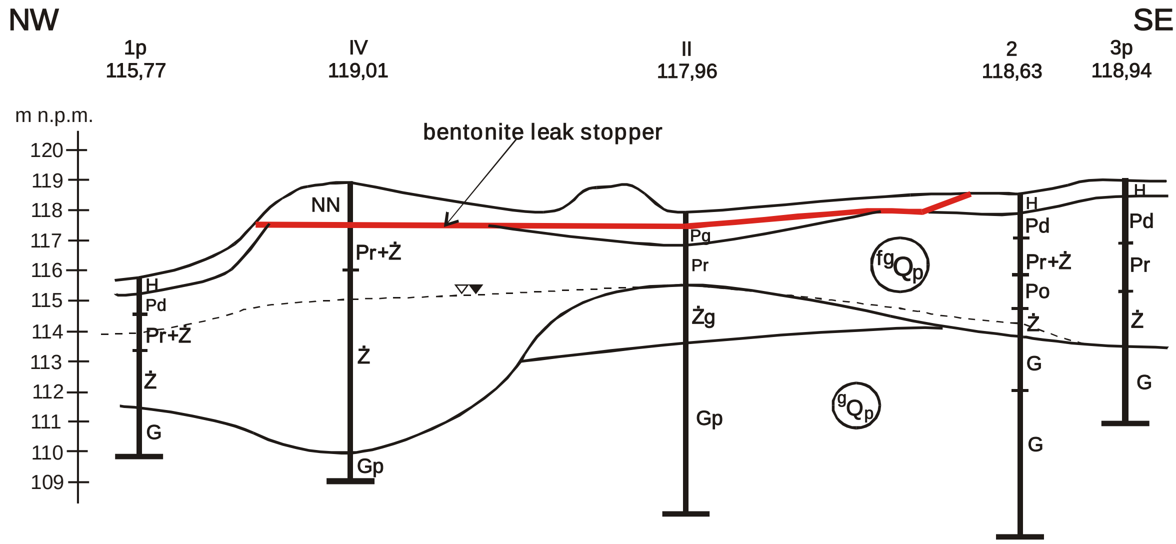


Fig. 3. **Geological cross-section A-A'**

Explanations: H- soil; NN – wastes; Pg- clayey sand, Pd – fine sand; Pr – coarse sand; Ż –gravel; G – clay; Gp – sandy clay.

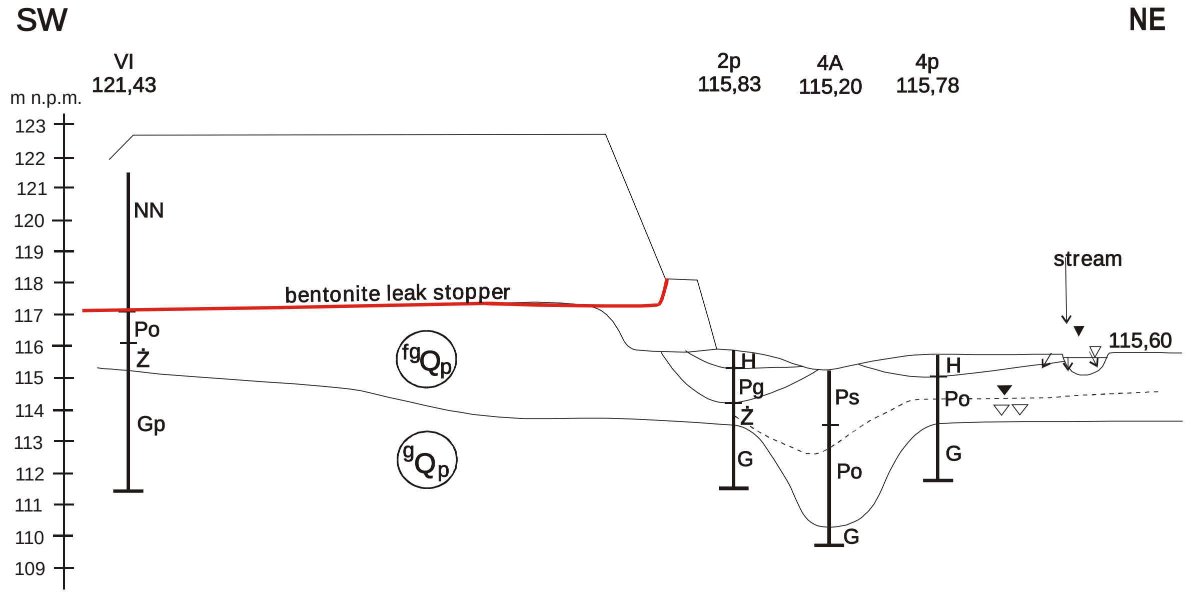


Fig. 4. **Geological cross-section B-B'**

Explanations – see Fig.3.

Changes of chemical composition of groundwater and surface water.

Discussion

The influence of the waste dump on the quality of ground- and surface water is periodically controlled in points of local monitoring net. This monitoring net is composed of four points of groundwater samples (piezometers) and two points of stream water samples (tributary of Bóbr river) (Fig.2.). All piezometers are installed in the north part of the investigated area, where the groundwater runs off from the waste dump. The monitoring net was installed in 1994, equivalently to leak stopper execution. All stored wastes were transferred into the sealed part of the waste dump. Presently the leak stopper made of bentonite composite is beneath the whole waste dump.

Laboratory tests of composition of ground- and surface water are run each three months and waste dump efflux – each six months. All the basic parameters, ions and heavy metals are examined.

ISBN 9984 – 779 – 06 – 8

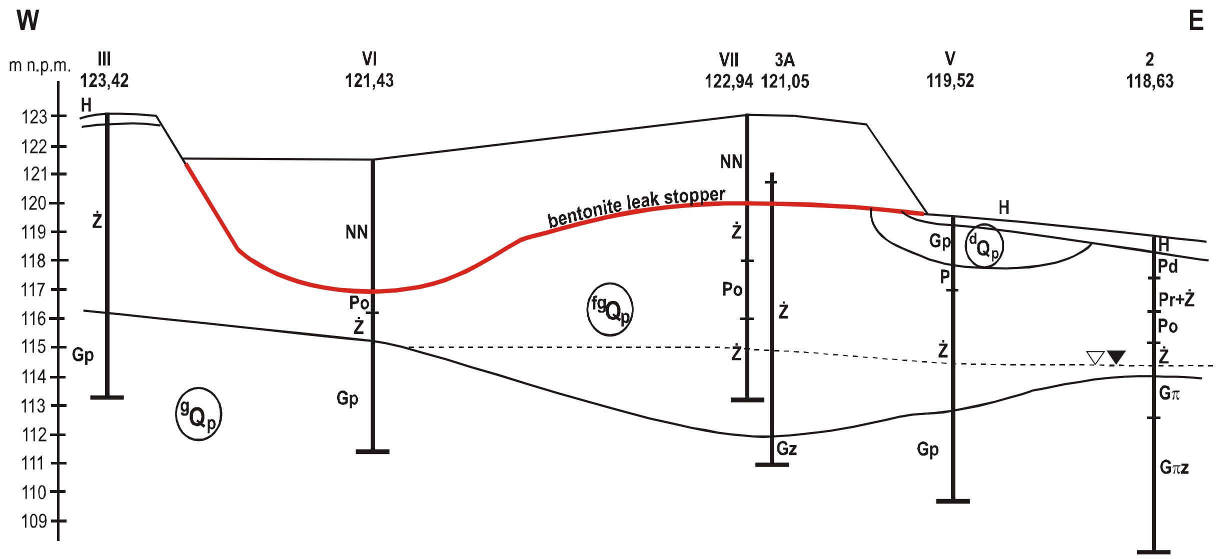


Fig. 5. **Geological cross-section C-C'**
Explanations – see Fig.3.

Unfortunately there is no data for years 1997-1998 and the piezometers P-2 and P-3 are dry since 1999 in consequence of groundwater level decreasing.

pH-value and contents of most important components of ground- and surface water are shown in diagrams below (Fig.6. - Fig.11.).

The analyse of those diagrams show that the discussed years (1994-2004) can be divided with respect of the groundwater quality into three periods: 1994–1996; 1999–2001 and 2002–2004. It is especially well demonstrated in case of potassium (Fig. 12), chlorides (Fig. 8.) and total solids (Fig. 10.).

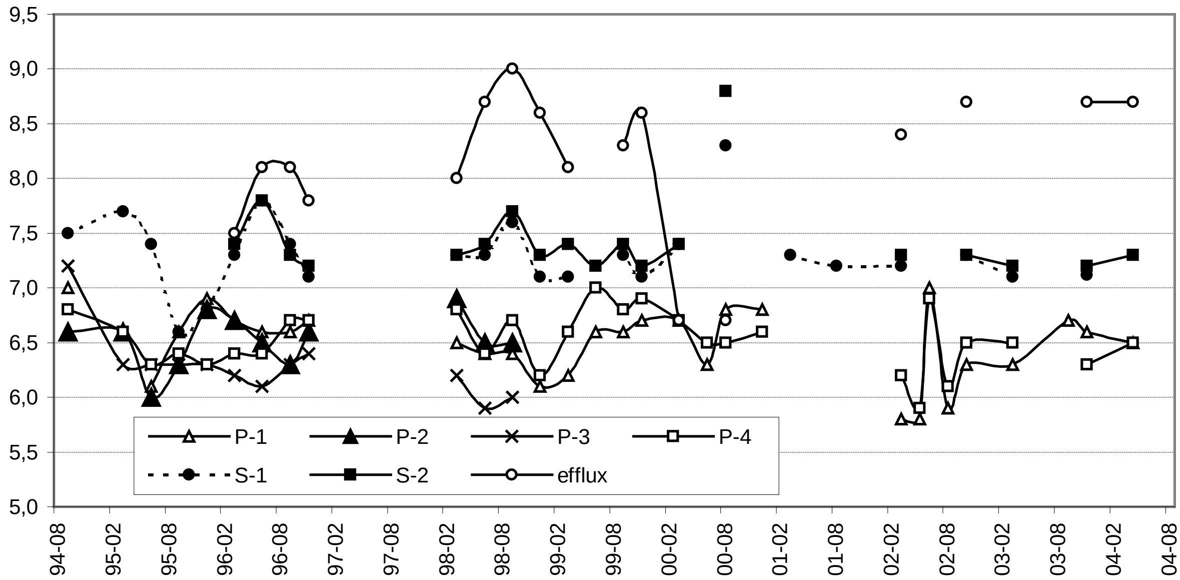


Fig. 6. **pH-value of surface water, groundwater and efflux.**

Explanations: P-1, P-2, P-3, P-4 – piezometers; S-1, S-2, – sample of surface water

ISBN 9984 – 779 – 06 – 8

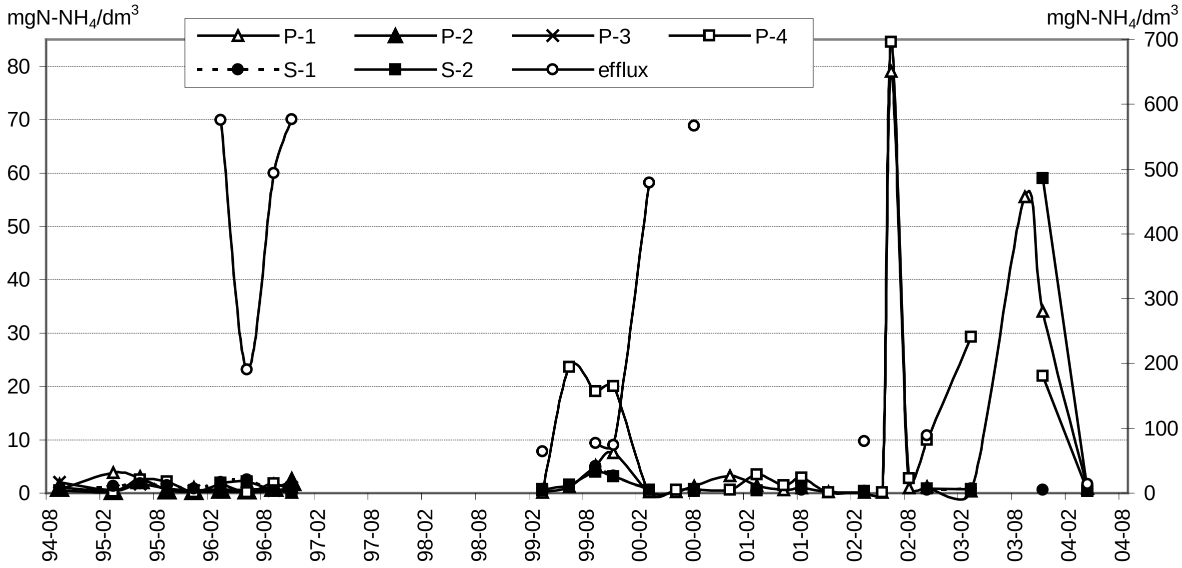


Fig. 7. **Value of ammonia nitrogen of surface water, groundwater and efflux.**
Explanations: See Fig.6. Right axis concerns to efflux.

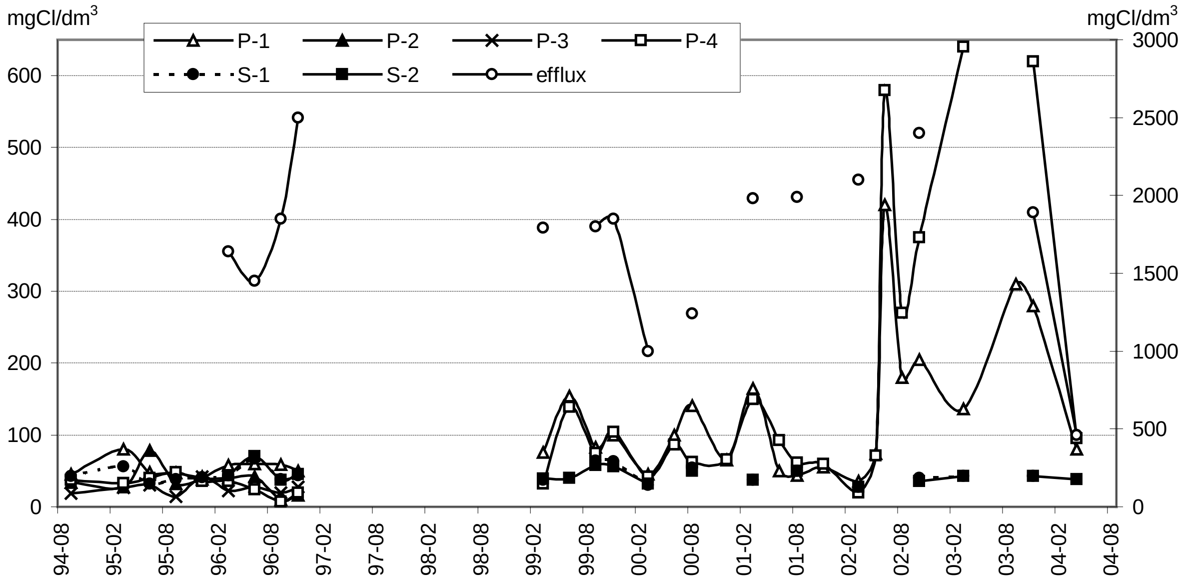


Fig. 8. **Value of chlorides of surface water, groundwater and efflux.**
Explanations: See Fig.6. Right axis concerns to efflux.

ISBN 9984 – 779 – 06 – 8

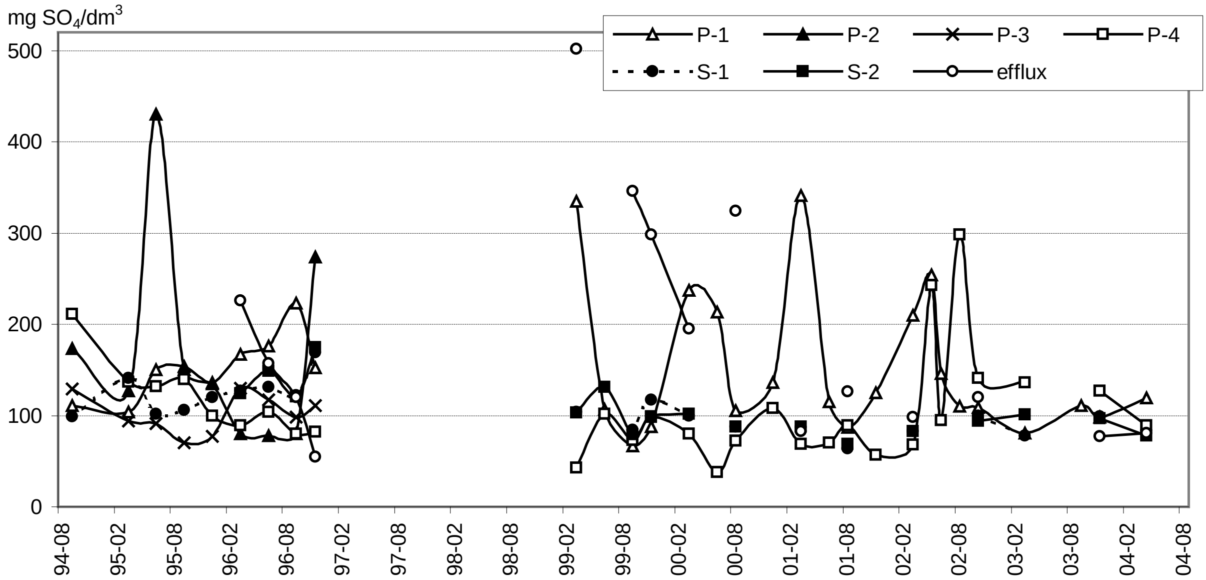


Fig. 9. **Value of sulphates of surface water, groundwater and efflux.**
Explanations: See Fig.6.

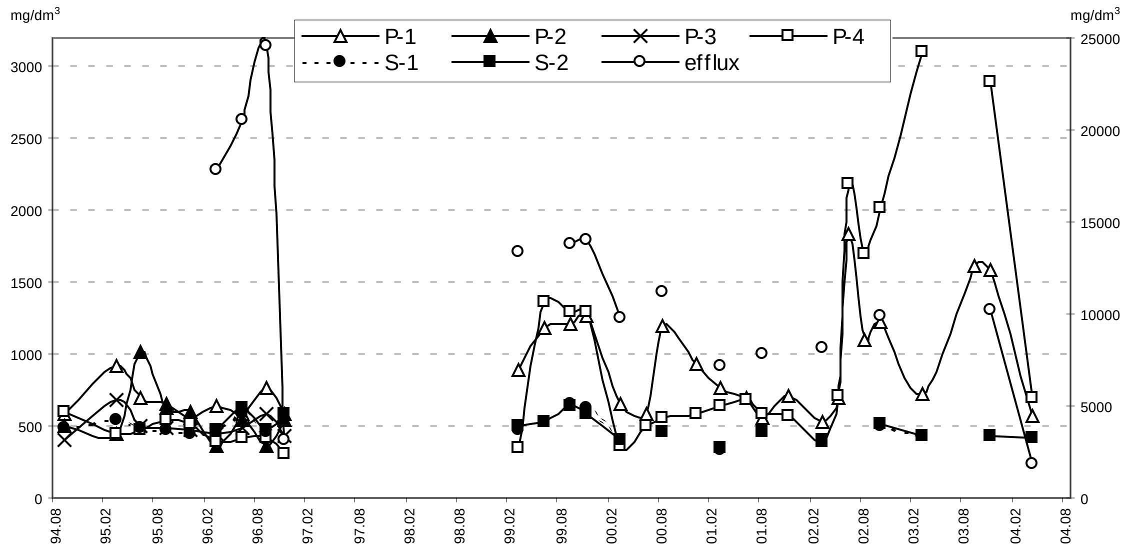


Fig. 10. **Value of total solids of surface water, groundwater and efflux.**
Explanations: See Fig.6. Right axis concerns to efflux.

ISBN 9984 – 779 – 06 – 8

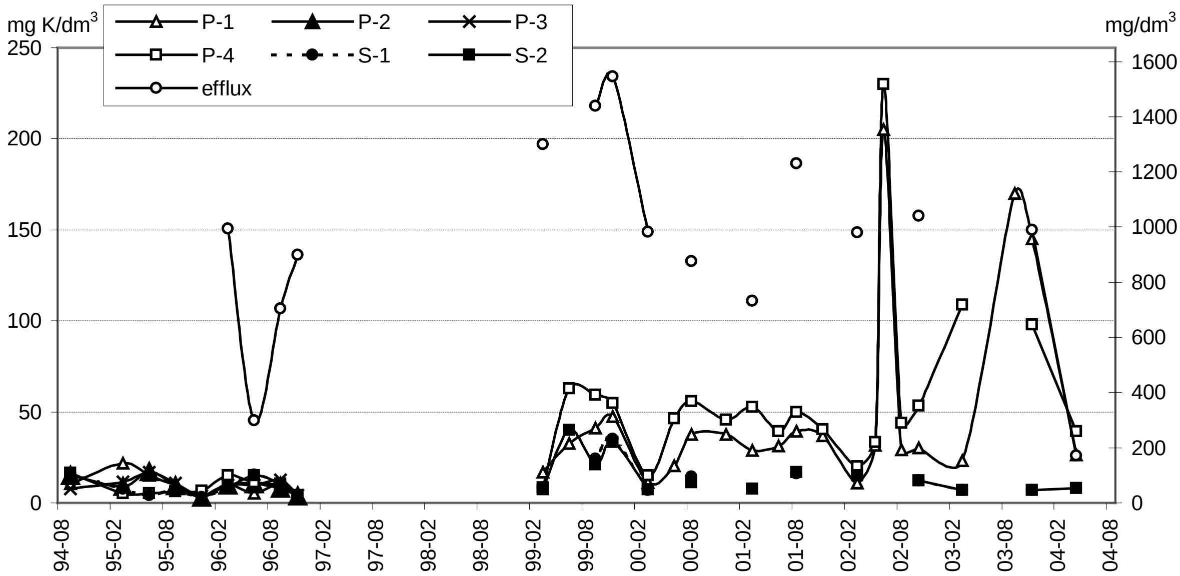


Fig.11. **Value of potassium of surface water, groundwater and efflux.**
Explanations: See Fig.6. Right axis concerns to efflux.

Table 1.

Average values of some components of groundwater and waste dump efflux in years 1994-2004

component	point of sampling	average value in years			% increment in years 1994 - 2004
		1994-1996	1999-2001	2002-2004	
chlorides Cl^-	P-1	54,3	84,9	230,1	324
	P-4	31,2	75,8	430,0	1278
	efflux	1860	1719	1583	-
sulphates SO_4^{2-}	P-1	152,6	172,9	110,6	-
	P-4	119,4	86,4	147,7	24
	efflux	139,5	246,5	92,7	-
ammonia nitrogen NH_4^+	P-1	1,1	1,6	24,5	2127
	P-4	1,0	5,2	24,8	2380
	efflux	459,4	223,5	51,3	-
sodium Na^+	P-1	25,2	67,5	169,0	570
	P-4	11,6	42,6	230,3	1885
	efflux	781	1250	539	-
potassium K^+	P-1	10,2	30,3	89,8	780
	P-4	8,9	41,7	95,6	974
	efflux	725	1136	734	-
total solids (TS)	P-1	666,4	841,5	1234,6	85
	P-4	455,7	732,1	2101,3	361
	efflux	16525	10290	7316	-

During the first period (1994-1996) parameters of groundwater and surface water had had similar value but later groundwater quality worsened. First worsening took place in 1999, next in 2002. The quality of surface (stream) water has remained without any changes or has even improve (e.g. sulphates – Fig. 8.) in the whole period of test. It means there is no connection between groundwater and surface water on the investigated area what is also shown on the geological cross-section (Fig. 4.). The hydrogeological conditions prevent pollutants migration from waste dump efflux to surface water. In Table 1. the authors have presented average values of the most important and the quickest migrating ions of groundwater and waste dump efflux. Only the

ISBN 9984 – 779 – 06 – 8

piezometers (P-1 and P-4) which were in operation during the whole period of investigation were considered. During the 10-years period of observation the value of ammonia nitrogen risen by more than 2000% and chlorides and sodium by more than 1000%. A general content of ions expressed as total solids increased in piezometer P-1 by 85% and in P-4 by 361%. The contents of particular ions of groundwater do not correlate with its contents in waste dump efflux. Almost all waste dump efflux components have lower values than the initial ones. Chemical content of waste dump efflux is situated in a typical range for municipal waste dump effluxes [1].

Conclusions

Improper preparation of location of to waste dump storage is the most important reason of groundwater contamination [2]. The risk of groundwater contamination occurs even though all available preventives are applied. Storage of solid waste material on the waste dump is still the cheapest method of their removal. Ca 70% of wastes in the EU states are stored on waste dumps. The other advantage of this method is possibility of methane producing or waste processing in the future.

The waste dump „Chrobrów" was founded in very unfavourable conditions: in an artificial area hollow in former gravel excavation.

There were a gravel and coarse sand layer with thickness from 2 to teens meters thick in waste dump subsoil. Besides there was a groundwater table in this layer. Filtering polluted water from waste dump could migrate deep into the ground till the roof of impermeable formation and then move with groundwater. It was only 10 years after the waste damp operation when a decision was made to install a leak stopper. Quality monitoring net of ground- and surface water was installed in 1994 so there is no information about the hydrogeochemical background of groundwater. Data from the first investigation period (1994 – 1998) shows increased values of some components (sulphates, Fig.9.) which might be caused by pollutants migration from waste dump [5]. Installing of bentonite leak stopper in 1994 did not cause gradual improvement of groundwater quality. This quality remained on the same level and then it deteriorated considerably in 1999 and then in 2002. This effect should not occur if the leak stopper operated correctly. A conclusion can be drawn that the leak stopper has been damaged and there is a gap where the pollutants can filter into a deeper layer of the subsoil. There is also possibility that the parts of the leak stopper have been welded incorrectly [6].

In connection with the planned closure of the waste dump and its recultivation the technical condition of bentonite leak stopper should be precisely investigated.

The remaining of defected stopper is a menace of long-lasting negative influence on groundwater under the closed waste dump in next tens of years.

References

1. Alloway B.J. & Ayres D.C. 1999 – Chemiczne podstawy zanieczyszczenia środowiska. Wyd. Naukowe PWN.
2. Bartosewicz S. 2002 - Wycieki ze składowisk odpadów zagrożeniem dla wód powierzchniowych i gruntowych. Odpady i środowisko. 16: 50-54.
3. Jeziorski J. 1989 - Zjawiska glacitektoniczne kształtujące podłoże osadów czwartorzędowych południowo-zachodniej części Ziemi Lubuskiej. VIth Glacitectonics Symposium, Zielona Góra : 65-80.
4. Lindner L. 1992 - Czwartorzęd, Wyd. PAE.
5. Macioszczyk A. & Dobrzynski D. 2002 – Hydrogeochemia strefy aktywnej wymiany wód podziemnych. Wyd. Naukowe PWN.
6. Rosik-Dulewska CZ. 2002 – Podstawy gospodarki odpadami. Wydawnictwo Naukowe PWN.

ISBN 9984 – 779 – 06 – 8

MODELLING OF TRAFFIC POLICY MEASURES FOR AMBIENT AIR QUALITY MANAGEMENT
IELU SATIKSMES POLITIKAS PASĀKUMU MODELĒŠANA GAISA KVALITĀTES VADĪŠANAS VAJADZĪBĀM

LINAS KLIUČININKAS, SIMONA BALKEVIČIENĖ, JOLITA MOCKUVIENĖ

Kaunas University of Technology, Department for Evironmental Engineering,
Radvilėnų 19, 50254 Kaunas, Lithuania,
Phone: + 370 37351008, *fax*: + 370 373000152,
e-mail: linas.kliucininkas@ktu.lt; jozaik@ktu.lt

Abstract. *This paper presents the application of the Integrated Transport Effect Modeling System ITEMS, taking into consideration existing vehicle fleet, traffic flows, and ambient air quality monitoring data. The objective of this study is to estimate the exhausts of CO, NOx, and SO_2 released by motor vehicles in relation to predictive traffic policy measures in Kaunas, Lithuania.*

This study analyses the extent to which some traffic policies and future trends may influence the ambient air pollution in urban environment. Three traffic policy measures such as: i) increase of car parking fee; ii) reduction of car parking places; iii) introduction of dedicated traffic lines for public transport are considered as the case studies to examine the extend to which they could reduce emissions from motor vehicles. At the same time, each policy measure comprises four scenarios including one, which indicates the current situation. The comparative analyses of the influence of different traffic policy measures on vehicle/passenger kilometres travelled and on emissions are presented.

Keywords: *ambient air quality, ITEMS, traffic modelling, transport policies, urban transport.*

Introduction

Cities notably experience increasing signs of environmental stress in the form of poor air quality. Automobile transport is now an inherent part of our civilisation and, as has happened with many other technological advancements, the negative aspects are becoming more and more pronounced. A vast majority of the urban population is exposed to conditions that exceed air quality guidelines established by the World Health Organization [1]. The use of automobiles has strongly increased during the last few decades. The number of passenger kilometres by private car per capita increased by 90% in Western Europe [2]. The number of motorized vehicles in the world grew by about 600 million between 1950 and 1990. Of the 675 million motorized vehicles in 1990, approximately 80% were for passenger transport [3]. In Western Europe motor vehicles have overtaken industrial processes in the combustion of coal as the major source of theair pollutants.

As motor vehicle traffic is projected to increase considerably, transport-related emissions are also expected to rise, exacerbating air quality problems. The problems appear even despite the increasing use of abatement measures. The introduction of catalytic converters is not sufficiently effective in urban areas where travel distances are too short to warm up the converter. Moreover, a substantial part of the pollutants originates from heavy vehicles, for which no effective cleaning technology is yet available. Air pollution from traffic, particularly in street canyons as well as in urban areas, is still a major issue of the environmental policy.

This continual traffic growth raises concerns over the impact of traffic emissions on human health and urban environmental quality. It fuels the demand for a coherent regulatory framework for the management of traffic, air quality, and emissions at local and regional scales.

Transport policies can have significant impacts on the environment. Solving any problem of transport impacts one should consider the management issues of transport and traffic systems as well. The sustainable growth respecting the environment is one of the main objectives of the Common Transport Policy [4]. The new urban policy emphasizing a compact urban structure

ISBN 9984 – 779 – 06 – 8

with mixed use, with high urban planning, and ecological qualities need to provide mobility in a sustainable way. At least the following classical strategies are necessary for this:

- Traffic avoidance: avoidance of increased distances throughout more compact city structures, mixed use and concentration on central locations within a region.
- Shift in the means of transport: a large portion of car traffic can be shifted to public transport, bicycle and pedestrian traffic.
- Slowing down traffic and planning of street space: danger, accidents and noise pollution can be significantly reduced by restricting vehicle speed.

The transport policy approaches towards travel in urban areas remain particularly challenging and now focus on the necessity of integrated strategies which combine the use of urban land and transport planning, as well as the improvement of public transport systems and pricing measures. The main goal of the EU environment and transport policies is the reduction of external costs of transport.

Overview of decision support systems for urban transport policies

For the first time the EU Framework Directive 96/62/EEC and the first Daughter Directive introduce the use of modelling in assessment and management of air quality. The directive recognizes that air quality models are valuable tools for the assessment and forecast of air pollution. They are essential tools in the development of action plans to improve air quality, what is the ultimate goal of Member States and the local authorities in order to fulfil their obligations under the directives. Models improve the effectiveness of the air quality management.

The application of this numerical tool is also important in the traffic management and in the definition of strategies for the air quality management in urban centres, as well as for the development of future traffic scenarios. Another main advantage to be gained from using models in the assessment and management of air quality is that it enhances the ability to map the spatial distribution of pollutant concentrations what is not possible with spatial coverage of air quality measurements. This gives a chance to relax on the measurement requirements (possibility to reduce a number of stations) and thus to produce a more cost-effective and complete air quality assessment. Models are the only available tools if the scenario at the impact of possible future sources or alternative future emissions on air quality is to be investigated.

Currently, there is a number of emission models that differ in the fleet composition (vehicle categories and age), driving patterns (average speed only or instantaneous speed and acceleration), covered pollutants, and types of emissions (hot, cold, or evaporative). The selection of the adequate model is an important step to reduce final uncertainties on air quality prediction [5]. The locations of the air quality assessment are to be sited in places, where the highest concentration, to which the population is likely to be exposed, occurs. An air quality model should focus not only on the urban background, but also on calculating representative values at street level. At traffic oriented sites the assessment point should be representative of the air quality in a surrounding area of at least $200m^2$ [6].

The ITEMS model

The Integrated Transport Effect Modelling System ITEMS consists of various modules that have been designed and tested, resulting in an urban air quality management tool that can provide reliable answers to policy makers and traffic planners. The ITEMS is made out of five models: transport model, economy model, vehicle stock model, energy-emission model, and environment model. These models are inter-related through a central data base from which they extract the input data and where they return their results which can therefore, become inputs of the other models. The model is developed as a cooperative effort of Enerdata S.A. and Grenoble municipality, France.

The ITEMS deals with the urban area only. This includes the centre as well as the closer surroundings of a monocentric city of 100,000 to 800,000 inhabitants. This limitation seems to

ISBN 9984 – 779 – 06 – 8

make sense because the most serious traffic problems occur in urban areas and not within regional areas. Metropoles have a multicentric structure that requires a specific modelling approach [7].
To keep the modelling system simple and to make it easier to transfer the ITEMS to other urban areas, only three different areas are distinguished: the city centre, the rest of the urban area and the suburbs. No networks are considered with the exception the only link between the three zones.
From environmental point of view, the most important is an energy-emission model, which calculates energy consumption and pollutants emissions due to the traffic of various vehicles. It is an engineering type model which takes into account the different technical influences acting upon energy efficiency and emissions of pollutants, for example:

- cold start
- driving behaviour
- age of vehicles
- technologies of vehicles and engines
- legislation on fuels and emissions
- maintenance programme.

An energy-emission model considers the following pollutants: CO_2, CO, HC, NOx, SOx, particulate matter, VOC.

The street traffic flows in Kaunas

Kaunas, the second major city of Lithuania, is situated in the central part of the country. The administrative area of the city makes up 157.15 km^2 and the number of inhabitants is approaching 400.000. Rapidly growing number of individual cars is identified as a major contributor to the ambient air pollution, especially, in the central part of the city. The authors divide the city area into three traffic zones according to the estimates of traffic flows and the character of the built-up areas (see Fig.1).

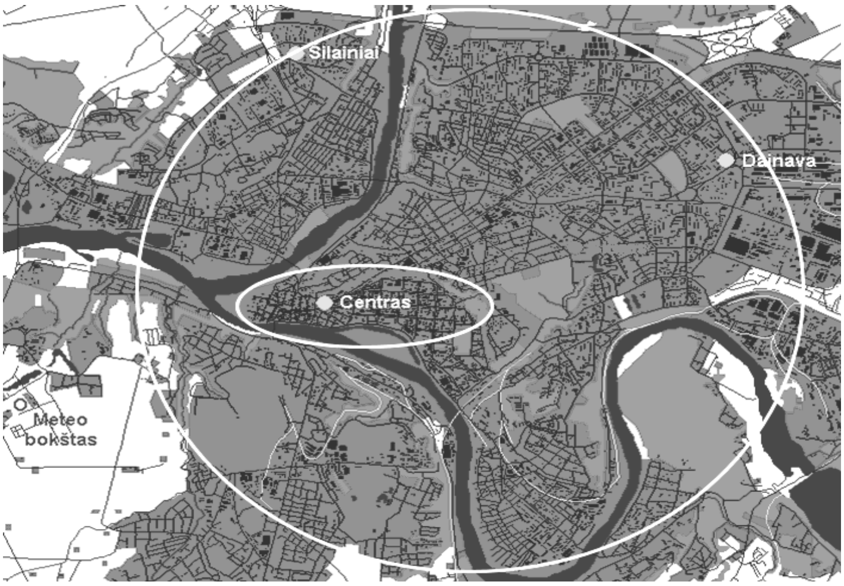


Fig. 1. **Defined traffic zones in Kaunas**

The analysis of the street traffic flows is based on the manual counts carried out during the years 1999 and 2000, as well as the automated traffic flows analysis, performed by Transport and Road Research Institute (TKTI, Lithuania) during the period June-November 2001 [8]. The study from 2001 involves measurements of traffic intensity, compositions of flows, and vehicle speed.
The analysis of the data sets for 2001 reveals that the average traffic intensity (ATI) for the central part of Kaunas city, based on 24-hour time series with the exceptional case of summer vacations, is rather stable during the whole year. The analysis of the street traffic flows in respect

ISBN 9984 – 779 – 06 – 8

to the driving speed shows that characteristic speed for the central part of the city ranges between 40-60 km/h. The stationary counter-classifier Marksman 660 (Golden River Traffic, United Kingdom) was used to identify 24-hour yearly flow averages in the different vehicle classification groups. Periodical traffic flow intensity measurements were carried out during one week each month in the period of June - November, 2001. The measurements estimate: a) annual averages of traffic intensity during 24-hours, b) variation of traffic intensity averages during 6 month, c) 24-hour traffic intensity for each day of the week, d) character of traffic intensity fluctuations during 24 hours, e) average speed of traffic flow.
Table 1 presents monthly and yearly 24-hour traffic intensity averages and ratios between monthly and yearly averages. The averages of weekly measurements serve as monthly averages of appropriate month. The authors distinguish that 'commuting circle' reflects temporal variations of traffic flows fairly well and is rather stable all over the year. It is taken into consideration was considered that meteorological conditions during winter and early spring have essential influence on urban traffic flows and have strong correlation with traffic flows intensity on the out of town roads. As a result, monthly urban traffic flows averages during January – April are estimated in comparison to the traffic flow intensity on the out of town roads.

Table 1.

Monthly and yearly 24-hours traffic intensity averages Donelaicio str. (The central part of the city)

Yearly 24hours average	**Month**											
	1	2	3	4	5	6	7	8	9	10	11	12
	24 hours monthly average (vehicles / 24hours) and ratios between monthly and yearly averages (%)											
12800	9900	10600	11600	12900	13700	13700	12600	12200	13900	14100	14200	14200
	0.77	0.83	0.91	1.01	1.07	1.07	0.98	0.95	1.09	1.10	1.11	1.11

Table 2.

Traffic intensity averages during weekdays, Donelaicio str. (The central part of the city)

Period	Average 24 hours intensity			**Ratio between working and weekend days**	**Week days**						
	Total	**Working days**	**Weekend days**		1	2	3	4	5	6	7
					24 hours yearly averages (vehicles / 24hours) and their ratios with weekly averages (%)						
July-August	12400	14300	7700	1.86	14200	14400	14100	14200	14400	9200	6200
					1.149	1.167	1.139	1.144	1.162	0.740	0.500
September-November	14100	15700	10000	1.57	15300	15400	15600	15600	16500	12100	7900
					1.093	1.094	1.110	1.110	1.173	0.859	0.561

Table 2 presents the average intensity of traffic flows during weekdays for the periods July-August and September –November respectively. The maximal values of traffic flows were recorded on Fridays. The differences of the traffic flow intensity from Monday to Thursday ranges within limits of 1.2%. The minimal values of the traffic flows were recorded on Sundays and comprised 60.7% of week averages. The traffic intensity values for working days exceeded weekend values by 1.44-1.67. This ratio was even more extensive during the period July – August.

Modelling transport policy measures

This section examines the extent to which some transport policy measures can affect local levels of pollutants. Each policy measure comprises four scenarios including one which indicates the current situation. This paper presents modelling results for the central part of the city. The

ISBN 9984 – 779 – 06 – 8

analysis is based on the comparison of local air quality from the point of view of different traffic policy measures:

- increase of car parking fee
- reduction of car parking places
- introduction of dedicated traffic lines for public transport
- complex policy measure is considered as alternate combination of three measures mentioned above.

Increase of car parking fee. In late 90‘s the central part of Kaunas was restricted for the individual car use. To reduce a number of individual transportation in the central part of the city, the municipality of Kaunas has introduced 1 Lt parking fee, which corresponds to 0.29 Euros (scenario a). In order to estimate the extent to which a parking fee could effect transport flows and minimize emissions, the authors have simulate the following hourly parking fees: 2, 3 and 4 Lt (scenarios b, c, d).

Reduction of car parking places. The experience of other European cities shows that the reduction of car parking places can have a significant influence on traffic flows. It reduces transport congestion in the central part of the city, however, it raises parking needs in the pre-centre zone. The limited number of parking places, well organised public transport, and accessibility by walking motivates visitors‘ of the city centre for moderate use of individual cars [10].

The authors assume that modelling scenarios will estimate the reduction by 25, 50, 75 % of car parking places (scenarios b, c, d) in comparison to the current situation (scenario a).

Introduction of dedicated traffic lines for public transport. Dedicated lines for public transport are applied to areas of intensive traffic flows, in particular to central areas of the cities [10]. It provides possibilities of fast mobility for public transport and shortens travelling time, however, at the same time it influences travelling time by car.

In the ITEMS model this alternative measure is expressed in minutes travelled by public transport or car. It is estimated that if dedicated transport lines are not introduced in the centre of Kaunas the same distance will require 7 minutes to travel by car and 17 minutes to travel by public transport (scenario a) . The authors elaborate several scenarios for introduction of dedicated traffic lines in the central part of the city:

- shortened travel time by public transport – 15%, elongated travel time by car – 15% (scenario b);
- shortened travel time by public transport – 25%, elongated travel time by car – 25% (scenario c);
- shortened travel time by public transport – 35%, elongated travel time by car – 35% (scenario d).

The validation of the energy-emission model for Kaunas was performed using data series from the stationary monitoring stations *Centras, Dainava,* and *Silainiai* (see Fig. 1). The concentration equation from linear source was applied to contemporize modelled amounts of emissions with the monitored NOx, CO, SO2 concentrations [9]:

$$C(x,y,0:H)=\left(\frac{2q}{\sqrt{2\pi\delta_z u}}\right)\exp\left[-\frac{1}{2}\left(\frac{H}{\delta_z}\right)^2\right] \qquad (1)$$

Under the overcast conditions with an average annual wind speed of 3.37 m/s, correlations δ_z based on the Pasquil stability class D was applied to the equation. The linear source strength q for CO, NOx and SO_2 was calculated and assigned value q_{CO} = 3.47 g/ms, q_{NOx} = 1.98 g/ms, q_{SO2} = 0.022 $*10^{-2}$ g/ms respectively. The estimation of ambient air concentration was performed at 10 metres distance from the street and the height of the sampling point was 3.5 metres above the ground level.

ISBN 9984 – 779 – 06 – 8

Results and discussion

The modelling results display changes in total vehicle/passenger kilometres travelled and demonstrate consequent reduction of CO, NOx and SO_2 emissions. The impacts of different traffic policy measures indicate moderation of kilometres travelled by individual car and increase of passenger kilometres travelled by public transport (buses) [11]. Each measure comprises four scenarios described in the previous section. The average changes are shown in Figure 2.

The minor effect is observed after the increase of parking fee. The taxation has no significant impact on vehicle and passenger kilometres travelled. The 'reduction of parking places' provides better results in comparison to the 'increase of parking fee', however, it is less attractive than the 'introduction of dedicated lines for public transport'. Surprisingly, 'the reduction of car parking places' gave rather limited increase of passenger kilometres. It is most likely that results are effected by a driver's personal behaviour.

The comparison of individual policy measure has revealed that 'the introduction of dedicated lines for public transport' has major effect on the reduction of emissions from transport. However, the complex implementation of all three measures described will give the most favourable results.

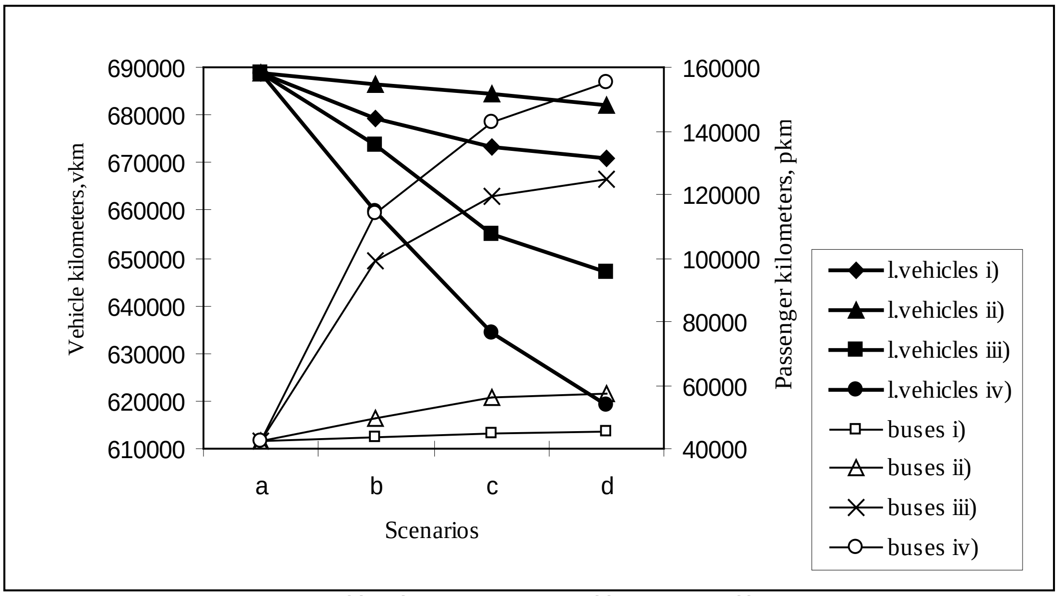


Fig. 2. **Estimated traffic flows under different traffic policy measures**

Figs. 3-5 show the effects of changes from different traffic policy measures on average levels of the CO, NOx and SO_2 emissions. The increasing share of passenger kilometres and the decreasing amount of vehicle kilometres produces the evident tendency in the pollution reduction.

ISBN 9984 – 779 – 06 – 8

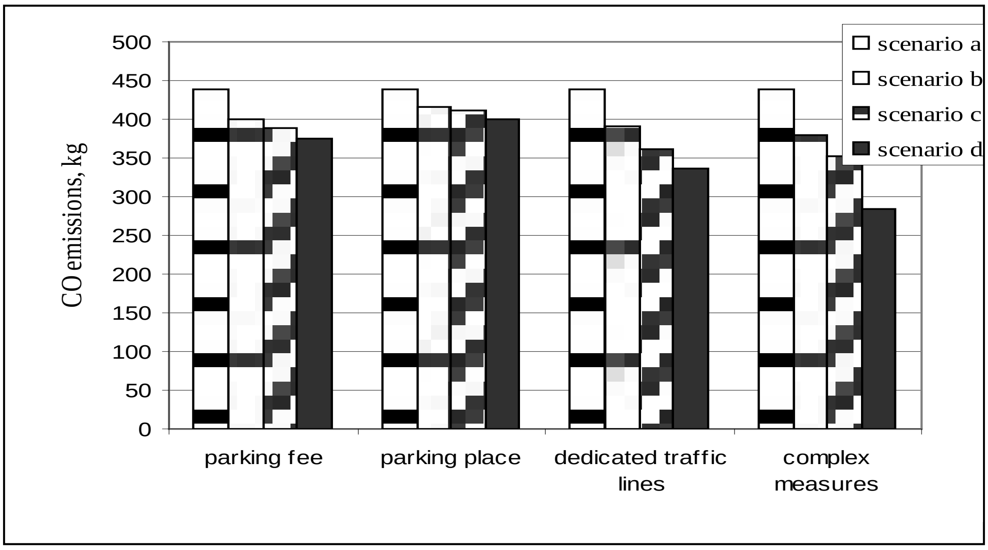


Fig. 3. **Estimated levels of CO emissions under different traffic policy scenarios**

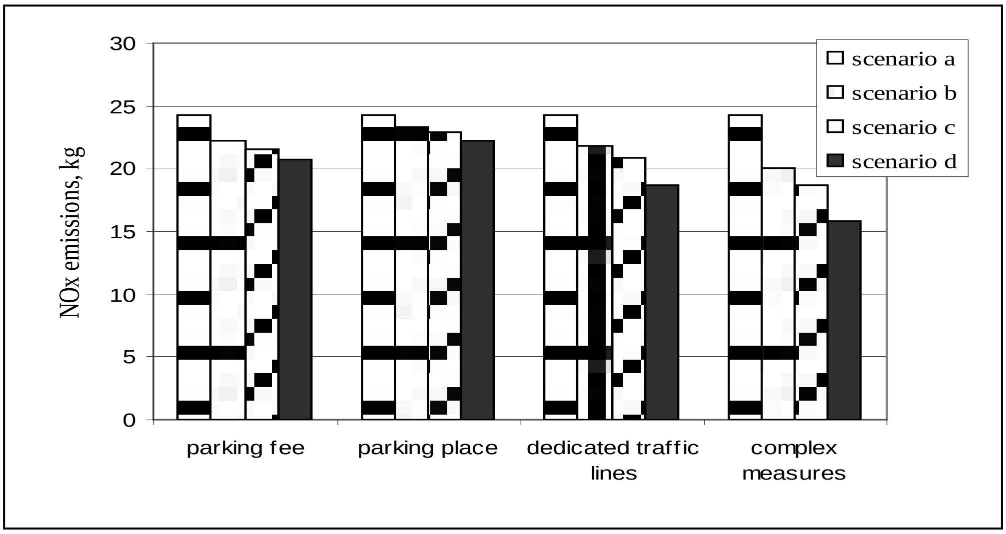


Fig. 4. **Estimated levels of NOx emissions under different traffic policy scenarios**

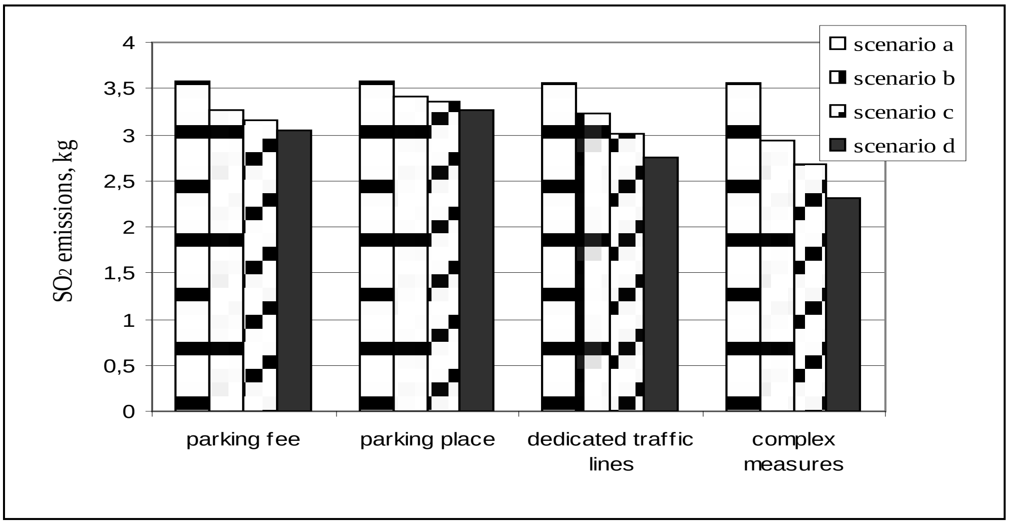


Fig. 5. **Estimated levels of SO_2 emissions under different traffic policy scenarios**

ISBN 9984 – 779 – 06 – 8

Conclusions

The ITEMS modelling system provides analytical possibilities for the implementation of some traffic policy measures in medium size cities. The results of the modelling are specified for Kaunas. However, the general trends found may be applicable in other urban areas under similar conditions as well. Since the policy analyses are carried out comparing the results with the 'current situation' scenario, it gives 'pure' estimates for each policy measure, and eliminates the effects of changes in traffic flows and car fleet.

This paper demonstrates the effects of some transport policy measures and the trends of changes in CO, NOx, and SO_2 emission. The modelling results show that policy measures have varying environmental impacts, particularly for different pollutants. This approach, which provides a range of air pollution indicators from different transport policy measures, is useful in decision making.

References

1. Europe's Environment: The Second Assessment. European Environmental Agency, Copenhagen: EEA, 1998a.
2. Towards Sustainable Transportation. Paris: OECD Publications, 1996.
3. Adams, J., 1999. The social implications of hyper mobility. In: OECD, Project on sustainable transport (EST). The economic and social implications of sustainable transportation. Proceedings of the Ottawa Workshop, 20–21 October 1998.
4. Meyer M.D., Transport planning for urban areas: a retrospective look and future prospects. *Journal of advanced transportation sector,* 2000, Vol 34, p. 143-171.
5. Hickman, J., Hassel, D., Jourmard, R., Samaras, Z., Sorenson, S. Methodology for calculating Transport Emissions and Energy Consumption. Luxembourg: European Commission, DG VII, 362pp, ISBN 92-828-6785-4, 1999
6. European Community. Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management. *Official Journal of the EC L 296,0055-0063,* 1996
7. ITEMS – Integrated Transport Effect Modelling System. Tutorial. Enerdata s.a. Grenoble-Gieres, France, 1999.
8. Transporto priemonių eismo intensyvumo skaičiavimas automatiniais eismo intensyvumo skaitikliais-klasifikatoriais. [Traffic intensity measurements using automatic counters-classifiers] Report. Kaunas municipality Environmental Protection Department, P. 93. 2001.
9. Turner, D. B. (1964), 'A diffusion model for an urban area'. Journal of Applied Meteorology.
10. Chiquetto, S., Mackett, R. Modelling the effects of transport policies on air pollution. *The Science of the Total Environment*, 1995, 169, p. 265-271.
11. Martuzevičius, D., Kliučininkas, L. Integrated modeling of transport effect in Kaunas city. Proceedings of the International Conference 'City Environment 2000', Kaunas, Technologija, 2000, p. 82-88.

ISBN 9984 – 779 – 06 – 8

KULTŪRVIDES PĀRVALDĪBA PAŠVALDĪBĀ: PROBLĒMAS UN RISINĀJUMI
MANAGEMENT OF CULTURAL ENVIRONMENT IN MUNICIPALITY: PROBLEMS AND DEVELOPMENTS

AGRITA OZOLA

Tukuma muzejs, Harmonijas iela 7, Tukums LV 3101
Tālr.: + 371 31 82390, *fax*: + 371 31 22237, *e-pasts*: tukmuz@apollo.lv

Abstract. *The paper deals with management system of cultural environment in municipality and emphasise the actuality of its interpretation. The author has made research of built heritage in Tukums town and defined changes in its cultural environment using methods of field research and analysis of documents, town plans and historical photographs. The research resulted on history of each of buildings in the historical centre of town. The author did case analysis of three interpretation methods used to increase cultural, social and economic value of cultural heritage in old town: museum exhibitions, live performances in the monument and interpretive heritage walk.*

Keywords: *cultural environment, cultural heritage, values, interpretation.*

Ievads

Ikvienas pašvaldības uzdevums ir veidot tās iedzīvotājiem patīkamu un harmonisku dzīvesvidi. Jauno tehnoloģiju iespējas un ekonomisko procesu strauja attīstība mūsdienās rada arvien lielākas izmaiņas kultūrvidē un tās pārvaldība kļuvusi vēl aktuālāka nekā dabas aizsardzības jautājumi.

Tradicionāli kultūrvide un tās galvenās vērtības - dabas un kultūras mantojums un kultūras aktivitātes - tiek vērtēta kā nozare, kas prasa lielus ieguldījumus. Postmodernajā sabiedrībā mūsdienās mainās vērtību sistēma un arvien aktuālāka kļūst nepieciešamība pēc jaunas pieejas arī kultūrvides pārvaldībā. Kultūras un dabas mantojuma aizsardzībā arvien vairāk tiek uzsvērta nepieciešamība saglabāt ne tikai valsts nozīmes pieminekļus, bet arī vietējas nozīmes objektus.

Līdzīgi kā Vides aizsardzības politikas plānā definētie vides politikas sekmīgas realizācijas priekšnosacījumi: labi attīstīta informācijas sistēma, vides aizsardzības institūcijas un organizācijas un sabiedrības apziņa[1] lielā mērā ir saistīti arī ar kultūras sektoru, kas ietver gan kultūras mantojuma aizsardzību vidē un tās vērtību izmantošanu muzejos, arhīvos un bibliotēkās, gan arī visa veida kultūras aktivitātes: mūziku, mākslu, deju, arhitektūru, kino, teātri, literatūru u.c. cilvēka radošas izpausmes un to izmantošanu sabiedrībā.[2]

Vairākos starptautiskajos dokumentos, tai skaitā UNESCO deklarācijā Par kultūras daudzveidību[3] tiek vērsta uzmanība uz kultūras mantojuma kā vietējās attīstības resursa potenciāla nozīmi, materiālās kultūras liecību un nemateriālās kultūras vērtību savstarpēju saistību, jaunu izglītības metožu izstrādi un pielietojumu, aktīvas komunikācijas procesa nepieciešamību.

Bieži vien pašvaldībās nav īstas izpratnes par kultūrvides pārvaldības komplekso raksturu, trūkst zināšanu par tās vērtību - dabas un kultūras mantojuma - izmantošanas iespējām, vienlaikus ievērojot dabas un kultūras pieminekļu aizsardzības normatīvo aktu prasības. Pašvaldības ne vienmēr pilnībā izmanto kultūras pieminekļu iespējas un kultūras radošo potenciālu, lai veicinātu teritorijas attīstību.

Pašvaldības līmenī kultūrvides pārvaldību ir iespējams padarīt efektīvāku, plašāk izmantojot un integrējot izglītības un kultūras iestāžu, tai skaitā muzeju, un kultūras pieminekļu iespējas. Rakstā īsi raksturoti Tukuma pilsētas kultūrvides izpētes rezultāti, analizētas trīs problēmsituācijas un raksturotas trīs dažādas kultūras mantojuma interpretācijas metodes, kuras lietotas, lai aktualizētu kultūrvides vērtību nozīmi pašvaldībā un veidotu izpratni par to saglabāšanas nepieciešamību.

ISBN 9984 – 779 – 06 – 8

Materiāli un metodes

Pētījums veikts Tukuma pilsētā, kas kā apdzīvota vieta pastāv jau vairāk nekā tūkstoš gadu, un šajā laikā divreiz mainījusi dislokācijas vietu. Laikā no 11. gadsimta līdz 13. gadsimtam apbūve atradās Veļķu pilskalnā un tā apkārtnē,[4] bet ap 14. gadsimtu - uz Slocenes upes senkrasta tagadējā Brīvības laukuma apkārtnē. Viduslaiku apbūve veidojusies pie kādreizējā Rīgas-Prūsijas tirdzniecības ceļa.[5] Gruntsgabali bijuši samērā lieli, neregulāras formas. Pilsētas tiesības Tukums ieguva 1795. gadā - pēc Kurzemes un Zemgales hercogistes inkorporēšanas Krievijas valstī un līdz ar to paplašinātas arī pilsētas robežas.[6] 19. gadsimta vidū uzsākta pilsētas apbūves plānošana un kopš 1881. gada tā notiek saskaņā ar apstiprinātiem apbūves noteikumiem un plāniem.[7] Tukuma pilsētas vēsturiskais centrs jeb vecpilsēta ir valsts nozīmes kultūras piemineklis un tās ielas, ēkas un būves, laukumi veidojušies ilgā laika posmā un satur dažādu laikmetu substances.[8] Daudzie uzslāņojumi apgrūtina to datējumu un interpretāciju, kā arī adekvātu uzturēšanas un konservācijas metožu izvēli un pielietojumu.

Pētījuma gaitā tika veikta vecpilsētā esošo objektu apsekošana un fotografēšana, tad tos raksturojošo dokumentālo un vizuālo avotu apstrāde, iegūto datu apkopošana, salīdzināšana un analīze, kam sekoja vecpilsētas vides objektu vērtēšana, kā arī interpretācija. Katrā no pētījuma etapiem izmantoti citi materiāli un atbilstošas metodes. Pirmajā pētījuma etapā vairākkārt tika apsekota vecpilsētas apbūve un veikta tās apskate un fotografēšana. Jaunās fotogrāfijas pēc tam jau muzejā tika salīdzinātas ar Tukuma muzeja krājumā esošajām vēsturiskajām fotogrāfijām. Salīdzināšanas procesā tika precizētas apbūvē notikušās izmaiņas, kā arī atpazīti vairāki līdz tam nezināmi objekti. Fotoattēlu salīdzināšanas procesā tika izmantoti arī dažādi pilsētas plāni un tas ļāva autoram identificēt arī pilsētas apbūvē reiz pastāvējušu un vairs neesošu objektu vietas identificēšanu.

Muzeja fotogrāfiju kolekcijā ir vairāki tūkstoši attēlu, no kuriem 664 fotogrāfijas raksturo Tukuma pilsētas apbūvi laikā no 19. gadsimta sākuma līdz 20. gadsimta beigām. Autors anotējis vairāk nekā 300 jaunas fotogrāfijas, kas raksturo pilsētas apbūvi 21. gadsimta sākumā, un pētījuma rezultātā tās iekļautas Tukuma muzeja krājumā. Attēli apstrādāti ar mērķi tos ievietot elektroniskajā muzeju kopkatalogā „Meandrs",[9] kuru savstarpējā sadarbībā veido Latvijas vēstures muzejs, Valsts Mākslas muzejs, Latvijas Dabas muzejs un Tukuma muzejs.

Pētījuma nākamā etapa laikā veikta muzeju un arhīvu materiālu apkopošana un datu salīdzināšana. Izmantota arī muzejā jau agrāk izveidotā vecpilsētas apbūves kartotēka, tā papildināta, precizējot ēku būvniecības laiku, pārbūves, to funkcijas un īpašnieku maiņu.

Pētījuma ceturtajā etapā veikta lauka pētījuma gaitā iegūto pilsētvides objektu izpētes materiāla un dokumentu, plānu, fotogrāfiju studiju rezultātā iegūtās informācijas sintēze un analīze. Tās rezultātā objekti tika grupēti pēc līdzīgām pazīmēm un noteikta to vēsturiskā nozīme pilsētvidē. Vērtēšanas rezultāti apkopoti un izmantoti vecpilsētas interpretācijas programmas izveidei un aprobācijai, kā arī ieteikumu sagatavošanai pilsētas teritorijas attīstības plāna aktualizācijai.[10]

Rezultāti un to izvērtējums

Apbūves attīstības periodi

Postmodernās sabiedrības uzmanība koncentrēta uz vienkāršo ļaužu dzīvi un ikdienas atspoguļojumu, mēģinot izprast kā un kādēļ viņi mainījuši savu dzīvesvidi. Kā atzīmējis angļu kultūrantropologs K.Teilors,[11] kultūras mantojuma pārvaldības galvenais jautājums ir saistīts ar to, kā kultūru prezentējam un kādēļ to darām. Viņa izpratnē dzīve ir kā daudzkrāsains audums, kurā katra vieta, notikums un katrs cilvēks ieauž pa krāsainam pavedienam. Pagātne dzīvo cilvēku atmiņās un cauri laikam tā saistīta ar citiem cilvēkiem, notikumiem un konkrētām vietām. Minēto K. Teilora tēzi var pilnībā attiecināt uz kultūrvidi un to apstiprina arī autora veiktais Tukuma vecpilsētas pētījums.

Tukums ir viena no Latvijas provinces pilsētām. Kā apdzīvota vieta tā veidojusies netālu no Livonijas ordeņa pils un viduslaikos pastāvēja kā neliels administratīvs centrs pie Rīgas -

ISBN 9984 – 779 – 06 – 8

Prūsijas tirdzniecības ceļa. 17.gadsimtā, kad visā Rietumeiropā notika strauja pilsētu attīstība,[12] Tukuma nozīme Kurzemes un Zemgales hercogistē pieauga un tas kļuva par vienu no četriem virspilskunga iecirkņa centriem. Nākamais straujās attīstības periods sākās ar saimniecības attīstību un industrializāciju 19.gadsimta beigās.

Apbūves attīstība saistīta ar minētajiem periodiem. Viduslaikos pils bija nošķirta no miesta apbūves ar aizsardzības grāvi. [13] Koka ēkas - būvētas tagadējās Lielās ielas sākumposmā - līdz mūsdienām nav saglabājušās. Brīvības laukuma dienvidu pusē atrodas vien neliels viduslaiku pils drupu fragments un 18.gadsimta otrajā pusē pārbūvētais Pils tornis. Otrajā attīstības periodā veidojušās pārējās tagadējās vecpilsētas ielas un apbūve ne tikai pletusies plašumā, bet arī pietuvinājusies viduslaiku pilij. No šī perioda saglabājusies 17.gadsimtā būvētā Sv.Trīsvienības baznīca un ap divdesmit dzīvojamo ēku, kas celtas 18.gadsimtā. Trešajā periodā pilsētas teritorijas strauji paplašinājusies. Šajā laikā pilsētnieku saziņā tiek nodalīta jaunapbūvētā teritorija tika nodalīta no vecpilsētas. Jauno pilsētas daļu sāka saukt par Jauntukumu un tur īpašumus iegādājās jaunienācēji no laukiem. Uz vecpilsētu attiecināja tagadējais Brīvības laukuma un Baznīcas, Elizabetes, Lielās, Dārza, Harmonijas, Talsu, Pasta, Pils un daļēji arī - Raudas ielas apbūvi. [14]

Tukuma pilsētas vēsturiskais centrs ir viens no 44 Latvijā pastāvošiem valsts nozīmes pilsētbūvniecības pieminekļiem, [15] pēc savas mākslinieciskās, vēsturiskās vai zinātniskās vērtības tas ir saglabājams nākamajām paaudzēm un tā pārvaldība ir noteikta ar LR Likumu par kultūras pieminekļu aizsardzību. Diemžēl valsts nozīmes pilsētbūvnieciskā pieminekļa Tukuma vēsturiskā centra robežas nesakrīt ar tā sauktās vecpilsētas robežām. Pils, Pasta, Raudas un vairāku citu ielu apbūve, kas ir Tukuma pilsētai raksturīga un vienreizēja, nav valsts nozīmes piemineklis un tā aizsardzību minētais likums nereglamentē. Tas nozīmē, ka pašvaldībai un ēku īpašniekiem nav obligāti jāsaglabā vēsturiskās apbūves apjoms, nav jālieto tradicionālie materiāli to atjaunošanā, ēku var pārbūvēt vai pat nojaukt.

Tukuma pilsētas pētījums pēc tā izstrādes tika nodots pašvaldības rīcībā un iesniegti arī ieteikumi pilsētas teritorijas plānojuma aktualizācijai. Tie ietvēra ierosinājumu paplašināt pilsētas vēsturiskā centra aizsardzības zonu, saglabāt tajā esošo apbūvi un iespēju robežās restaurēt zudušās detaļas, kā arī saglabāt ielu plānojumu un trajektorijas. Vietās, kur padomju varas periodā apbūve nojaukta, autors ieteica iezīmēt kvartālu robežas ar zaļajiem stādījumiem.

Vēsturiskie nosaukumi pilsētas kontekstā

Pētījuma procesā iegūtie dati raksturo ne tikai pilsētas attīstību kopumā, bet arī sniedz plašu un daudzpusīgu informāciju par katru vecpilsētas robežās esošo īpašumu, tā īpašniekiem, īrniekiem. Katra iela, gruntsgabals un ēka ir vieta, kas saistīta ar kādu personību. K. Teilors atgādina E. Relfa tēzi, ka vietas identitāti veido cilvēku aktivitātes, viņu darbības materiālās liecības, kā arī simboli un nozīmes, ko cilvēki piešķir kādai vietai, vai atsevišķiem objektiem.[16]

Diemžēl līdzīgi citām mazpilsētām arī Tukumā padomju varas laikā ir apzināti pārrauta pilsētas tradīciju pēctecība un daudzi notikumi, cilvēki, arī vietu nosaukumi un nozīme ir mainīta un vēlāk aizmirsta. Bieži vien nezināšana ir bijusi par iemeslu nepārdomātu lēmumu pieņemšanai. Piemēram, 20.gadsimta piecdesmitajos gados izveidoto „kara pilsētiņu" tagad sauc par Jauntukumu, kaut vēsturiski šis nosaukums attiecināms uz pavisam citu pilsētas mikrorajonu, kurš veidojās 19.gadsimta beigās un aptvēra vecpilsētu. Neapdomīgi notikusi vēsturisko ielu nosaukumu atjaunošana 20.gadsimta 90.gados un bieži vien tas apgrūtina vēsturisko objektu identificēšanu mūsdienās. Vairāki vecie ielu vai nosaukumi zuduši, apvienojot divas vai pat trīs ielas un dodot tām vienu nosaukumu. Piemēram, vēsturiskais Vecmoku ielas nosaukums nav atjaunots vārda nelabskanīguma dēļ. Ielas sākumposms pievienots Brīvības laukumam (īpašumi Vecmoku ielā nr. 1-12), bet pārējā daļa - Talsu ielai. Likvidēts Jelgavas un arī Lazaretes (30.gados - Aizsargu iela) ielas nosaukums, tajās esošos īpašumus pievienojot Pasta ielai. Likvidēta arī vēsturiskā Ūdens iela, kurā atradās tikai divi īpašumi, pievienojot to Lielajai ielai.

Ielu nosaukumi un to maiņa ir viena no pilsētas vēstures izpētes būtiskā pētniecības tēmām, jo

ISBN 9984 – 779 – 06 – 8

vietvārdi uzskatāmi raksturo pilsētvidi ne tikai no ģeogrāfiskā viedokļa, bet arī no vēsturiskā. Katrā pilsētas attīstības periodā ielu nosaukumi veidojušies nedaudz citu apstākļu un arī mērogu apzināšanās kontekstā. Līdz pat 18.gadsimta vidum orientācijai lietoja vārdu ceļš un tā nosaukums norādīja virzienu uz tuvējo apdzīvoto vietu - parasti muižu. Piemēram, tagadējā Talsu iela, veidojusies gar Moku ceļu, kas veda uz Moku muižu. Pēc muižas sadalīšanas radās divi atsevišķi īpašumi -Vecmoku un Jaunmoku muiža un iela tika pārdēvēta par Vecmoku ielu. Tagadējā Raudas iela veidojusies gar ceļu uz Raudas muižu. Tās nosaukums ticis mainīts tikai padomju laikā, tai dodot Ļeņina ielas nosaukumu. Ielu nosaukumi Tukumā noteikti lietoti vismaz 18.gadsimta beigās, iespējams pat jau trešajā ceturksnī. Lielā iela ir vecākā un vairākus gadsimtus bijusi galvenā pilsētas iela. Vēl 18.gadsimta vidū tā dēvēta par Baznīcas ielu, jo uz tās atradās dievnams (tagad Sv.Trīsvienības evaņģēliski luteriskās draudzes baznīca). 1804.gada pilsētas plānā tā jau dēvēta par Lielo ielu. Baznīcas ielas nosaukums pilsētā atkal parādījās 1881.gadā, kad sadalot tā sauktajos Šteinbauma laukus apbūves gabalos, tika veidota jauna iela iepretim tolaik jaunuzbūvētai Sv.Nikolaja pareizticīgo draudzes baznīcai.
Atsevišķos gadījumos ielas nosaukumi norādījis uz tās funkciju, piemēram, Dārza iela veidojās kā ganību ceļš un tās senākais nosaukums -Vidus iela - norāda uz tā sauktās tās aizmugures ielas statusu. Samērā daudzu ielu nosaukumi atspoguļo tās iedzīvotāju nodarbošanos, piemēram, Ādģēru, Kalēju, Kautuves (arī Lopkautuves), kā arī sniedz norādes uz notikumiem pilsētas vēsturē - Uguns iela ieguvusi savu nosaukumu pēc 1865.gada ugunsgrēka. Tukumā ir arī ielas, kuru nosaukumos atspoguļojas senie vietvārdi - Avotu iela atrodas Slocenes upes nogāzē un ved uz avotiņu. Tās trase veidojusies senas takas vietā. Ūdens un Aizsprostu ielas ved uz bijušo pilsētas ezeru un iezīmē pilsētas jeb Dzirnavu ezera aprises.
19.gadsimta otrajā pusē attīstītās modernās pilsētas iezīmes un tas atspoguļojas arī ielu nosaukumos. Rīgas, Jelgavas, Talsu ielu nosaukumos jau atspoguļojas cits mērogs - virziena norādes uz tuvākajām pilsētām. Otra iezīme saistās ar sava laika Krievijas valsts augstāko amatpersonu - caru un carieņu - vārda izmantošanu. Ādģēru iela pārdēvēta par Elizabetes ielu, izveidotas Katrīnas, Aleksandra un Annas ielas. 20.gadsimtā notiek ielu pārdēvēšana dažādu politisku motīvu dēļ un to nosaukumi atspoguļo katras sabiedriski politiskās iekārtas ideoloģiju. Lielā iela bijusi gan Z.A.Meierovica, gan H.Gēringa, gan 1905.gada iela, savukārt Pils iela saukta gan par K.Ulmaņa, gan Ā.Hitlera, gan Komjaunatnes ielu.
20.gadsimta beigās parādījās jaunas iezīmes pilsētas ielu nosaukumos parādījās Tukuma sadraudzības pilsētu vārdi. Akmens (padomju laikā V.Zimjagina) ielu pārdēvēja par Šēseles, bet daļu Dārza ielas - par Tidaholmas ielu. Postmodernajā sabiedrībā ienākusi izpratne par pilsētas saitēm Eiropas mērogā, bet vienlaicīgi tomēr arvien lielāka interese rodas par lokālo vēsturi un īpatnībām
Minētie un vēl citi piemēri liecina, kultūrvides pārvaldības process pilsētā ir visai komplicēts tā daudzslāņainības un nepārtraukto, samērā straujo pārmaiņu dēļ. Lai iepazīstinātu pilsētas iedzīvotājus un arī iebraucējus ar pilsētas bagāto kultūras mantojumu, lai veidotu izpratni par tā nozīmi pilsētas identitātes veidošanā, lielāka uzmanība būtu pievēršama atsevišķu vietu, ēku un ielu vēstures, kā arī pilsētas attīstības un būtības skaidrošanai jeb interpretācijai.

Vecpilsētas kultūrvides interpretācija

Kā ikvienā komunikatīvā procesā. svarīgi ir izvēlēties notikumu vai stāstu, kuru interpretēt, un pielietot atbilstošas metodes un līdzekļus tā sekmīgai realizācijai. Tukuma vecpilsētas vide ir veidojusies ilgstošā laika periodā un nepārtraukti mainījusies. Daudzie uzslāņojumi no vienas puses apgrūtina izvirzītā uzdevuma veikšanu, no otras ouses - padara to interesantu.
Izvērtējot pilsētas aktualitātes, autore izvēlējās tēmas un tām atbilstošas interpretācijas metodes. Pirmā tēma saistījās ar tēzi, ka kultūrvide ir laikā nepārtraukti mainīga. Izmaiņas kultūrvidē nosaka gan ekonomiskie, sabiedriski politiskie un sociālie apstākļi, gan cilvēki, kuri dzīvojuši pētāmajā pilsētas daļā. Ja ārējie jeb varētu teikt arī globālie apstākļi nosaka visā valstī, reģionā vai Eiropā līdzīgu procesu norisi, tad cilvēki, kuri dzīvojuši konkrētajā pilsētā, ienesuši tikai šai

ISBN 9984 – 779 – 06 – 8

pilsētai raksturīgs iezīmes. Vēl viens ļoti būtisks faktors pilsētvides fizisko parametru un ārējā veidola, kā arī daudzu tradīciju veidošanā ir dabas pamatne. Ņemot vērā minētos faktorus, autors izvēlējās realizēt praksē Tukuma pilsētai ļoti raksturīgas vietas - tagadējā Brīvības laukuma- mainīguma interpretāciju.
Tukuma muzeja fotogrāfiju kolekcijā bija atrodams plašs un daudzpusīgs vizuālo materiālu klāsts, ar kura palīdzību bija iespējams atspoguļot laukuma apbūves, funkciju, nosaukumu un vizuālā tēla maiņas 20.gadsimtā. Trūkstošā informācija iegūta avotu materiāla studiju un analīzes gaitā, kā arī izmantojot arhitekta, celtniecības arheologa I.Dirveika [17] atzinumus par apbūves arhitektoniski - mākslinieciskо vērtību. Rezultātā tika sagatavots izejmateriāls mākslinieciskās skices izstrādei un tās realizācijai maketā. Darbnīcā „Animācijas brigāde" tika izgatavots kustīga pamatne, uz kuras uzlikti trīs skati: Tirgus laukums 1914.gadā, Brīvības laukums 1936.gadā un Sarkanais laukums 1976.gadā. [18] Nospiežot slēdzi, makets griežas un muzeja apmeklētāji viegli uztveramā formā var iegūt priekšstatu par būtiskām pilsētvides izmaiņām. Savukārt izejot no pilsētas vēstures muzeja ēkas, kas atrodas Pils tornī, katrs apmeklētājs var izvērtēt situāciju laukumā mūsdienās.
Otra metode izvēlēta ar mērķi pēc iespējas vairāk cilvēku informēt par vecpilsētas ēku vēsturisko nozīmību. Parasti informācija par vecpilsētas vēsturi tiek sniegta laikrakstos, tūrisma ceļvežos vai arī ekskursijās gidu pavadībā. Katra no minētajām metodēm ir noderīga, tomēr domāta tikai šaurai mērķauditorijai - pilsētas vēstures interesentiem. Tādā veidā sniegto informāciju izmanto neliela sabiedrības daļa. Lai informētu ne tikai interesentus, bet arī vecpilsētas iedzīvotājus autors sagatavoja īsu informāciju par katru ēku, tās būvniecību, pilsētā ievērojamiem ļaudīm un pasūtīja informatīvās plāksnītes. Projektu atbalstīja Valsts Kultūras pieminekļu aizsardzības inspekcija un plāksnītes tika piestiprinātas pie katras ēkas Pils ielā. Jau pirmajā dienā garāmgājēji pievērsa uzmanību plāksnītēm, apstājās un tās lasīja, savukārt ēku īpašnieki nāca uz muzeju un jautāja, ko vairāk par savu īpašumu. Pilsētas dome atbalstīja šo projektu un katru gadu ieplāno līdzekļus kādas ielas namiem. Patlaban plāksnītes uzliktas Brīvības laukumā, Elizabetes, Harmonijas ielā un tiek gatavotas arī Lielās ielas namiem.
Pilsētas būvvaldes darbs vērsts uz vecpilsētas saglabāšanu un šīs nelielās plāksnītes pie namiem nodrošina papildus informāciju. Līdzās zili baltajām valsts nozīmes kultūras pieminekļa atšķirības zīmēm, dzeltenās plāksnītes tiek uztvertas kā īpašas Tukuma kultūrvēsturisko objektu zīmes. Projekts darbojas sekmīgi, arvien vairāk iedzīvotāju interesējas par savu īpašumu vēsturi un lūdz sagatavot vēsturiskas izziņas. Arī tūristi var izstaigāt pilsētu patstāvīgi un iepazīt kultūrvēsturiskās nianses, lasot minētās plāksnītes.
Interpretācijas pastaigas ir samērā jauna metode. To izstrādājusi un aprobējusi trīs pētnieku grupa Austrālijas pilsētas Ņūkāstlas (Newcastle) priekšpilsētā Maifildā (Mayfield): K.Markvels (Markwell), D.Stīvensons (Stevenson) un D.Rove (Rowe).[19] Pētnieku grupa veica minētās priekšpilsētas vēstures pētījumu un izvēlējās tās vietas un objektus, kam piemīt vēsturiska vērtība. Viņi sagatavoja brošūru, kurā apkopota informācija par nozīmīgākajiem objektiem. To izmantojot jebkurš var patstāvīgi izstaigāt pilsētu un iepazīt to visā to daudzveidībā. Pētnieki uzskata, ka interpretācijas pastaigas ir efektīga kultūras mantojuma interpretācijas metode un tā ne tikai palīdz attēlot pilsētvides būtību un veidot vietas piederības sajūtu tās iedzīvotājos, bet arī ietekmē vietas ekonomisko attīstību, piesaistot tūristus.
Salīdzinājumā ar Austrālija piemēru, Tukumā pie vecpilsētas ēkām izvietotās plāksnītes padara interpretācijas pastaigu daudz vienkāršāk organizējamu. Nav nepieciešama brošūra, uz ielas nav jāšķirsta un jāmeklē pareizā lapaspuse. Pie ēkām piestiprinātās plāksnītes var izlasīt jebkurš garāmgājējs, tātad projekta mērķauditorija ir daudz plašāka.

Pieminekļu integrācija sabiedrībā

Kultūras mantojuma vērtība laika gaitā mainās, jo mainās tā nozīmes izpratne sabiedrībā. Piemēram, 18.gadsimtā Tukuma iedzīvotāji ar vietējo varas iestāžu atļauju pakāpeniski nojauca viduslaiku pili tās akmeņus izmantoja jaunu ēku celtniecībā. 1827.gadā ģenerālgubernators

ISBN 9984 – 779 – 06 – 8

Paulуči to aizliedza darīt.[20] 20.gadsimta divdesmitajos gados, kad Latvijā apzināja iespējamos kultūras pieminekļus, Tukuma viduslaiku pils drupas novērtēja kā neatbilstošas pieminekļa statusam. Tikai 20.gadsimta sešdesmito gadu beigās Tukuma viduslaiku Pils tornis tika iekļauts valsts nozīmes kultūras pieminekļu sarakstā. Neskatoties uz to, ēka tika izmantota kā Tukuma rajona iekšlietu daļas noliktava, savukārt pilsdrupu fragmenti tā arī sabruka laika zoba ietekmē.

Pirmo reizi pilsētas sabiedrības uzmanība viduslaiku pils atliekām tika pievērsta 1941.gadā, kad nojaucot vecā Praviņu kroga ēku Sarkanajā (tagad - Brīvības laukumā), skatienam atklājās tā sauktais Pils tornis. Jau toreiz Tukuma pilsētas mākslas muzeja direktors gleznotājs Leonīds Āriņš izteica domu par muzeja paplašināšanu un izvietošanu Pils tornī un blakus esošajā apriņķa tiesas ēkā. Ideja tika aktualizēta tikai 1978.gadā, kad ēkai jau bija piešķirts valsts nozīmes pieminekļa statuss. Tika izstrādāts ēkas restaurācijas projekts, [21] bet ieceres realizācija tika uzsākta tikai pēc desmit gadiem. Pilsētas vēstures muzejs Pils tornī tika atvērts tikai 1995.gadā. [22] Nelielās ēkas (platība tikai 108 m^2) remonta - restaurācijas darbu projekts finansiāli mazietilpīgs projekts. To kavēja deputātu un ierēdņu neizpratne par celtnes kā vienīgā viduslaiku vēstures un arhitektūras pieminekļa nozīmību pilsētvidē, kā arī iespējamo sociālo ietekmi pilsētā. Jau muzeja atklāšanas dienā to apskatīja vairāk nekā tūkstotis pilsētas iedzīvotāju un viesu.[23] Pie muzeja durvīm nepārtraukti stāvēja rinda. Interese nav noplakusi visus desmit tā pastāvēšanas gadus. Katrs, kas ieiet šajā muzejā, novērtē tā atraktivitāti.

Ekspozīcijas koncepcijas pamatā ir ideja par to, ka Tukuma pilsētas vēsture ir notikumiem bagāta un atbilstoši eksponēta, tā var būt interesanta ikvienam. Pamatojoties uz pilsētas vēstures pētījumu autors izvēlējās desmit viņaprāt pilsētas vēsturē raksturīgākos notikumus, sagatavoja aprakstu, izvēlējās attiecīgā laikmeta pilsētvidi raksturojošus vizuālos materiālus un sagatavoja uzdevumu ekspozīcijas māksliniekam. Ekspozīcija tika veidota kā nelieli maketi ar lellēm. Izvēlētais mākslinieciski spilgtais un viegli uztveramais izteiksmes veids karu gadu piesaista vidēji vairāk nekā trīs tūkstošus apmeklētāju. [24]

M.Trimarši (M.Trimarchi) [25] pētījis vēsturisko pieminekļu aizsardzības un izmantošanas dažādus aspektus un nonācis pie atziņas, ka pieminekļu nozīme sabiedrībā nepārtraukti mainās un izmaiņas notiek gan horizontāli (pateicoties pieminekļu plašākai pieejamībai un lielākām iespējām tos izmantot), gan vertikāli (pateicoties patreizējās vērtības dažādām modifikācijām, kas ietekmē pieminekļa pagātnes kultūras nozīmes un lomas vērtējumu). Izmaiņas var radīt ēkas funkcijas maiņa no vienas puses un kultūras aktivitātes no otras puses. M. Trimarši veicis pētījumu Itālijā, kura gaitā aplūkojis mantojuma un tēlotājas mākslas vertikālās integrācijas piemērus. Viņa pielietotie argumenti ir viegli izmantojami dažādos gadījumos neatkarīgi no kultūras pieminekļa piederības un juridiskā statusa.

M.Trimaršī tēzi apstiprina arī Pils torņa piemērs Tukumā. Līdz 1995.gadam ēka sabiedrībai nebija pieejama un tā nebija pietiekami informēta par Pils torņa vēsturisko un kultūras nozīmību. Ēka bija ieguvusi valsts nozīmes kultūras pieminekļa statusu, bet tā nedeva ne sociālu, ne ekonomiskus ieguvumus pilsētai. Pēc muzeja atvēršanas piemineklis ir pieejams pilsētas iedzīvotājiem un tūristiem. Kaut arī ieejas biļetes cena ir simboliska, pieminekļa izmantošana dod arī zināmu finansiālu ieguvumu muzeja, kas ir pašvaldības iestāde, budžetā. Pieminekļa kultūras nozīmību apstiprina arī regulārās pilsētas viesu delegāciju vizītes muzejā, [26] t.i. muzejs kļuvis par viesu uzņemšanas protokola sastāvdaļu.

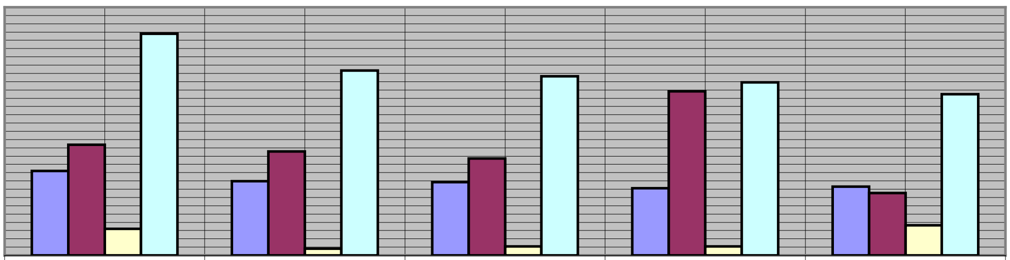
Pieminekļa nozīme maina arī tajā notiekošās kultūras aktivitātes. Pils torņa otrajā stāvā reizi gadā tiek mainītas izstādes un to atklāšana notiek Pilsētas svētku laikā - parasti jūlija trešajā piektdienā. Atklāšanas pasākums ir saistīts ar izstādes tēmu, tas veidots kā sižetisks vēstījums un tajā ir iesaistīti ne tikai muzeja, bet arī citu kultūras institūciju darbinieki: mūziķi, literāti, aktieri, vēsturnieki un citi. Tie ir mūziķi, literāti, dejotāji, aktieri vai citi radošo profesiju pārstāvji, kas spēj nodrošināt profesionāli laba līmeņa priekšnesumu un minētā pieminekļa būtībai tematiski atbilstošu kultūras produktu.

Pilsētas kultūras dzīvē īpašu nozīmi ieguva izstāde par Tukuma Viesīgo biedrību - nacionālu kultūras biedrību, kas pastāvēja no 1873. līdz 1940. un no 1941. līdz 1945.gadam un bija sava laika nozīmīgs kultūras centrs. 2003.gadā ar autora līdzdalību veikts pētījums par biedrības

ISBN 9984 – 779 – 06 – 8

vēsturi, izveidota izstāde un izveidota amatierteātra izrāde par nacionālās atmodas notikumiem un personībām Tukumā 19.gadsimta otrajā pusē.[27] Izstādes atklāšanas dienā izrāde Pils tornī tika spēlēta trīs reizes, izstādes laikā tā vairākkārt tika atkārtota.

Intervijās ar apmeklētājiem [28] tika noskaidrots, ka viņiem bija interesanti skatīties izrādi tieši izstādē, kur par katru no lugas varoņiem atrodams plašs materiālu klāsts: fotogrāfijas, dokumenti un arī memoriāli priekšmeti. Milzīgu interesi izpelnījās diskusijas ar muzeja speciālistiem pēc izrādes. Savukārt aktieri atzina, ka viņiem tieši izstāde un muzeja speciālistu komentāri palīdzēja labāk izprast savus tēlus un arī to vēsturisko vidi, kurā tie dzīvoja.



	2000.gadā-	2001.gadā-	2002.gadā-	2003.gadā-	2004.gadā-
Individuālie	2040	1796	1769	1626	1659
Ekskursanti	2676	2510	2344	3967	1511
Pasākumi	639	160	217	215	727
Kopā	5355	4466	4330	4182	3897

1.attēls. **Pils torņa apmeklētāju dinamika**

Dzīvās izrādes paplašināja Pils torņa apmeklētāju loku. Pasākumus apmeklēja ļaudis no citām sociālajām grupām nekā ikdienas apmeklētāji, kas parasti ir pilsētas vēstures interesenti, skolēni vai tūristi. Kā atzīmējis M.Trimaršī [29] pasākumi veicina kultūras produkta zināmu demokratizēšanos, kultūras pieminekļi kļūst atraktīvāki un notiek to aktīvāka iekļaušanās kultūrtūrisma apritē. Kā liecina novērojumi Pils tornī, pieminekļa kultūras nozīmi paaugstina arī mākslinieku radošo iespēju paplašināšanos un viņiem dotā iespēja radīt augstas kvalitātes kultūras produktus.

Kultūrvides pārvaldības risinājumi

Pētījumu aktualitāti kultūrvides pārvaldībā nosaka tā pielietojamība. Šis aspekts bijis aktuāls visā Tukuma pilsētas kultūrvides izpētes procesā. Kultūrvides pārvaldības mērķi ir saistīti ar materiālās un nemateriālās kultūras mantojuma saglabāšanu un ilgtspējīgu izmantošanu un šajā procesā būtiski ir nevis sašaurināt pieminekļa nozīmību, bet gan to paplašināt.

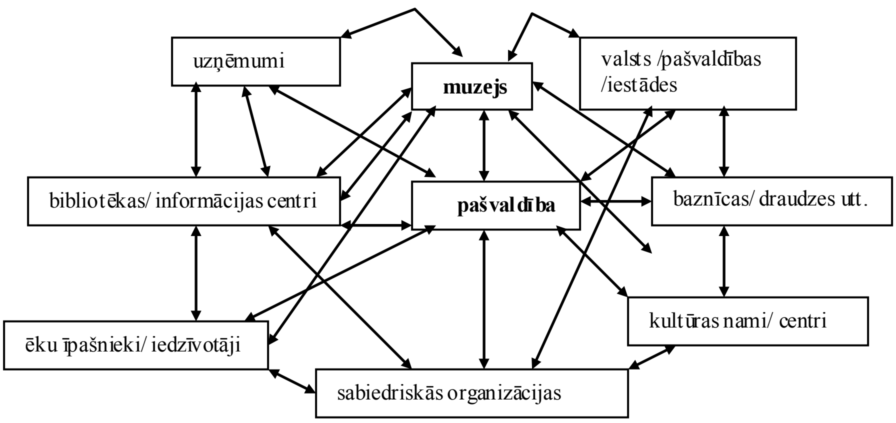
Kā atzīmē M.Trimaršī, [30] kultūras mantojuma aktīva izmantošana un vienlaikus atbilstoša saglabāšana var tikt nodrošināta, ieviešot precīzus un efektīvus noteikumus pieminekļu aizsardzībā un izmantot elastīgu pieeju to izmantošanā. Katram pieminekļa izmantošanas gadījumam jābūt ilgstpējīgam, t.i. tā izmantošanas procesā jānodrošina ikviena tā materiālā vai nemateriālā raksturlieluma (izpausmes) saglabāšana, lai to varētu nodot nākamajām paaudzēm. Ēkas vai būves identitāti veido tās forma, krāsa, dekorējums un citas zīmes, kas padara to neatkārtojamu un kultūrnozīmīgu.

Analizētajos gadījumos nav notikuši materiāli zaudējumi, tieši pretēji, organizējot augstas kvalitātes mākslas pasākumu kultūras pieminekļos, demokratizēts pakalpojumu saņēmēju loks un vairots apmeklētāju intelektuālais kapitāls.[31] Ja fiziskais kapitāls netiek samazināts un intelektuālais kapitāls pieaug, tad laika gaitā pieaug sabiedrības sociālais labums.

Tukuma pilsētas dome savā darbībā līdz šim veicinājusi vairāku kultūras institūciju sadarbību kultūras mantojuma aktualizēšanā. Viens no apmeklētāju iemīļotiem un tradicionāliem pasākumiem ir Mākslas svētki Durbes pilī, [32] ko sadarbībā ar Tukuma pilsētas bērnu un jauniešu centru (no 2004.gada - Tukuma mākslas skola), Tukuma Mūzikas skolu un Tukuma pilsētas kultūras namu ik gadus organizē Tukuma muzejs. Pasākums notiek jau 20 gadus un, neskatoties uz ieejas maksu, ik gadus pulcē vairāk nekā tūkstoš apmeklētāju. Tukuma muzejs

ISBN 9984 – 779 – 06 – 8

rīko arī klasiskās mūzikas koncertus, Dzejas dienas un citus pasākumus. Jau vairākus gadus notiek Bērnu mākslas plenēri pilsētas skolu audzēkņiem.
Tieši vecpilsētā pasākumi notiek samērā reti. Lielākoties tie ir saistīti ar izstāžu atklāšanām Mākslas muzejā, kas atrodas Harmonijas ielā, un Tukuma mākslas skolā, kas atrodas Lielajā ielā. Viens no lielākajiem un masveidīgākajiem pasākumiem, kas notiek vecpilsētā ir Pilsētas svētki, kuru organizēšanā faktiski iesaistīti visi pašvaldības uzņēmumi un iestādes, kā arī sabiedriskās organizācijas. Organizatorisko vadību parasti uzņemas pilsētas domes izglītības, sporta un kultūras speciālists.
Katrs šāds pasākums, kurā iesaistītas vairākas institūcijas, prasa rūpīgu sagatavošanas darbu un labu menedžmentu. Kultūras mantojuma vertikālās integrācijas koncepts parasti ir realizējams balstoties uz institucionāliem pamatiem un līdz ar to lēmumu pieņemšanas process ir daudz sarežģītāks. Izmantojot šādu sadarbības modeli, svarīgi ir iesaistīt visas iespējamās jautājuma risināšanā ieinteresētās puses, uzklausīt visus viedokļus un panākt vienošanos *consensus* ceļā. Kā liecina pieredze, dažkārt īstermiņā rezultāta kvalitāte varētu būt labāka, tomēr strādājot ilgtermiņā, tiek nodrošināta kultūras institūciju un citu ieinteresēto pušu aktivitāte, informācijas pieejamība un pārdomātāka darbība kultūrvides pārvaldībā. Šāds sadarbības modelis var ienest kultūrvides pārvaldībā jaunu pieredzi un arī iespējas. Ierobežota finansējuma apstākļos šis modelis sniedz iespēju pašvaldībai problēmas risināt kompleksi un profesionāli, kā arī radīt augsni iedzīvotāju sociālās aktivitātes veicināšanai.
Otrs risinājums saistīts ar tādas jaunas struktūras izveidi pašvaldībā, kurā strādā profesionālu kultūras darbinieku un kultūras mantojuma aizsardzības speciālistu komanda. Piemēra, Jūrmalas pilsētā par pieminekļu aizsardzības jautājumiem atbild domes struktūrvienība. Šāds risinājums nodrošina ātru un profesionālu lēmuma sagatavošanas procesu īstermiņā, kā arī garantē augstas kvalitātes pasākumu realizāciju. Neiesaistot pārvaldības procesā sabiedrības pārstāvjus, ilgtermiņā varētu rasties zināma plaisa starp domi un iedzīvotājiem, jo to intereses kultūras mantojuma aizsardzības jautājumos un apbūves modernizācijā ir atšķirīgas.



2.attēls. **Kultūrvides pārvaldības modelis pašvaldībā**

Tukuma pilsētā konceptuālos apbūves attīstības jautājumus lemj dome, praktiskos risinājumus akceptē un arī kontrolē būvvalde. Šajā pārvaldības jomā, kas saistīta materiālās kultūras liecību saglabāšanu, sadarbības pieredze ir mazāka nekā nemateriālās kultūras jomā. 2002.gadā pilsētas dome sadarbībā ar Tukuma muzeju un Valsts kultūras pieminekļu aizsardzības inspekciju uzsāka informatīvo plāksnīšu uzstādīšana vecpilsētā, bet 2004.gadā realizēja valsts nozīmes kultūras pieminekļa - ēkas Brīvības laukumā 21- arhitektoniski-mākslinieciskās un tehniskās izpētes projektu.[33] Visoptimālākais risinājums būtu vismaz viena kultūras mantojuma speciālista štata vietas izveide domē un cieša sadarbība ar valsts un pašvaldības institūcijām, uzņēmumiem, sabiedriskajām institūcijām un iedzīvotāju pārstāvjiem.
Šobrīd Tukuma pilsētas domē par kultūras, izglītības un sporta darba organizēšanu atbild viens

ISBN 9984 – 779 – 06 – 8

darbinieks, kultūras mantojuma aizsardzības jautājumu risināšanai domē speciālistu nav, notiek sadarbība ar kultūras pieminekļu aizsardzības inspektoru. Domes aktīvais partneris materiālās kultūras mantojuma problēmu risināšanā ir rajona pašvaldības iestāde- Tukuma muzejs. Nemateriālās kultūras jomā notiek domes, muzeja un kultūras nama, komercstruktūru sadarbība, kurā iesaistās arī atsevišķi interesenti no iedzīvotāju vidus.

Realizētie projekti ir interesanti un katrs no tiem ir devis ieguldījumu pilsētas kultūrvides materiālo liecību saglabāšanā un kultūras aktivitāšu veicināšanā, tomēr kultūrvides pārvaldība varētu būt efektīvāka, ja tiktu realizēta holiska un uz sabiedrību centrēta pieeja un izstrādāta kultūras stratēģija pašvaldībā, kā arī reģionu un valsts līmenī. Visā kultūrvides pārvaldības jomā būtu svarīgi veicināt kultūras pieminekļu un kultūras aktivitāšu horizontālo un vertikālo integrāciju, t.i. paplašināt to pieejamību un veicināt to nozīmes izpratni plašākā sabiedrībā.

Secinājumi

Kultūrvides pārvaldībā pēdējos gados arvien noteiktāk ienāk jauni aspekti un tie skar dabas un kultūras mantojuma definēšanu, saglabāšanu un aizsardzību, kā arī izmantošanu. Līdz šim ar kultūrvidi un tās pārvaldību tika asociēti galvenokārt valsts nozīmes kultūras pieminekļi un to aizsardzība nav pašvaldības kompetence. Mūsdienās arvien lielāka nozīme tiek ierādīta tai kultūras mantojuma daļai, kas neatbilst valsts nozīmes kultūras pieminekļa statusam, bet raksturo cilvēka un dabas mijiedarbības rezultātu pagastā, pilsētā vai reģionā. Par vietējas nozīmes pieminekļiem tiek uzskatītas kultūrainavas, vietas, ēkas, objekti, kas vietējo iedzīvotāju vērtējumā ieguvušas īpašu nozīmi. To definēšanā un aizsardzībā plaši izmantojamas pašvaldību muzeju resursi un iespējas: kolekcijas, pētījumi, muzeju ekspozīcijas. ekskursijas, lekcijas, kā arī citu vides interpretācijas metodes.

Līdzīgi kā pilsētas vēstures muzejs Tukumā daudzi pašvaldību muzeji atrodas ēkās, kas ir valsts nozīmes kultūras pieminekļi. No vienas puses tas muzejam uzliek saistības pieminekli uzturēt atbilstoši normatīvajos aktos noteiktajām prasībām, no otras puses rada iespēju sabiedrībai šo muzeju identificēt ar pieminekli. Kultūras aktivitāšu vai kultūras institūcijas integrācija ar kultūras piemineklī ne tikai paver jaunas iespējas tūristu piesaistei un iedzīvotāju izglītošanai, bet arī palielina kultūras pieminekļa kultūras, sociālo un ekonomisko nozīmi pilsētā. Tas savukārt Tukuma muzeja gadījumā ir palīdzējis definēt muzeja lomu sabiedrībā un tā saistās ar kultūrvides vērtību izpēti, saglabāšanu, popularizēšanu sabiedrības attīstības un izglītības labā. Muzeja sociālā loma līdz ar to uzliek pienākumu aktīvi iekļauties arī kultūrvides pārvaldības procesā, kas ietver gan tās pētījumus un izvērtēšanu, gan konservāciju un izmantošanu. Muzeju kolekcijas līdz šim vēl nav pietiekami izmantotas kultūrvides pētījumu veikšanai. Pastāv arī plašas iespējas izmantot citas kultūrvides interpretācijas metodes, ne tikai rakstā analizētās. Svarīgi, lai izvēlētā metode būtu piemērota problēmsituācijas risināšanai un dotu maksimāli iespējamo efektu.

Kultūrvides pārvaldības efektivitāte pašvaldībā lielā mērā ir atkarīga ne tikai no pašvaldības ierēdņu kompetences, bet arī no iedzīvotāju informētības un sociālās aktivitātes. Pieredze liecina, ka kultūrvides pārvaldība ilgtermiņā ir efektīvāka, ja to veic attiecīgā pašvaldības struktūrvienība, iesaistot kultūras un izglītības institūcijas, kā arī iedzīvotāju pārstāvjus. Muzeju, bibliotēku, kultūras namu, skolu un tūrisma informācijas centru, kā arī uzņēmumu, sabiedrisko organizāciju un privātpersonu aktivitāte nodrošina pārdomātāku lēmumu pieņemšanas procesu un kompleksu problēmu risinājumu. Savas kompetences un iespēju robežās katrs pārvaldības procesā iesaistītais var veikt kaut nelielus pētījumus, izstrādāt un realizēt dažādus vides interpretācijas un izglītības projektus, tādējādi veicot funkcijas, kuras pašvaldība neveic vai veic daļēji.

Pilsētvides kvalitāti un pievilcību nosaka ne tikai izcili materiālās kultūras pieminekļi, bet visa tās apbūve kopumā, tradīciju pēctecība un notiekošās kultūras aktivitātes. Ja pašvaldības, tās teritorijā esošajām iestādēm, uzņēmumiem un sabiedriskajām organizācijām, kā arī namu īpašniekiem un iedzīvotājiem ir pieejama informācija par katru vēsturiski, mākslinieciski, zinātniski vērtīgu objektu pilsētā, par vēsturiskām tradīcijām, vietvārdiem un citām nemateriālās kultūras vērtībām, tiek stiprināta piederības sajūta savai pilsētai un izpratne par tās vērtībām.

ISBN 9984 – 779 – 06 – 8

Pateicības
Pētījumu atbalstīja Tukuma pilsētas dome. Autors saņēmis arī Latvijas Izglītības fonda stipendiju pilsētas izpētei pilsētbūvnieciskā aspektā. Pateicība pienākas arī manai kolēģei - Tukuma muzeja galvenās krājuma glabātājas vietniecei Inārai Znotiņai par palīdzību fotoattēlu atlasē.

Summary

There are significant changes going on in the post-modern society depending on social, economic and cultural transformation. People are more interested in questions like: what has happened in their place many years ago, how the place looked like, why people have shaped the place it is etc. They would like to know more about the place they are living.
The author would like to specify that cultural environment is closely linked to a place, which is undergoing changes all the time because of people's activities. According to E. Relf the identity of place is related to three components: material evidences of people living in the place, their cultural activities and meaning or significance people are giving to the place or object. The aim of the management of cultural environment is to develop heritage conservation strategies, methods based on research and wise practises.
Museums are institutions, which are collecting evidences of tangible and intangible culture, researching their cultural environment and educating society. They are related to the natural and cultural heritage and as cultural institutions are involved into cultural activities and therefore they can easily understand importance of holistic approach in the process of management of cultural environment. Museums can be easily used as instruments in the process of management of cultural environment.
Heritage interpretation is a communicative process and it helps people to learn more and understand the place they are living. Museums are seen as mediators between heritage and society and interpretation methods are often used to educate society and make them aware of local traditions and values.
The author did several case studies of different heritage interpretation methods used in Tukums museum. The one, which is very traditional, is an exhibition in the museum of Tukums town history. It is situated in a small two-store building, which during medieval period was a part of a castle of Livonia order state but rebuilt at 18th century. The author has done research of the development of the town and defined the main periods of changes in its planning. The aim of the exhibition was to explain how rich is a tapestry of life in the town and it always was like this in spite of deformity of history during the soviet rule. The author decided to make models of town in eight different periods of time and show to everybody how it has been changed. The number of visitors, which has seen the exhibition, is more than 3000 people per year and it is quite good for small museum in provincial town.
Another case study is devoted to the thesis that the cultural environment is constantly changing, which one can prove using different research methods but it is not so easy to make ordinary people or even decision makers of local authority to realise the trough of this. The author decided to make one new moving model in the exhibition and show how one place - the central square of the town- has been changed during 20th century. Using visual material and analysing documents in the collection of museum and archives it was possible to show how the place looked like in 1914, 1936 and 1976. Because the museum is situated on the central square of the town, visitors of exhibition can compare what they have seen looking on the model and what the same place looks like, when they go outside of building. Observations of visitors prove that this method of heritage interpretation is very successful.
The third case study is about new method - self guided interpretive walks. The idea was to facilitate learning and appreciation of urban landscape and help people to experience the place they are living. On basis of research of the each of 230 houses of the old town of Tukums small plaques were made and they gave information about house, data of its building, people once living in, events once taking place in the house. This is an excellent way how to open multiple

ISBN 9984 – 779 – 06 – 8

layers of history of Tukums old town. Observations prove that people are interested in the history of their own house as well as their neighbours place. They are reading plagues and more often they are coming to the museum and asking for some references. There is a book going to be printed in year 2005 and will contain information also about the history houses but it is not so easy to stay on the street and look for right page in it to orient oneself. The project of Tukums museum was supported from the municipality and State inspection responsible for cultural heritage protection but it has been developed very slowly. The aim is to have plaques on each of the house in the historical centre of the town.

According to M. Trimarche the value of heritage tends to increase horizontally if the historical building or monument is accessible for people and vertically if it is used for cultural activities. He is stressing importance of integration of monuments and cultural activities. There was case in Tukums museum when the local poet has written a play and local theatre of amateurs made a performance about national awakening processes in Tukums at the end of 19th century. The performance was based on historical research of group under the leadership of the author. It took place in the exhibition devoted to Tukuma Viesīgā biedrība (Latvian society). Visitors and also actors pointed that were very excited to see the performance about real people. Looking on photos and their memorial things they experienced that time, events, people and got wider and deeper enjoyment.

Each case is different and other cultural activities allow another scenario. The integration of heritage and cultural activities not only derives much higher educational or cultural benefit, it makes people to become familiar with history, traditions, signs and symbols in their locality and helps to identify themselves with the place they are living.

Municipality is responsible for sustainable development of the territory and it means also that it is responsible for transmission of material and immaterial or tangible values to future generations. The management of cultural heritage in municipality concerns not only with just monuments left without people but also the places where people are living, where continuity of traditions is still perceived. To make this system more effective it is suggested to integrate experiences of management of cultural actions and projects with principles and methods and practises, which are used in preservation of built heritage or nature.

Literatūra

1. Vides aizsardzības politikas plāns Latvijai. LR Vides un reģionālās attīstības ministrija, Rīga, 1995.
2. Nacionālā programma Kultūra. 2000-2012.LR Kultūras ministrija,Rīga, 2001, 182.lpp.
3. UNESCO Vispārējā deklarācija par kultūru daudzveidību, UNESCO Ģenerālās Konferences 31.sesijas materiāli, Parīze, 2001 http://www.un.lv/unesco/lv_htm/docs/starptaut_dok.html
4. Asaris J. Tukuma pilskalna arheoloģiskās izpētes materiāli. Valsts Kultūras pieminekļu aizsardzības inspekcija, Tukuma muzejs, 2000, 2001.
5. Dimbira I. Tukuma pilsētas vēsturiskais centrs pirmsprojekta izpēte. 2.sēj. 1983., TMNM Za 667.
6. Centrālais Valsts vēstures arhīvs Pēterburgā 1329. fonds, 179. apraksts, 7. lieta.
7. Latvijas Valsts Vēstures arhīvs 467. fonds, 3. apraksts, 47. lieta, 1881. gads.
8. LR Valsts nozīmes kultūras pieminekļu saraksts, 1994.
9. Eiropas zinātnes programmu projekts „Informācija par muzeja vērtībām tiešsaistē", „MEANDRA" Nacionālā muzeju krājuma kopkatalogs.
10. Ozola A. Tukuma pilsētas attīstība pilsētbūvniecības aspektā. Vēsturiska izpēte Tukuma pilsētas teritorijas plānojumam. Tukuma muzejs, 2002., 26 lpp.
11. Taylor K. Cultural heritage Management: A Possible Role for Charters and Principles in Asia.// International Journal of Heritage Studies. Vol.10, No.5, December 2004, pp. 456-473.
12. Bākule I. Rātsnami Latvijas pilsētās. Zinātne, Rīga, 2004.
13. Tukuma pilsdrupas. Situācijas plāns pirms Tukuma apriņķa tiesas nama būves. 1826.
14. Latvijas Valsts vēstures arhīvs, 467. fonds, 3. apraksts, 47. lieta.
15. LR Valsts nozīmes kultūras pieminekļu saraksts, 1994.
16. Taylor K. Cultural heritage Management: A Possible Role for Charters and Principles in Asia.// International Journal of Heritage Studies. Vol.10, No.5, December 2004, pp.456-473.
17. Dirveiks I. Rekomendācijas vēsturiskās apbūves rekonstrukcijas darbiem ielas fasādēs. 1993. TMNM Za 1447.
18. Tukuma pilsētas vēstures ainas. 13.-20. gadsimts Pilsētas vēstures muzejs Pils tornis, 1995, 2001. Za 1053.

ISBN 9984 – 779 – 06 – 8

19. Markwell K., Stevenson D., Rowe D. Foortsteps and memories: Interpretting an Australian Urban landscape through Thematic Walking Tours.// International Journal of Heritage Studies. Vol.10, No.5, December 2004, pp.456-473.
20. Bēts Z. Tukuma ordeņa pils vēsturiskās izpētes materiāli.1978. TMNM Za 669.
21. Tukuma pilsētas vēstures muzeja Pils tornis rekonstrukcijas projekts. LR Pieminekļu restaurācijas zinātniskās institūts, 1978.
22. Tukuma muzeja darba plāni un atskaites. 1989.-1995. Tukuma muzeja arhīvs.
23. Tukuma muzeja apmeklētāju reģistrācijas grāmata. 1995. Tukuma muzeja arhīvs.
24. Tukuma muzeja gada atskaites. 1995.-2004. Tukuma muzeja arhīvs.
25. Trimarchi M. Regulation, Integration and Sustainability in the Cultural sector.//International Journal of Heritage Studies. Vol.10, No.5, December 2004, pp.401-415.
26. Tukuma muzeja gada atskaites. 1995.-2004. Tukuma muzeja arhīvs.
27. Tukuma muzeja izstādes „Tukuma Viesīgā biedrība" materiāli.2003.- Tukuma muzeja zinātniskais arhīvs.
28. Intervijas ar Pils torņa apmeklētājiem pēc teātra izrādēm. 2002. gada jūlijs- 2003. gada jūlijs.
29. Trimarchi M. Regulation, Integration and Sustainability in the Cultural sector.//International Journal of Heritage Studies. Vol.10, No.5, December 2004, pp.401-415.
30. Trimarchi M. Regulation, Integration and Sustainability in the Cultural sector.//International Journal of Heritage Studies. Vol.10, No.5, December 2004, pp.401-415.
31. Tukuma muzeja gada atskaites. 2003., 2004. Tukuma muzeja arhīvs.
32. Tukuma muzeja gada atskaites. 1985.-2004. Tukuma muzeja arhīvs.
33. Ēka Brīvības laukumā 21. Vizuālās izpētes projekts. AIG, Rīga, 2004.

ISBN 9984 – 779 – 06 – 8

SADZĪVES ATKRITUMU POLIGONA „GETLIŅI" PAZEMES ŪDEŅU, VIRSZEMES ŪDEŅU UN INFILTRĀTA MONITORINGS

GROUNDWATER, SURFACE WATER AND LEACHATE MONITORING IN HOUSEHOLD WASTE LANDFILL „GETLINI"

EDMUNDS TEIRUMNIEKS

Rīgas Tehniskā universitāte, Materiālzinātnes un lietišķās ķīmijas fakultāte,
Āzenes 14/24, LV – 1048, Rīga, Latvija
Rēzeknes augstskola, Inženieru fakultāte, Atbrīvošanas aleja 76, LV – 4601, Latvija
Phone: + 371 4625145, *fax*: + 371 4625167, *e-mail*: edmunds@ru.lv

JĀNIS PROLS, AIJA DĒLIŅA

SIA „Geo Consultants", K.Ulmaņa gatve 3, Rīga, LV - 1004, Latvija
Phone: + 371 7627504, *fax*: + 371 7623512, *e-mail*: gc@parks.lv

Abstract. *The paper is about the largest landfill in Latvia Getlini. Waste from Riga city and surroundings are disposed here. The waste landfilling once was started in the old sand-gravel quarry, next to the Getlini bog, and no environment protection measures were taken. Currently total area of the Getlini landfill is 87 ha and 36 ha of it occupy the old dumpsite (waste hill). Contaminants from the waste with storm water leached to the over groundwater and under groundwater and contaminated it. In the paper contamination level and spreading of leachate, surface water and groundwater are described.*

Keywords: *groundwater, leachate, monitoring, pollution, surface water, waste landfill.*

Ievads

Getliņu izgāztuve (kopš 2004. gada – poligons) ir lielākā atkritumu deponēšanas vieta Latvijā. Tā darbojas kopš 1973. gada, un tajā tiek apglabāti Rīgas pilsētas un tuvējās apkārtnes atkritumi. Savulaik izgāztuve tika izveidota izmantotā smilts – grants karjerā Getliņu purva malā, neveicot nekādus vides aizsardzības pasākumus. Laika gaitā izgāztuve pletās arvien lielāka, un atkritumi tika izvietoti arī purva malā.

Tagad atkritumu poligona kopējā platība ir 87 hektāri, no kuriem vecā izgāztuve (atkritumu kalns) aizņem apmēram 36 hektārus. Tā kā izgāztuve bija ierīkota, neveicot vides aizsardzības pasākumus, dažādas piesārņojošās vielas no atkritumiem līdz ar lietus ūdeņiem ieskalojās pazemes ūdeņus. Jau pēc pieciem gadiem (1978.g.), kad Ģeoloģijas pārvaldes speciālisti ierīkoja pirmos urbumus, tika konstatēts gruntsūdens piesārņojums izgāztuves apkārtnē. [1]

1996. gadā tika uzsākts Pasaules Bankas atbalstīts projekts "Getliņu izgāztuves turpmākās izmantošanas tehniski – ekonomiskais pamatojums un projektēšanas skices". Vēlāk tika atrasts finansējums un uzsākta Getliņu cieto sadzīves atkritumu apsaimniekošanas projekta realizācija, balstoties uz minēto priekšizpēti un ieteikumiem.

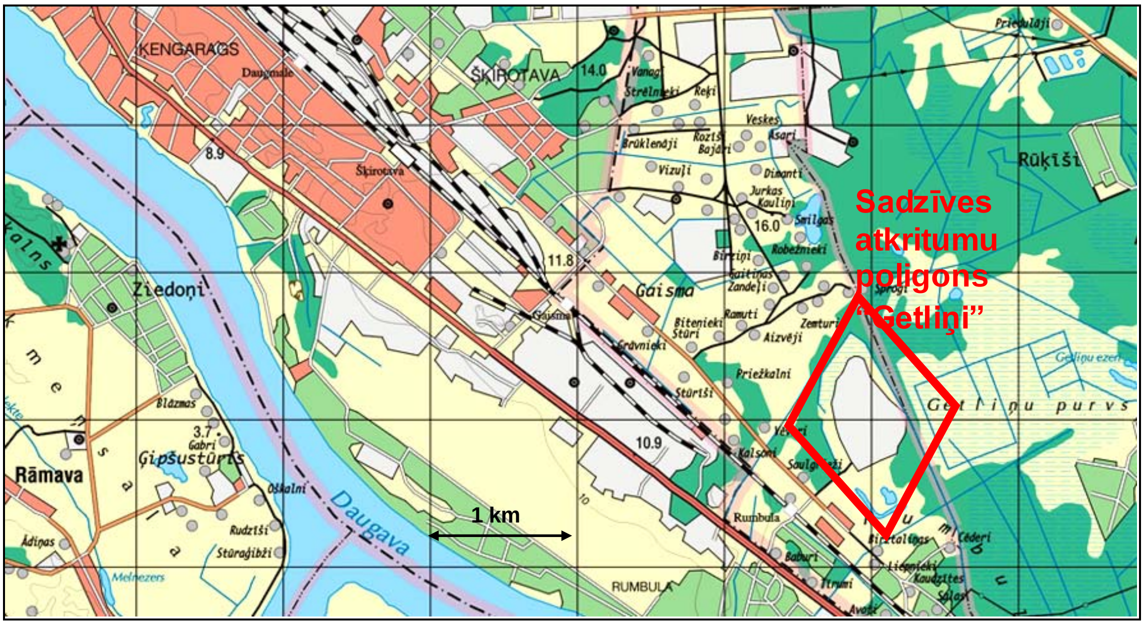
Projekta ietvaros tika rekultivēts vecais atkritumu kalns un tiek veidotas jaunas, vides aizsardzības prasībām atbilstošas vietas – šūnas – atkritumu apglabāšanai. Kā vecajā kalnā, tā arī jaunajās šūnās ir izveidotas izgāztuves gāzes savākšanas sistēmas.

Atkritumu izgāztuves vienmēr ir bijušas vienas no galvenajiem punktveida apkārtējās vides piesārņotājiem. Atkarībā no izgāztuves platības, atrašanās vietas, apglabāto atkritumu daudzuma, sastāva un apsaimniekošanas veida, apkārtējās vides piesārņojums var būt ļoti dažāds. Visās izgāztuvēs un tagad arī atkritumu apglabāšanas poligonos ir jāveic monitorings un galvenie analizējamie objekti ir virszemes ūdeņi, gruntsūdeņi un infiltrāts.

ISBN 9984 – 779 – 06 – 8

Sadzīves atkritumu poligona „Getliņi” raksturojums

Sadzīves atkritumu poligons “Getliņi” atrodas pie Rīgas pilsētas dienvidaustrumu robežas, apmēram 15 km no pilsētas centra (skat. 1. att.), attālums līdz Daugavai ir 1650 metri. Starp poligonu un Daugavu stiepjas Rīgas – Daugavpils dzelzceļš un Rīgas – Daugavpils šoseja.



1. attēls. **Sadzīves atkritumu poligona “Getliņi” izvietojuma shēma**

Dienvidos un rietumos no poligona atrodas dzīvojamās mājas un mazdārziņi. Atsevišķas mājas – Saulgrieži, Auziņas – atrodas tikai dažus simtus metru no poligona. Vietējie iedzīvotāji, kā arī daļa mazdārziņu īpašnieku iebilda pret izgāztuves atrašanos šajā teritorijā un tās turpmāku izmantošanu. Šie protesti tika pamatoti ar sūdzībām par dzeramā ūdens kvalitāti, kura neatbilst dzeramā ūdens standartam, kā arī par to, ka piesārņojums ietekmējot dārziņu augsni un izaudzēto augļu un dārzeņu kvalitāti.

Savulaik tika veikti daudzi pētījumi par dzeramā ūdens, aku ūdens, gruntsūdeņu un virszemes ūdeņu, grunts un augļu un dārzeņu kvalitāti apkārtējās mājās un mazdārziņos. Tie norādīja, ka pazemes un virszemes ūdeņi ir piesārņoti, savukārt, augsnes piesārņojums ir konstatējams lokālos iecirkņos un nav saistīts ar izgāztuves darbību. Pētījumos netika konstatēts nozīmīgs augļu un dārzeņu piesārņojums, kas liegtu tos izmantot uzturā. Aku un seklo urbumu ūdeņi visbiežāk ir piesārņoti, bet akās piesārņojuma intensitāti parasti nosaka to sliktais sanitārais stāvoklis. Apkārtējo māju iedzīvotāji neizmanto piesārņotos pazemes ūdeņus, bet tiek nodrošināti ar kvalitatīvu dzeramo ūdeni. [1]

Poligona teritorijā ir labi izveidots grāvju tīkls, daļa no tiem ir dabiski veidojušies, un daļa – mākslīgi izveidoti. Ūdens plūsma Getliņos ir vērsta uz dienvidrietumiem, uz Daugavu. Arī tieši ap izgāztuvi ir ierīkoti daudzi novadgrāvji. Novadgrāvis ap izgāztuvi savāc virszemes noteces ūdeņus un daļu infiltrāta no izgāztuves, kā arī daļu ūdeņu no piegulošā Getliņu purva. Tālāk šie ūdeņi tiek novadīti uz Daugavu. Pašu izgāztuvi, izņemot tās austrumu daļu, aptver iekšējais grāvis (infiltrāta dīķis), kas nav savienots ar drenāžas sistēmu.

Iekšējo grāvju dziļums ievērojami mainās – no 6 m uz dienvidiem no izgāztuves līdz 1 m izgāztuves ziemeļu daļā, bet parasti novadgrāvji ir 1-2 m dziļi.

Visu teritoriju sedz kvartāra nogulumi, kurus ģeoloģiskā griezuma augšējā daļā veido:

- purvu nogulumi, līdz 5 m biezi,
- eolie nogulumi – smalkgraudaina smilts, līdz 3 m biezi,
- Baltijas Ledus ezera nogulumi – smalka un vidēji graudaina smilts, līdz 10 m biezi,
- limnoglaciālie nogulumi – māls un aleirīts, līdz 5 m biezi,
- morēnnogulumi – smilšmāls un mālsmilts, līdz 3 m biezi.

ISBN 9984 – 779 – 06 – 8

Laika posmā no 1997. gada janvāra līdz 2004. gada septembrim Getliņu poligonā kopumā tika pieņemti 8,05 miljoni kubikmetri atkritumi.
2002. gadā lielāko daļu jeb 70 % veidoja sadzīves atkritumi, 20 % rūpniecības atkritumi, 8 % celtniecības atkritumi, bet parku un dārzu atkritumi 2 % [2].

Materiāli un metodes

Lai izvērtētu poligona ietekmi uz apkārtējo vidi tika apsekoti un paraugoti urbumi, kas atsedz kā gruntsūdens tā spiedienūdeņu horizontus, kā arī veiktas infiltrāta paraugu analīzes.
Urbumu paraugošanas laikā tika veikta virkne secīgu darbu, kas ietvēra:

- pazemes ūdeņu līmeņa noteikšanu,
- urbuma atsūknēšanu ar vienlaicīgu ūdens hidroķīmisko parametru (pH, elektrovadītspēja, temperatūra) noteikšanu,
- pazemes ūdens paraugu noņemšanu pēc ūdens hidroķīmisko parametru stabilizācijas.

Pazemes ūdeņu līmenis tika noteikts ar elektrisko līmeņmēru SEBA KLL 15. Urbumu atsūknēšanā tika izmantoti iegremdējamie sūkņi - Supersub 88, MP1 Grundfos vai WP 20X HONDA, un atsūknēšanas debits svārstījās no 0,09 līdz 3,0 l/s. Pirms parauga noņemšanas tika atsūknēti vismaz pieci urbumā esošā ūdens tilpumi. Atsūknējamā ūdens ķīmiskā sastāva stabilizāciju kontrolēja, izmantojot WTW mikroprocesorus ūdens pH (pH 330/340) un elektrovadītspējas (LF 330/340) noteikšanai. Pazemes ūdeņu paraugs tika paņemts pēc ūdens pH un elektrovadītspējas rādītāju stabilizācijas.
Ūdens paraugi tika pildīti 1 litra un 0,25 litru pudelēs, kurus analizēja Lielrīgas reģionālās vides pārvaldes (RVP) Ekoloģiskajā laboratorijā. Viena parauga kopējais tilpums bija 3,25 litri. Ūdens paraugi līdz nogādāšanai laboratorijā tika uzglabāti aukstumkastē. Laboratorijā ūdens paraugi tika nogādāti to noņemšanas dienā.
Saskaņā ar Vides monitoringa programmu un Lielrīgas RVP prasībām, pilnās pazemes ūdeņu analīzes ietver sekojošus komponentus:

- pH, elektrovadītspēju (lauka apstākļos un laboratorijā),
- izšķīdušo vielu saturu, ĶSP, BSP_5, permanganāta indeksu,
- biogēnos elementus – amonija, nitrītu, nitrātu un kopējo slāpekli un kopējo fosforu,
- hlorīdjonus, sulfātjonus, fenolus, naftas produktus,
- smagos metālus – Zn, Fe, Cr, Cu, Mn, Cd, Pb, Co, Hg. [3]

Pazemes ūdeņu kvalitāte tika vērtēta, salīdzinot rezultātus ar fona urbuma vērtībām un pēc Valsts Ģeoloģijas dienesta izstrādātās metodikas pazemes ūdeņu izpētei, kurā tiek izmantotas robežas A, B un C, kur:

A – salīdzinošā koncentrācija, gruntsūdeņu reģionālais fons,
B – maksimālā dabiskā koncentrācija vai specifisko vielu analīzes jūtīgums,
C – stipra piesārņojuma robeža.

tīri	A	vāji piesārņoti	B	piesārņoti	C	stipri piesārņoti

Rezultāti un to izvērtējums

Virszemes ūdeņi

Kopumā, virszemes ūdeņi izgāztuves apkārtnē ir piesārņoti un visintensīvākais piesārņojums ir vecā kalna apkārtnē. Dienvidu daļas grāvji ir relatīvi tīrāki un pēdējā gada laikā piesārņojošo vielu saturs tajos ir samazinājies. Daļa piesārņojuma pa novadgrāvi aizplūst Daugavas virzienā. Lai arī izplūdē uz Daugavu piesārņojošo vielu koncentrācijas ir ievērojami zemākas, kā pārējos grāvjos (10-20 reizes), tās tomēr līdz 10-15 reizēm pārsniedz fona vērtības. Iekšējā grāvī ap veco izgāztuvi virszemes ūdeņu piesārņojums ir visaugstākais, tas pārsniedz fona vērtības līdz 150-180 reizēm. Turklāt, jāatzīmē, ka ziemeļu stūrī virszemes ūdeņu piesārņojums vēl arvien ir nedaudz augstāks, kā infiltrāta savākšanas dīķī, kaut gan pēc pēdējiem datiem ziemeļu stūrī atsevišķu piesārņojošo vielu vērtības ir samazinājušās (ĶSP, kopējais slāpeklis, amonijs, hlorīdi), bet rietumu malā paaugstinājušās (hlorīdi, BSP_5). Visaugstākās ir tādu parametru vērtības, kā

ISBN 9984 – 779 – 06 – 8

hlorīdi, slāpekļa savienojumi, it īpaši amonijs un BSP. Tie ir parametri, kas raksturo sadzīves atkritumu izgāztuvju radīto piesārņojumu, turklāt, augstās amonija vērtības norāda, ka grāvjos ieplūst svaigs piesārņojums. Infiltrāta savākšanas dīķī vērojams piesārņojuma samazinājums, ko var izskaidrot ar vecā kalna pārklāšanu, kā rezultātā ir samazinājies infiltrāta daudzums. [1]
Salīdzinot ar iepriekšējo gadu novērojumiem, virszemes ūdeņu piesārņojuma intensitāte, kopumā ir samazinājusies, lai gan atsevišķos mērījumu punktos vērojama pretēja tendence. Ir vērojamas arī samērā lielas mērījumu svārstības gada laikā, jo vasarā ūdens urbumos gandrīz pilnīgi izžūst, bet pārējos gada laikos uztver purva ūdeņus, kas atšķaida relatīvi nelielos infiltrāta daudzumus.
Jāatzīmē, ka izplūdē uz Daugavu piesārņojošo vielu koncentrācijas ir zemas, un bīstamo vielu robežvērtības (MK 118.noteikumu 2.pielikums) nav pārsniegtas [4].

Infiltrāts

Infiltrāta paraugi tiek ņemti savāktā infiltrāta izplūdes vietā infiltrāta dīķī, bet no 2003.gada – infiltrāta recirkulācijas akā.
Piesārņojošo vielu koncentrācijas – tādu kā nitrātu, nitrītu, dažu smago metālu vai naftas produktu – ir zemas, visbiežāk nepārsniedz metodes noteikšanas robežu. Atzīmējamas ir tikai augstās dzelzs un mangāna savienojumu, kā arī cinka koncentrācijas infiltrātā (lai gan arī tās ievērojami svārstās) – no apmēram 150 mg/l dzelzs 2003.gada augustā līdz apmēram 6 mg/l dzelzs 2004.gada maijā (skat. 1.tabulu). Tas, visdrīzāk, ir skaidrojams ar parauga ņemšanas vietas maiņu, nevis krasām izmaiņām infiltrāta veidošanās procesā. Vēl pēdējā gada laikā nedaudz palielinās dzīvsudraba saturs infiltrātā, bet to saturs ne tuvu nepārsniedz 2003. gada augustā konstatēto maksimālo koncentrāciju 1,54μg/l.

1. tabula

Piesārņojošo vielu koncentrācijas infiltrātā

Parametrs	Mērvien.	2003.g.				2004.g.		
		11-Feb.	20-Maijs	19-Aug.	10-Nov.	11-Feb.	11-Maijs	17-Aug.
pH		6,40	6,29	6,36	7,3	7,72	8,26	7,36
Elektrovadītspēja	μS/cm	5720	7770	15030	9080	11990	23100	17320
Izšķīd. vielas	mg/l	5865	6894	22965	10005	10013	15326	20537
ĶSP	mg/l	2916	4272	18593	10908	9520	7605	66211
BSP_5	mg/l	711	713	2504	4830	6145	5341	7870
Amonijs	mg/l	122	92	62	360	718	1393	936
N_kop	mg/l	157	188	74	561	846	1875	1140
P_kop	mg/l	1,40	0,86	2,80	0,14	1,96	5,46	2,00
Zn	mg/l	0,445	0,495	9,57	1,50	2,93	1,44	0,600
Fe	mg/l	6,22	2,88	149	18,5	70,2	6,65	19,40
Cr	mg/l	0,105	0,093	0,286	0,178	0,200	0,260	0,105
Mn	mg/l	2,3	0,133	8,40	4,28	11,3	0,575	0,955
Permanganāta oks.	mg/l	976	990	987	296	652	1956	1428
Hlorīdi	mg/l	851	649	1968	1003	1086	3794	1870
Sulfāti	mg/l	69,1	142	370	137,8	181	29,6	207
Fenolu indekss	mg/l	3,2	1,28	2,28	2,87	2,49	1,70	1,63
Naftas produkti	mg/l	<0,05	0,35	0,05	< 0,05	<0,05	< 0,05	< 0,05

* - ĶSP vērtība, kas noteikta 17. augustā var būt nepareiza

Vairums piesārņojošo vielu koncentrācijas ir palielinājušās, salīdzinot ar 2003.gadu, izņemot Zn, Fe, sulfātus, fenolu indeksu un naftas produktus. BSP5, ĶSP, Amonija un kopējā slāpekļa augstākās vērtības norāda, ka infiltrātā pieaug bioloģiski oksidējamo un ķīmiski viegli oksidējamo organisko savienojumu klātbūtne. Visas piesārņojošo vielu absolūtās vērtības ir daudzkārt augstākas par noteiktajām robežvērtībām virszemes ūdeņos (saskaņā ar 12.03.2002. MK noteikumiem Nr. 118 "Noteikumi par virszemes un pazemes ūdeņu kvalitāti") [4].

ISBN 9984 – 779 – 06 – 8

Pazemes ūdeņi

Pazemes ūdeņu monitorings Getliņu izgāztuves apkārtnē tiek veikts jau kopš 1978.gada. Laika gaitā monitoringa urbumu tīkls ir ievērojami paplašinājies. 2001.gadā tika izstrādāta Getliņu poligona Vides monitoringa programma, kura paredz pazemes ūdeņu novērojumu veikšanu 16 urbumos.

Piesārņojošo vielu spektrs gruntsūdeņos ir plašs, tomēr galvenās piesārņojošās vielas ir slāpekļa (NH_4^+) un fosfora savienojumi, hlorīdi. Šāds galveno piesārņojošo vielu spektrs ir raksturīgs sadzīves atkritumu izgāztuvēm.

Galvenie gruntsūdens piesārņojuma raksturlielumi paraugotajos urbumos ir redzami 2.tabulā, un tie norāda uz ievērojamu gruntsūdeņu piesārņojumu Getliņu izgāztuves apkārtnē. Dažos paraugotajos urbumos ir pārsniegtas piesārņojuma robežvērtības (B). Turklāt, četros urbumos ir pārsniegta arī stipra piesārņojuma robeža (C).

Gruntsūdeņu piesārņojuma oreols ir izstiepts no ziemeļaustrumiem uz dienvidrietumiem – galvenās gruntsūdeņu plūsmas virzienā. Oreola garākā ass ir apmēram 2,5 km, bet īsākā – 1 km, un piesārņojuma oreola platība ir apmēram 2 km^2. Pieņemot, ka vidējais smilts nogulumu biezums Getliņu apkārtnē ir 10 metri, piesārņoto gruntsūdeņu tilpums ir apmēram 20 000 m^3.

Piesārņojošo vielu koncentrāciju maiņas laikā un telpā norāda divu profilu – piesārņojuma oreola garenass un šķērsass virzienā – analīzes rezultāti. Sekojot hlorīdjonu un ĶSP vērtību maiņai garenass virzienā, vērojama neliela piesārņotājvielu koncentrāciju stabilizēšanās. Jāatzīmē, ka gandrīz visos urbumos hlorīdjonu saturs ir pieaudzis. Savukārt ĶSP vērtības būtiski nav mainījušās. Arī amonija jonu koncentrācijas pēdējā gada laikā nedaudz mainījušās. Tā ir pieaugusi gan tiešā poligona tuvumā, kā arī līdz 1 km attālumā, kur pieaugums un absolūtās vērtības ir mazākas, bet tendence saglabājas. Amonija jonu klātbūtne parasti liecina par svaiga piesārņojuma pieplūdi gruntsūdeņos. Tomēr, tik nelielas izmaiņas drīzāk varētu būt saistītas ar vecā atkritumu kalna pārklāšanu ar māla slāni. Tā rezultātā atkritumos neiekļūst skābeklis un slāpekļa savienojumi (sākotnēji, galvenokārt, amonija slāpeklis) nevar oksidēties, veidojot nitrītus un nitrātus.

2. tabula

Gruntsūdens kvalitātes novērtējums

Parametrs		ĶSP	Izšķīdušās vielas	Hlorīdi	$N_{kop.}$	NH_4^+
Mērvienība		mgO_2/l	mg/l	mg/l	mg/l	mg/l
Robežvērtības [5]	A	40	500	50	3	0,5
	B	100	900	100	10	3
	C	300	3000	1000	50	20
Getliņu izgāztuve	Urbumi					
	1	**2504**	**10152**	**3528**	**1121**	**857**
	9b	*118*	504	14,6	3,12	1,45
	24b (fons)	20,1	353	26,8	0,52	0,27
	59	*241*	*2140*	*739*	*32,6*	**20,1**
	60	**384**	**3376**	**1161**	**141**	**123**
	61	17,2	450	68,3	0,66	0,47
	63 (fons)	38	417	4,25	3,51	*2,97*
	67	**311**	*1967*	*635*	**81,8**	**72,1**
	72	*182*	*1958*	*633*	9,50	2,20
	73	**619**	**4181**	**1365**	**276**	**270**
	74	**802**	**5326**	**1436**	**524**	**452**

Izcelts (iekrāsots) – pārsniedz C robežvērtību, stipri piesārņots

Izcelts (slīps) – pārsniedz B robežvērtību, piesārņots

ISBN 9984 – 779 – 06 – 8

Līdz ar to, var secināt, ka vecā atkritumu kalna pārklāšana tik īsā laikā nevar ietekmēt gruntsūdens kvalitāti – lai arī virszemes ūdeņu infiltrācija atkritumos ir samazināta, piesārņojošās vielas turpina noplūst gruntsūdeņos, mainās tikai dominējošie ķīmiskie savienojumi.
Piesārņojuma kodols koncentrējas gar piesārņojuma pārvietošanās garenasi. Tātad, piesārņojums no izgāztuves pārvietojas, galvenokārt, gruntsūdens plūsmas virzienā, īpaši neplešoties plašumā. Pēdējā gada laikā ir novērots neliels piesārņojuma intensitātes pieaugums (izšķīdušās vielas, ĶSP un hlorīdi) oreola frontālajā daļā, līdz ar to, var pieļaut, ka piesārņojuma oreola frontes pārvietošanās ir nedaudz paātrinājusies.

Secinājumi

Virszemes ūdeņi izgāztuves apkārtnē ir piesārņoti un visintensīvākais piesārņojums ir veco kalnu ietverošajos apvedgrāvjos (dīķos). Izplūdē uz Daugavu virszemes ūdeņu piesārņojums 10-15 reizes pārsniedz fona vērtības, bet kopumā ir relatīvi zemas un nepārsniedz likumdošanas aktos (MK noteikumi Nr. 118, 12.03.2002) noteiktās bīstamo vielu robežvērtības virszemes ūdeņos. Kopumā vērojama tendence piesārņojuma intensitātei samazināties.
Gruntsūdeņu piesārņojums, kas Getliņu poligona apkārtnē ir izveidojies jau septiņdesmitajos gados, turpina pārvietoties līdz ar gruntsūdens plūsmu uz dienvidiem – dienvidrietumiem, Daugavas virzienā. Piesārņojuma oreola frontālajā daļā piesārņojošo vielu koncentrācijas pēdējā gada laikā ir nedaudz pieaugušas, kas norāda par piesārņojuma migrāciju līdz ar gruntsūdens plūsmu. Centrālajā daļā 2004.gadā, salīdzinot ar 2003.-2002.gadu, atsevišķu parametru vērtības ir pieaugušas. Veikto vides aizsardzības pasākumu ietekme (piesārņojuma intensitātes samazināšanās) izpaudīsies tikai pēc ilgāka laika.

Summary

Solid household waste landfill Getlini is located near the south-eastern border of the Riga city, about 15 km from the city centre. The landfill is located in the former sand-gravel quarry and partially on Getlini bog near Daugava river. Distance to the river is 1650 m. There are dwelling houses and summer gardens located south and west from the landfill. Some houses are located within few hundred meters from the landfill.
There is a well-developed ditch network in the Getlini area, some of them are natural and some – artificial. Surface waters run to the southwest, towards the Daugava river. There are number of ditches around the landfill as well. The ditch surrounding the landfill collects surface run-off and some of the leachate from the landfill and some waters from the Getlini bog and discharges them to the Daugava. The internal ditch (leachate pond) surrounds the waste disposal area, and is not connected to the external ditches.
For water and leachate monitoring the following parameters were analyzed:
pH, electrical conductivity (EC), alkalinity, dissolved solids, COD-Cr, BOD_5, COD-Mn;
nitrogen compounds – ammonia, nitrites, nitrates, total nitrogen and phosphorus compounds as a total phosphorus;
heavy metals – Zn, Fe, Cr, Cu, Mn, Cd, Pb, Co, Hg;
chlorides, sulphates;
phenols index, oil products.
Surface water samples are taken at 7 points in ditches around the landfill and leachate – from site, where leachate is collected from the new energy cells.
Changes in surface water contamination intensity depend not just on accidents, but also on season changes. After prolonged rainfalls contamination intensity was the lowest, but in wintertime, when part of the ditches were dry, surface waters contamination intensity increases. It should be noted that surface waters contamination intensity to a great extent depends on leachate and contaminated groundwater discharges to the ditches not on contaminated surface run-off.

ISBN 9984 – 779 – 06 – 8

Surface waters at Getlini landfill are contaminated and the most intensive contamination is found close to the old waste hill. The ditches at the southern part of the landfill are cleaner. Some contamination is discharged via the drainage ditch to the Daugava river. Concentration of contaminants at the discharge to the Daugava is significantly lower then in the other ditches (10-20 times lower). The main contaminants are chlorides, nitrogen compounds, especially ammonia, and BOD. These are parameters that are typical contaminants from the solid waste landfills, and besides – high ammonia content shows that fresh contamination is being discharged into the ditches.

Leachate. Concentration of contaminants on a great extent depend on climate conditions, mainly – precipitation. The concentration of a number of contaminants – such nitrates, nitrites, some heavy metals or oil products – are low, in most cases they do not exceed the detection limit of the analytical method applied. Elevated values of BOD and COD-Mn show increase of biologically oxidising and easily oxidising chemically compounds. It should be noted that the values of all the contaminants in leachate are many times above the limited values stated for surface waters (according to the CoM regulation No 118 (12.03.2002.) "Regulations on surface water and groundwater quality").

Contamination of shallow groundwater. There is a wide range of contaminants to be found in the shallow groundwater, but the main ones are nitrogen (mainly ammonia) and phosphorus compounds and chlorides. These are the contaminants characteristic for the solid household waste landfills. Groundwater contamination was found in all the wells downstream of the landfill. The contamination plume in the shallow groundwater is elongated from northeast to southwest – along the main direction of groundwater flow. The area of the contamination plume is about 2 km^2.

Pateicības

Šis darbs izstrādāts ar Eiropas Sociālā fonda atbalstu Nacionālās programmas „Atbalsts doktorantūras programmu īstenošanai un pēcdoktorantūras pētījumiem" projekta „Atbalsts RTU doktorantūras attīstībai" ietvaros.

Literatūra

1. Sadzīves atkritumu poligona „Getliņi" 2003. – 2004. gada pārskats. – SIA „Geo Consultants", Rīga, 2004. – 57 lpp.
2. Pazemes ūdeņu monitorings „Getliņu" izgāztuves apkārtnē. – SIA „Geo Consultants", Rīga, 2002. – 52 lpp.
3. Pazemes ūdeņu monitorings „Getliņu" izgāztuves apkārtnē. – SIA „Geo Consultants", Rīga, 2000. – 73 lpp.
4. LR MK noteikumi Nr. 118. "Noteikumi par virszemes un pazemes ūdeņu kvalitāti", 2002. gada 12. marts.
5. Pazemes ūdeņu piesārņojuma izpēte. Metodiskie norādījumi. - VARAM, Valsts ģeoloģijas dienests, Rīga, 1998.

ISBN 9984 – 779 – 06 – 8

ENERGY DISPERSION X-RAY FLUORESCENCE ANALYSIS FOR ENVIRONMENT PROTECTION

RENTGENA STAROJUMA ENERĢIJAS DISPERSIJAS FLUORISCENCES ANALĪZES PIELIETOJUMI VIDES AIZSARDZĪBĀ

EDUARDS VALBAHS, ALEKSANDRS SOKOLOVS, ZIGMĀRS STRŪVE

Baltic Scientific Instruments (A Bruker AXS Company),
Ganību dambis 26, a.k.33, Riga, Latvia
Phone: + 371 7383947, + 371 7383919, *fax*: + 371 7382620, *e-mail*: bsi@bsi.lv

Abstract. *Environmental monitoring is aimed mostly at pollution levels change tendency estimation and high sensitive analysis methods are applied for this purpose. X-Ray fluorescence analysis (RFA) allows getting information of metal content in ten or hundred seconds. The analyzers with Si(Li) detectors were used for measurements. Our report deals with some examples which are given as new RFA methods (with secondary target) application in the laboratory and field conditions.*

Keywords: X-Ray fluorescence analysis, Si(Li) detectors, analyzing equipment, sensitivity.

Introduction

X-Ray fluorescence analysis is successfully used for determination of composition for various objects (ground, water, air, industrial products). The application of cooled Si(Li) detectors of X-ray emission was appeared particularly promising in RFA, having significant advantages in comparison with other types of detectors.

In 90s years of the last century X-Ray fluorescence analyzers with Si(Li) the detector developed that used measurement method of samples with intermediate thickness by means of a substrate method [1-3]. Do to the high sensitivity of idem equipment and method are used for environmental monitoring.

Environmental monitoring is mainly directed to an estimation of changes in pollution levels. For example, in some cases, methods of high-sensitivity analysis allow to receive the information of the maintenance of metals in 10 or 100 s. Our report considers some examples which are represented as application of RFA methods in a laboratory and field conditions.

Materials and methods

The analyzing equipment, which is used for carrying out energy dispersion fluorescence analysis, involves CRL-7 (the analyzer of x-ray emission) [4]. The CRL-7 includes a sensor and a detector. The sensor contains a source of ionizing radiation manufactured by BSI firm [4]. The detector mentioned has following characteristics: energy of resolution is 160 eV for 5,9 eV quant energy, the area of sensitivity is 30 mm^2 (diameter in mm) and the thickness of the sensitive surface is 4 mm. The rings of radioactive sources, with the data mirrored in Table 1, are used as sources of an ionizing radiation.

Table 1.

The rings of radioactive sources

Isotope	Half-life period	The primary radioactive emission that is used
Fe-55	2,7 years	X-ray emission MnKα 5,9 keV
Cm-244	17,8 years	X-ray emission PuKα 14,3 keV
Cd-109	7,3 years	X-ray emission AgKα 22,6 keV
Am-241	458 years	γ - emission Eγ 59,6 keV

ISBN 9984 – 779 – 06 – 8

Standard measured samples are placed in plastic ditches that internal diameter is 30 mm. The plastic ditches have a tightening ring for setting a polypropylene film to the bottom part of a ditch. Primary x-ray radiation passes through a film (the polypropylene thickness is 5 microns). A sample and substrate (that is located above the sample) are excited by primary X-ray radiation. Also, X-ray characteristic radiation of a sample goes through the polypropylene film. The sample represents as a layer of intermediate thickness of the measured object which is placed directly on a film. The metal substrate adjoining the sample is placed above it. This substrate is one of the massive metal disks of pure metal (99,9 %): Ni, Cu, Mo, Sn, Pb, Bi. The disks diameter is 30 mm and thickness is 3 mm.
Besides the sensor the analyzing equipment includes:

- Multispectrum as spectrometric device;
- PC with MCA emulation software and applied software

Approximate position of an ionizing radiation source, the capsule with the measured sample, Si(Li) detector and a substrate are represented on Figure 1.

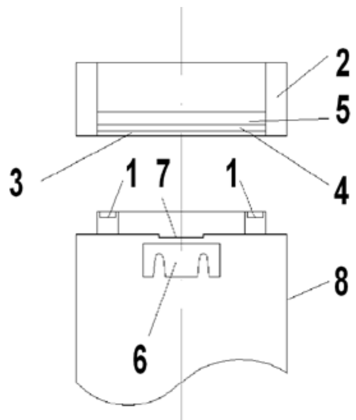


Fig. 1. **Approximate position a of an ionizing radiation source, the capsule with the measured sample, Si(Li) detector and a substrate**

1-The ring of radioactive source (one from Table.1), 2- Plastic capsule, 3- Polypropylene film, 4- The measured sample of intermediate thickness, 5- Metal substrate, 6- Cooled Si(Li) detector (), 7- Window of Be (thickness 12 microns), 8- Cover of the vacuum cryostat

φ - corner between the normal from center of sample surface and the direction of falling primary flow of photons is accepted as equal to 45^o.
ψ - corner of selection for flow of characteristic radiation from the sample. This corner is accepted as equal to 0^o.
Intensity of characteristic X-ray radiation of each i element, which is a part of the homogeneous sample, can be represented as the sum:

$I_x^i = I_1^i + I_2^i + I_p^i$ (1) [5]

I_1^i – intensity of primary fluorescence, quantum/(cm^2*s);
I_2^i – intensity of characteristic radiation (ICR) appeared due to excitation for atoms of each i element. ICP of the elements with are a part of the sample, quantum/(cm^2*s);
I_p^i – ICP for each i element of the sample that appears due to excitation of X-ray radiation of the substrate, quantum/(cm^2*s).

ISBN 9984 – 779 – 06 – 8

Value of intensity components for each i element is defined according to the formulae containing in [5, 6].
The full equation (1) is written for each element of multicomponent sample system. That is why, the system of equations is obtained. The obtained system of equations can be sometimes simplifed excepting secondary excitation if its value is so small. The system of equations is usually solved by a method of iterations, i.e. being set by the first set of values C_i (mass concentration of each i element) and calculating its new set (C_1 from I_x^1, C_2 from I_x^2 and etc.). The decision process of the equations commonly converges rather quickly to agreement by a method of iterations. For example, it is usually enough several iterations for solving.

Results

RFA and equipment ensure vanadium detection starting from 15 to 25 g/t in the soil around a power station and from highway ditch. Analysis of soil samples from Riga – Jelgava highway ditch shows ten times higher vanadium concentration level than in the field 100 meters far away from the ditch. Analyzer "CRL – 7" is developed in BSI that allows S, V to be detected and other elements in raw oil, fuel oil and other kinds of liquid fuel. The information of element concentration in fuel allows activities to be conducted for decreasing atmosphere pollution. The same equipment was applied for monitoring of margarine manufacturing process. Margarine manufactured from vegetable oil is in the presence of Ni and Cu catalizators. The catalizator content in intermediate products is a checking index, measurements sensitivity being approximately 3 mg/kg at exposition 800 s. The results received from the measurements have confirmed a possibility to provide required quality of production.
Coal is an important source for reception of energy and will be continued to play a role in satisfaction of energy needs. Coal ash is pollutant of the environment and contains such substances as Al2O3, SiO2, K2O, CaO and Fe2O3. The analysis of the containing of coal ashes with CRL-7 analyzer and using the method mentioned above is shown in Figure 2. The weight concentrations of substances of coal ashes that were accrued from spectrum are represented in Table 2.

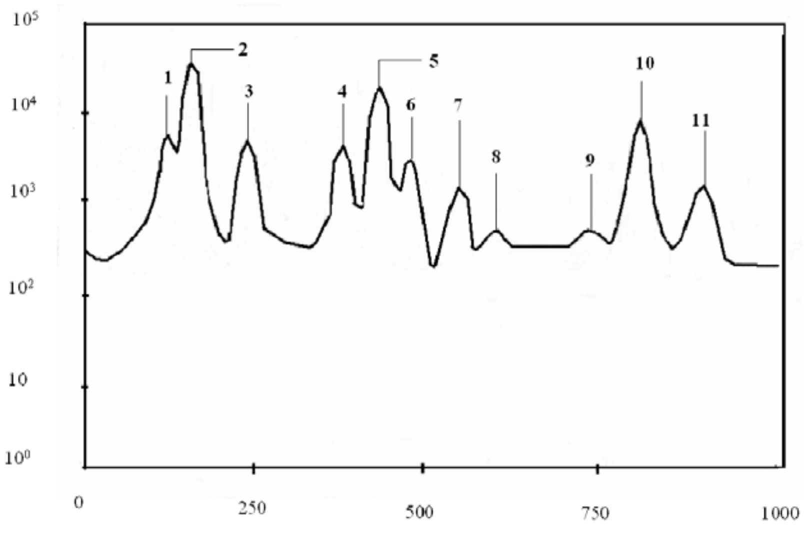


Fig. 2. **A spectrum of coal ashes; Si(Li) detector (Source: Cm-244, Substrate: Cu, LT = 300 s)**

X-ray Emission Energies: 1-AlKα, 2-SiKα, 3-SKα, 4-KKα, 5-CaKα, 6-CaKβ, 7-TiKα, 8-TiKβ, 9-MnKα, 10-FeKα, 11-FeKβ

ISBN 9984 – 779 – 06 – 8

Table 2.

Concentration of some substances in coal ashes

Substances	SiO_2	Al_2O_3	Fe_3O_4	TiO_2	CaO	SO_3	K_2O
Concentration, %	47,76	14,72	3,08	1,03	12,08	8,96	1,28

Light particles of substances in the air can be a major case of human diseases and increase the environmental pollution. The elements (such as F, V, Se, Cd, Hg and Pb) polluting the atmosphere can appear from a different number of sources. It is necessary to investigate and supervise levels of their concentration, sources, conditions of spreading and etc.

CRL-7 analyzer has been applied to the analysis of city air. The city air is analyzed deposition in the paper filters with RFA including Mo substrate and the method mentioned above. Approximately 10 m^3/cm^2 of city air was passed through the filter. After that the filters were used as samples for RFA. The spectrum of the covered aerosols is mirrored in Figure 3, but occurred the concentrations are given in Table 3.

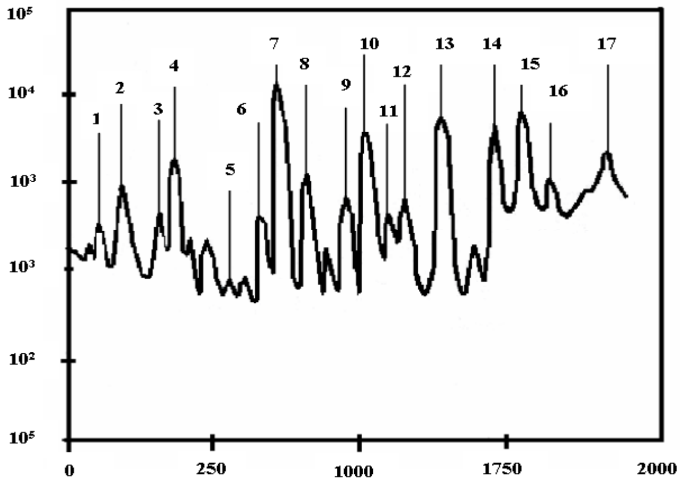


Fig. 3. **The Spectrum of the city aerosols besieged on the paper filter**

X-ray Emission Energies: 1-SiK, 2-SK, 3-KKα, 4-CaKα, 5-VKα, 6-CrKα, 7-FeKα, 8-FeKβ, 9-CuKα, 10-ZnKα, 11-PbL1, 12-ZnKβ, 13-PbLα, 14-BrKα, 15-PbLβ, 16-BrKβ, 17-PbLγ

Table 3.

The concentration value of the elements in city air

Elements	**Si**	**S**	**K**	**Ca**	**V**	**Cr**	**Fe**	**Cu**	**Zn**	**Br**	**Pb**
Concentration, nanograms/m^3	$2*10^4$	$5*10^3$	$8*10^2$	$6*10^3$	$8*10^2$	9*10	$6*10^3$	$2*10^4$	$2*10^3$	$2*10^2$	$2*10^{-1}$

Conclusions

In the course of the new RFA method application in measurement for an environmental (air, ashes) and manufacturing objects (mineral oil and foodstuff) analytical results with high sensitivity, accuracy and low detection range have been received as a result. It gives a technical decision that allows increasing a quality and measurement quickness for control of environmental pollution in future.

ISBN 9984 – 779 – 06 – 8

Acknowledgment

This research project was supported by European Social Fund.

References

1. Padee L. K. Nucl. Inst. and Methods in Phys. Res., 1984. v.205, N1-2, p. 269-278.
2. Langvitton D., Parrish W. Anal. Chem. 1977, v. 49, N8, p. 1152-1156.
3. Наумцев Ф. Е. и др. Заводская лаборатория, 1988, т 54, N 4, с. 30-33.
4. Catalog of Baltic Scientific Instruments, Riga, via, “Semiconductor detectors and Nuclear Electronics for Radiation Measurement”, 1998.
5. Назаров В. В. Заводская лаборатория, 1991, т. 57, N9, с. 27-29.
6. R. Woldseth, X-ray Energy Spectrometry, published by Kevex corporation, Burlingame, California, 1973.

ISBN 9984 – 779 – 06 – 8

AN INFORMATION DATA BASE OF GEODETIC SERVICES ENGINEERING INVESTMENTS - THE IDEA OF DATA ORGANISATION

INFORMATĪVĀS BĀZES KONCEPCIJAS RADĪŠANA INŽENIERTEHNISKO INVESTĪCIJU ĢEODĒZISKO VAJADZĪBU APKALPOŠANA

JANINA ZACZEK-PEPLINSKA, RYSZARD KOWALSKI

Institute of Applied Geodesy, Warsaw University of Technology, Plac Politechniki 1, 00-661 Warsaw, Poland, *e-mail*: j.peplinska@gik.pw.edu.pl

Abstract. *The goal of the project, being run by the Institute of Applied Geodesy of the Warsaw University of Technology, is to create a prototype database of building structures, which are typical from the point of view of the tasks of engineering geodesy.*

The database is expected to be available through the Internet and is planned to be filled with the information collected from surveying companies, which would like to present their realizations both from owners and users of engineering structures.

Examples of modern solutions in the area of geodetic services for engineering investments realization is supposed to create a base for changes in the methods of teaching and presenting these issues at the Faculty of Geodesy and Cartography of the Warsaw University of Technology and at other Faculties interested in such problems.

Keywords: *geoinformation, Land Information System (LIS), engineering-industrial geodesy, investment's realization, geodetic documentation.*

Introduction – Geodetic services of investments

High diversification of tasks, which can be faced by a surveyor, is specific for engineering geodesy. Particular objects require that specific geometric conditions are met in the course of their implementation and that control of those conditions is often performed in the period of exploitation. Implementation networks, which are set in order to perform geodetic services, must be usually adapted to requirements of an object, with respect to their shapes and accuracy. Methods of setting out detailed points, as well as of control measurements, must be adapted to conditions of the task implementation. Limited time of access to an object, operations performed in poor illumination, increased temperature, or vibrations of the instrument foundations, often require untypical measurement methods. At the same time, those methods must be adapted – with respect to their accuracy - to requirements of the Project or to requirements settled with contractors of building works.

Geodetic services of investments consist of a set of operations performed at the stages of pre-design studies, technical design and investment implementation, as well as in the course of object measurements during exploitation of objects [4].

The data issue

Diversification of works included in the geodetic services of investments.

In practice, every task of engineering geodesy connected with a particular building object and technology of geodetic works, related to implementation of such an object, must be adapted to the object requirements. On the other hand, independently on the type of an object, successive stages of geodetic works may be distinguished for every task; those works are performed following obligatory standards specified by legal norms, which regulate the rules of implementation of geodetic works [5]; (Fig.1).

The scope of works which include geodetic services of investments (which often consist of many engineering objects) must be always compliant with corresponding technical and legal regulations and it should be enlarged by certain elements, depending on characteristic features of the given objects and on expectations of the investor. For many typical building objects and

ISBN 9984 – 779 – 06 – 8

engineering constructions rules concerning the surveyor’s participation in the process of investment implementation are regulated in details by various legal acts, sectoral norms, as well as by surveying instructions and guidelines. On the other hand, detailed solutions must be adapted to conditions of implementation of typical objects.

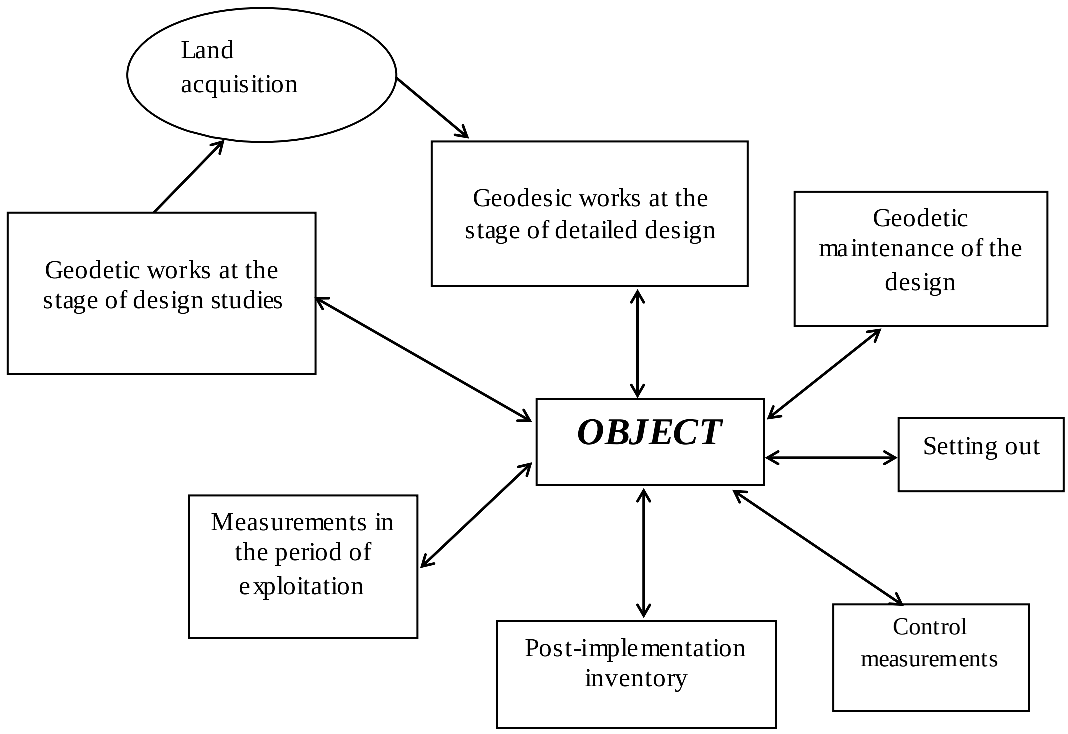


Fig. 1. **Elements of geodetic services of engineering investments**

Implementation of engineering geodesy tasks and their reporting in technical documentation. In the natural way geodesy is understood as the main technical domain which is specialised in acquisition, processing and distribution of land information. Basing on resources from state archives (in Poland: Geodetic-and-Cartographic Documentation Centres) various national and regional land information systems are created, being the main databases used for the needs of implementation of investment processes.

Engineering geodesy is one of the active users of spatial information and, at the same time, it delivers information for data updating.

Specific tasks, which should be solved by an engineering surveyor, may include the necessity to produce appropriately documents at all stages of the works. Each surveyor’s operation is reflected in technical documentation which is developed before (as setting out sketches), as well as in the course of (field sketches and logs) and after completion of the given stage of works (as calculations, analyses and maps). Every developed document is related to an object which is located within the particular area.

The Land Information System (LIS, SIT in Polish) is understood as a supportive tool for the process of making economic decisions as well as the support in planning processes; it is also one of the basic data sources (beside information acquired during updating measurements), which are used for development documentation for designing purposes [1];(Fig. 2).

A good example is a map used for designing purposes; in the course of waiting for an investor such a map is supplied with geo-spatial data from various sectors related to geography, natural environment, city technical infrastructure etc. (Fig. 3).

The base map and the topographic map exist in the social awareness as products of geodesy and cartography and – following legal regulations – they are used to meet various economic requirements. It should be noticed that users of such maps include not only designers, urban planners, road construction specialists or experts for spatial management; such maps are mainly used by surveyors, who are often agents operating between the data resources and the data user.

ISBN 9984 – 779 – 06 – 8

The task of surveyors dealing with geodetic services for investments is to acquire land information in a form required for implementation of particular designs.
Therefore, the database concerning geodetic services for engineering objects, which comprises surveying documentation, should be considered as support in searching for data required for preparation of geodetic works.
Updated information about the resources as well as suggestions concerning possible ways of reaching the data and utilisation of acquired information will considerably support operations of contractors. Beside surveyors, such information will be also used by architects, environmental engineers, geologists – all specialists who use such data for their work.

Base of information on geodetic services for engineering investments.

In the case of many objects and constructions the resources of land information, which are by obligation acquired and stored in the national system, are not sufficient; detailed sectoral regulations require that the surveyor must acquire various auxiliary information. The question arises whether the information must be collected every time for particular designs or it would be cheaper and easier to develop a system of storing such data.
Geodetic services for a building object are usually completed with post-implementation inventory, which should meet two objectives - apart from controlling the compliance between the implementation and the design: it should allow for updating the Land Information System and it should ensure acquisition of geometric information about the location and shape of the implemented object, which result from sectoral regulations.
It may be generally stated that at the stage of data preparation for the design, as well as in the course of post-implementation measurements, engineering geodesy acquires many information which may be specified as geodetic inventory of building objects. Therefore, some questions arise whether information of this type is useful for generally understood economic purposes and whether it can exist in national archives, as well as how it should be delivered to those archives and what should be covered by such information.The objectives of the Project performed at the Laboratory for Engineering-and-Industrial Geodesy of the Institute of Applied Geodesy of the Warsaw University of Technology is to create an example information base concerning building objects, which are characteristic from the point of view of tasks of engineering geodesy.

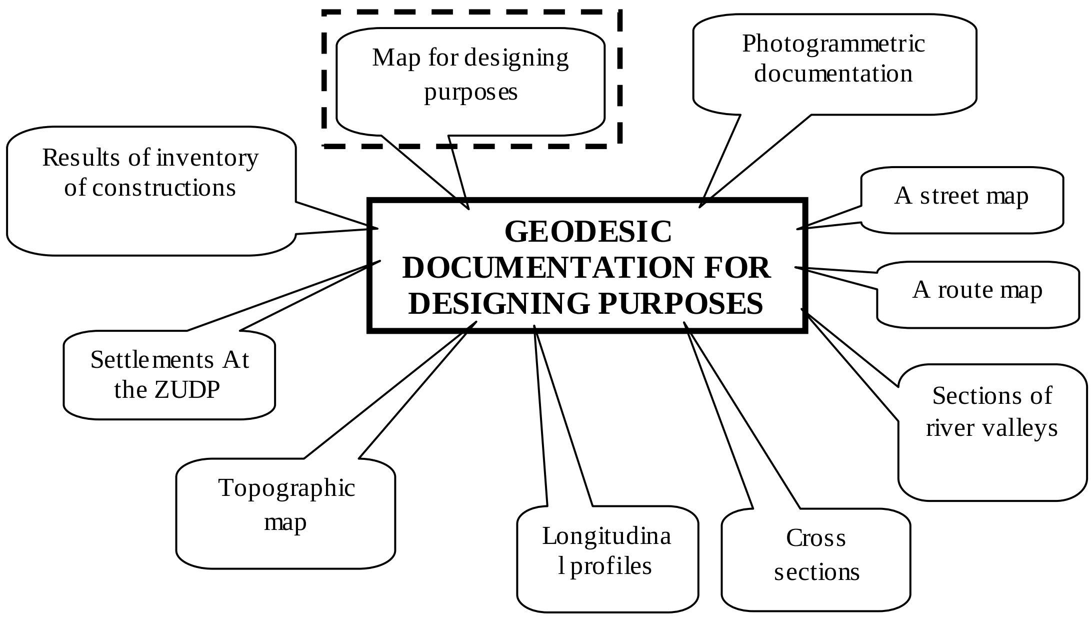


Fig. 2. **Complexity of geodetic documentation for designing purposes**

Definition of information in the context of services for investments.

From the engineering geodesy point of view, the most important features of the object are geometric relations between its elements and location of an object in the space. Location and technical requirements concerning the object geometry (resulting from its functions and

ISBN 9984 – 779 – 06 – 8

exploitation expectations of an investor) are elementary data required for the design implementation – definition of a set of geometric features, such as: verticality, parallelism of axes or collinearity of constructional elements [4]. To a certain extent, complexity of those features forces the appropriate sequence of implementation of geodetic works, and documentation, which is developed at every stage of works performed by the surveyor, should be coherent and it should be the base for successive operations. Geometric features of the object, measuring technology and documentation cannot be considered separately – therefore, the information unit included in the information data base concerning geodetic services form engineering investments have been defined as a series of operations, which is started with the design and completed with development of geodetic documentation of geodetic services, characteristic for the given stage [2]; (Fig. 4).

A suggestion to solve the problem

A concept of the information data base organization.

The concept described below was the basis for implementation of a prototype database – the Database on Geodesic Services for Investments (BIGOS) [2]. The database, which was developed at the Institute of Applied Geodesy of the Warsaw University of Technology has not been populated with real data yet; all data concerning engineering objects, elements of geodetic services and related documentation are used only for testing the correctness of implementation of searching algorithms and functionality of the user interface.

The engineering object, such as a chimney, a lift shaft, an overpass, a building, a bridge or a tunnel is defined with a series of features which describe its nature. Those features have been divided into four groups:

- Objective of implementation (eg. to by-pass a roadblock, to ensure roof coverage),
- A system (eg. high, linear, underground, surface),
- Functions (eg. transport, housing, industrial),
- Geometry – geometric features, which are implemented in the course of geodetic services and controlled in the course of the object exploitation (eg. rectilinearity, perpendicularity, verticality).

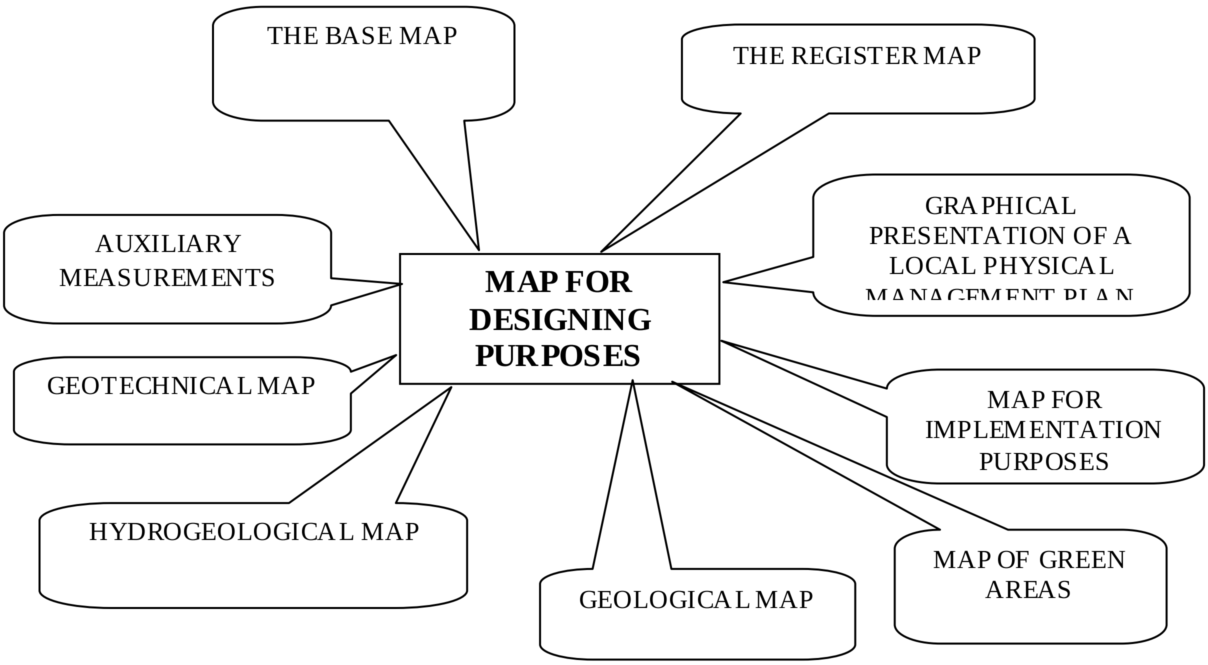


Fig. 3. **Examples of information sources used for development of a map for designing purposes**

ISBN 9984 – 779 – 06 – 8

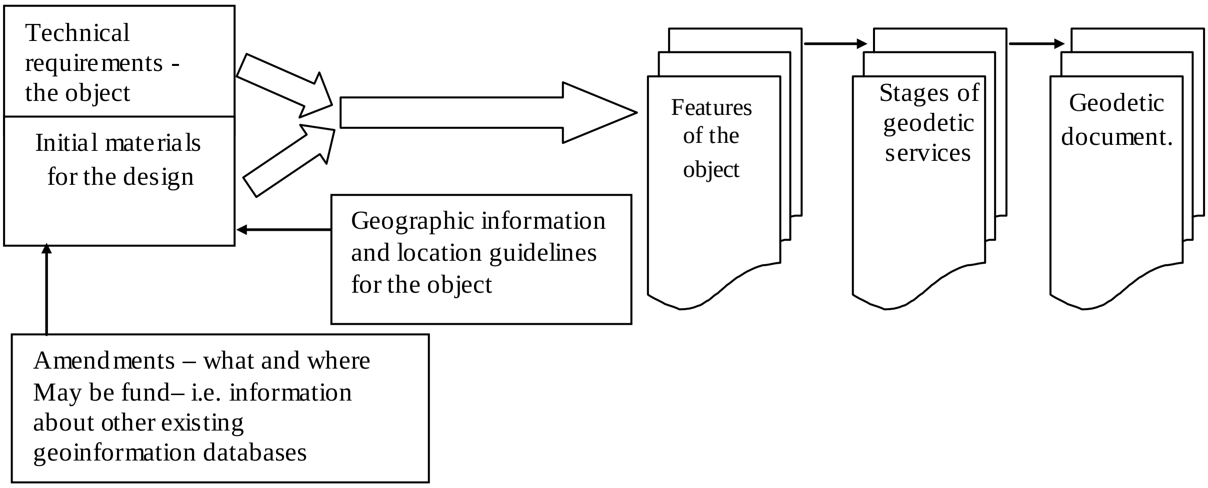


Fig. 4. **Information unit concerning geodetic services for investments**

Table 1.

An example of an object definition

OBJECT	FEATURES			
	Implementation objectives	System	functions	geometry
Water dam	- water damming up, - water supply, - power production, - flood protection	- linear, - high	- industrial, - transport	- rectilinearity, - maximum height

Lists of features are “open” dictionaries which will be enlarged by introducing new objects to the database, described in a way that ensures its explicit identification. Explicit features do not exclude the possibility to meet a certain condition by a group of similar objects.

Those features are reflected in a technical design, which is developed basing on the investor’s “idea” and technical-and-legal, as well as geospatial information connected with the spatial location of the given object. Basing on all mentioned above objects are defined in the design.

Geometric features of the object are implemented in appropriate stages of geodetic services, which – apart from implementation of field works (measurements, setting out) – result in geodetic documentation (Fig. 5).

The scope of presentation of information stored in the database depends on a way of searching. An engineering object may be accessed in the database by selecting this object from a list of objects defined in the database or by searching for objects with a specific geometric features or such objects, which require that a specified stage of geodetic services is performed.

Due to the outstanding role of geodetic documentation in the process of investment implementation, as well as considering its complexity and repeatability at various stages of services (a good examples are a sketch and its various types: a field sketch, a setting out sketch, a network sketch, a documentation sketch etc.), it is possible to search for objects in the database basing on previously defined elements of geodetic services as well as on types of documents. Geodetic documents will be presented and described in the database basing on particular examples related to engineering objects, introduced to the database.

Searching for engineering objects, and thus interesting elements of geodetic services and related documentation, is performed by means of creation of “and” or “or” conditions.

ISBN 9984 – 779 – 06 – 8

Stages of geodetic services in BIGOS System.

Description of geodetic works performed in the course of the object implementation and developed documents, is the basic information included in the database. Therefore, the general division of geodetic works performed within services for the investment, is very important. After long discussions held at the Institute of Applied Geodesy, the following division of geodetic works into particular elements of geodetic services has been approved:

0. Cartographic materials (acquired for designing and location purposes)

I. At the designing stage

1. A map for designing purposes,
2. A longitudinal profile of the area,
3. A cross section of the area,
4. A digital elevation model,
5. Auxiliary surveys.

II. At the stage of location setting out

1. A documentation sketch,
2. A horizontal implementation network,
3. A vertical implementation network (operating benchmarks),
4. A sketch of setting out main axes,
5. Control of setting out.

III. At the stage of detailed setting out

1. A building and assembly network (a local implementation network),
2. A sketch of setting out,
3. A sketch of control of setting out,
4. Control measurements of an element positioning,
5. Measurements of verticality of an element,
6. Measurements of flatness,
7. Control of dimensions,
8. Control of shapes.

IV. Post-implementation inventory

1. The base map updating,
2. Inventory underground installations,
3. Control of rectilinearity,
4. Control of verticality,
5. Control of expansion of constructional axes,
6. Post-implementation inventory of a roadway,
7. Control of settlements of a bridge (an overpass) plate.

V. Control measurements in the exploitation phase

1. Measurements of dislocations
2. Control of stability of geometric conditions.

The above list is the initial content of the dictionary of „elements of geodetic services" implemented in the database; it may be expanded and modified according to existing needs.

Functionality of the Geodesic Services Information Base (BIGOS).

Since the Information Base is to be finally accessible in the Internet, its user interface should be readable and user friendly. The operating path has been designed in such a way that windows containing various information may be simultaneously viewed, provided that the sequence order of access to particular elements of an information unit is maintained:

- ⇒ WYBRANY OBIEKT (SELECTED OBJECT) (Description, features and information concerning elements of services and documentation defined in an object),

ISBN 9984 – 779 – 06 – 8

⇒ ELEMENT OBSŁUGI GEODEZYJNEJ (ELEMENT OF GEODETIC SERVICES) (Description and a list of related documents),
⇒ DOKUMENT (DOCUMENT)

or

⇒ WYBRANY OBIEKT (SELECTED OBJECT) (Description, features and information concerning elements of services and documentation defined in an object),
⇒ RODZAJ DOKUMENTU (DOCUMENT TYPE) (Description and a list of documents of a selected type),
⇒ DOKUMENT (DOCUMENT).

Each of selected documents is presented in a separate window, what allows the user to develop the customized screen composition and selection of documents and descriptions for further comparisons.

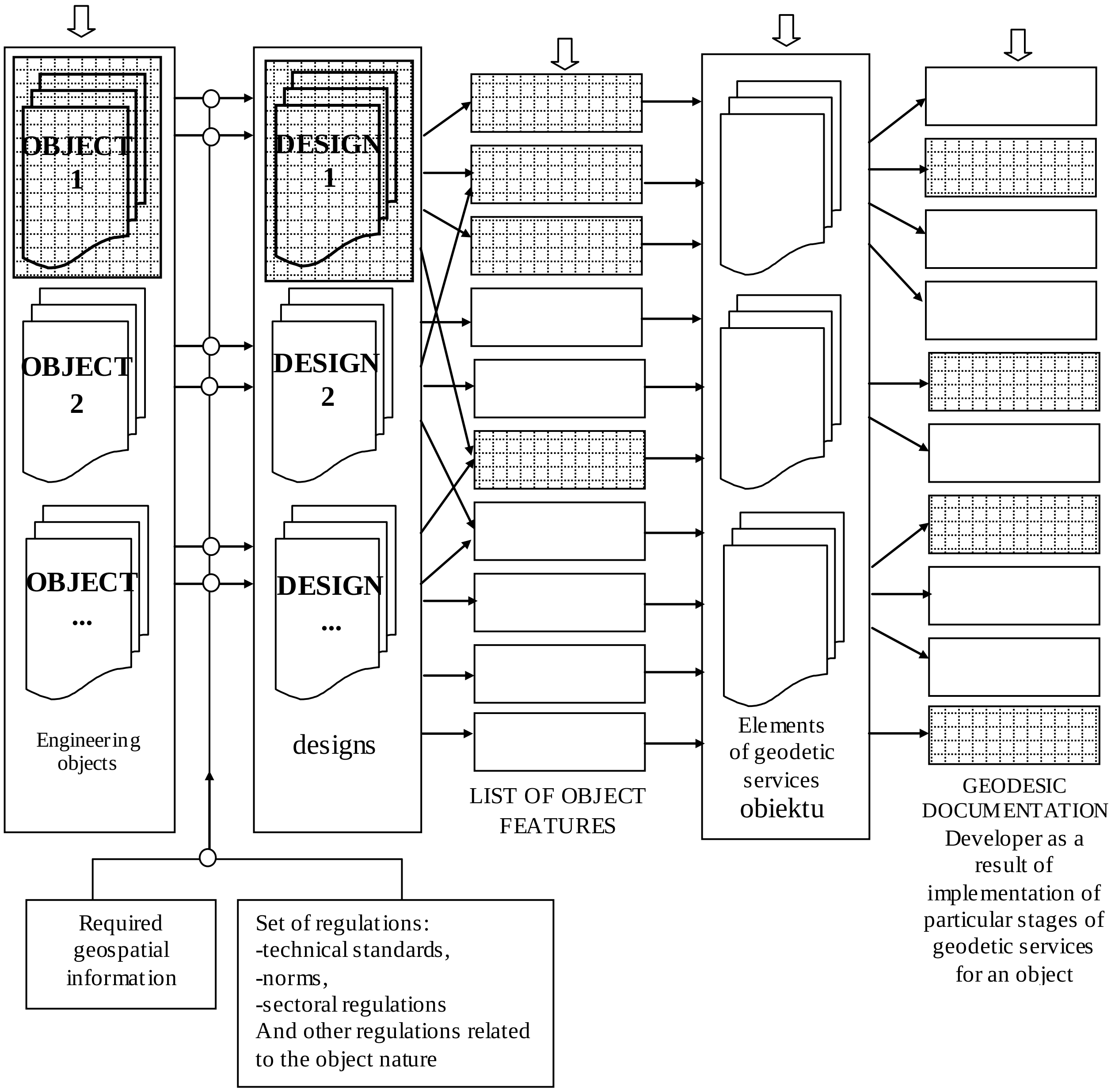


Fig. 5. **Organisation of the information base**

ISBN 9984 – 779 – 06 – 8

Acquisition, distribution and utilization of data.

The information data base concerning geodetic services for investments will be supplied with information acquired from surveying companies, which are interested in presentation of their achievements, as well as from geospatial database providers (with respect to specification „what" and „where") and from owners and users of engineering objects. We also look forward to co-operation with state archives (Geodesic and Cartographic Documentation Centres) as well as with technical control units [6]. It seems to us that such a database, containing examples of digital-and-graphical works for various objects, may be also the source of knowledge, presenting ways of proper preparation of technical documentation.

Examples of modern solutions in the field of geodetic services for implementation of engineering objects should also be the basis for modifications of education curricula and presentation of those issues at the Faculty of Geodesy and Cartography of the Warsaw University of Technology as well as at other faculties [3], which are interested in those topics.

The discussed database is to be finally accessible in the Internet – in the first phase mainly as presentation of complexity of engineering-and-industrial geodesy. In the future it will become a tool delivering information for didactic purposes, being also an inspiration for specialists dealing with engineering geodesy.

Conclusions

When completed, the database concerning geodetic services for engineering investments, may become the aid for didactic works at universities, which run studies in the field of geodesy, as well as it may be the aid for practicing surveyors in their professional operations.

At present, the main reasons for creation of such a database may be listed as follows:

1. for didactic and training purposes – presentation (in a widely accessible way) of implemented projects concerning geodetic services for various investments may be supportive for permanent development of professional qualifications of surveyors practitioners,
2. in order to popularise knowledge concerning the importance and the role of surveying in the process of investment implementation among specialists from involved sectors,
3. in order to promote unified standards,
4. for university education needs, in order to create an accessible information base concerning ways of implementation of works in the field of engineering-and-industrial geodesy.

Appropriate visualisation of data stored in the database and distribution of his data among wide groups of interested individuals may result in popularisation of engineering geodesy and, thus, it may contribute to wider presentation of surveying companies, which were involved in implementation of presented engineering investments.

References

1. Gaździcki J. „Systemy informacji przestrzennej" (Spatial Information Systems) , PPWK , Warszawa-Wrocław 1990;
2. Kowalski R., Zaczek-Peplinska J. „Koncepcja utworzenia bazy informacji o geodezyjnej obsłudze inwestycji inżynierskich" (A concept of creation of the information base concerning geodetic services for engineering investments), Roczniki Geomatyki 2004, Tom II, Zeszyt 2;
3. Olenderek H., Parzyński Z., „Stan i perspektywy rozwoju edukacji w dziedzinie geomatyki" (Status and perpectives of educational development in the field of geomatics), Materiały XII Konferencji Naukowo-Technicznej „Systemy Informacji Przestrzennej", Warszawa 2002;
4. Praca zbiorowa „Geodezja inżynieryjna" (Engineering Geodesy), PPWK, Warszawa-Wrocław 1989;
5. Instrukcja techniczna G-3 „Geodezyjna obsługa inwestycji" (Geodetic services for investments), wydanie III, GUGiK, Warszawa 1989;
6. Instrukcja techniczna O-3/O-4 „Prowadzenie Państwowego Zasobu Geodezyjnego i Kartograficznego oraz kompletowanie dokumentacji prac geodezyjnych i kartograficznych" (Technical Instruction O-3/O-4 "Maintenance of the State Geodetic and Cartographic Resources and collection of documentation of surveying and cartographic works"), GUGIK, 2001.

ISBN 9984 – 779 – 06 – 8

CHANGES OF ECOLOGICAL-GEOCHEMICAL STATE OF TOPSOIL AND RIVER SEDIMENTS IN VILNIUS

EKOLOĢISKI- ĢEOĶĪMISKĀ GRUNTS UN UPES NOGULŠŅU STĀVOKĻA IZMAIŅAS VIĻŅAS PILSĒTĀ

RIMANTĖ ZINKUTĖ, RIČARDAS TARAŠKEVIČIUS, ALFREDAS RADZEVIČIUS

Institute of Geology and Geography, T. Ševčenkos 13, LT 2600 Vilnius
Phone: + 370 2104708, *fax*: + 370 2104695
e-mail: Zinkute@geo.lt, Taraskevicius@geo.lt, Alfredas.Radzevicius@geo.lt

Abstract. *The changes of environmental quality were revealed according to temporal differences of additive contamination indices calculated for topsoil and sediments of Neris and Vokė rivers in Vilnius. Topsoil contamination indices were calculated on the basis of Ag, Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, V and Zn contents for 2 different periods (1985 and 1996-2002) and their comparison was realised on 237.86 sq.km territory of the first sampling. The areas, where topsoil ecological-geochemical state has worsened have been determined. Part of them with unallowable topsoil pollution level indicates the quarters, where population health risk increase is possible. Monitoring is necessary there, also health protection measures. The tendency of improvement of ecological-geochemical state of river sediments is observed, but potential sources of secondary pollution in sediments can be hazardous for downstream segments.*

Keywords: *ecological-geochemical state, heavy metals, topsoil, stream sediments, urban quality.*

Introduction

Due to intensive traffic, fuel and waste incineration and industrial activity, urban territories are polluted by heavy metals. They are hazardous to human health and the whole environment. Not only the geochemical quality of air and water is important, but also of soil and stream sediments. The investigation of topsoil is especially important, because heavy metals accumulate there and the routes of human exposure to them can be direct (accidental ingestion of contaminated soil or dermal contact with it) or indirect (drinking of water contaminated due to migration of hazardous substances from soil, inhalation of air contaminated by soil particles with heavy metals, eating of contaminated fruits, vegetables, fish, meat). Similar routes of human exposure are from contaminated sediments. Besides, their research enables to analyse the migration of pollutants. Therefore geochemical mapping of urban topsoil is done in various countries [1, 2]. It is often supplemented by investigations of bed sediments of streams crossing urban territories. This enables to find out the input of each town to stream pollution.

Geochemical investigations of Vilnius were started in the ninth decade of the XXth century by geochemists of the Institute of Geology. The first topsoil sampling was done in 1985 in the area covering large part of Vilnius territory and part of its environs. However, regular geochemical monitoring of topsoil in Vilnius was not done. So further sampling was for different aims and not in the same sites. Repeated sampling of topsoil was done in 1995-1998 in 6 central districts of Vilnius and Valakampiai. It revealed that Naujamiestis and Senamiestis districts were contaminated most of all [3]. Regular monitoring of stream sediments was also not done. Their early sampling was in the ninth decade of the XXth century, e.g. samples from Neris and Vokė were taken in 1981-1983. Some samples from these streams were taken also in 1991. The last sampling of topsoil and stream sediments was in 2002 during implementation of the program "Urban environmental quality and its change" aimed at complex evaluation of Joniškis, Mažeikiai, Šiauliai and Vilnius. Topsoil samples were taken from the territory of 15 peripheral districts of Vilnius and sediment samples from Neris, Vokė and Vilnelė. The quality of topsoil and stream sediments was compared in these towns, in Šiauliai lake sediments were also analysed [4]. Comparison of topsoil quality in four urban land use groups (public, residential,

ISBN 9984 – 779 – 06 – 8

industrial-infra-structural and recreational) revealed the highest pollution level in Vilnius, especially in its industrial-infra-structural zones [5].
The aim of present research was to reveal the changes of environmental quality in Vilnius from the ninth decade of the XXth century till the end of XXth century according to temporal differences of additive contamination indices (Z13) calculated for topsoil and sediments of Neris and Vokė rivers taking into account the following potentially hazardous elements: Ag, B, Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, V, Zn.

Materials and methods

Complex samples consisting from several sub-samples were taken from the upper (0-10 cm depth) soil layer. In 1985 topsoil samples (652) were taken at scale 1:50000, in 1995-1998 from central districts of Vilnius and Valakampiai (2237) at scale 1:7500-1:15000 and in 2002 from peripheral districts at scale 1:100000. Due to great difference in scales all samples were classified into 2 groups: 6 central districts, which were mapped in more detail, and 15 peripheral. Stream sediment samples were taken with a scoop. In 2002 they were taken from Nėris and its tributaries Vilnelė and Vokė. Comparison of changes in topsoil ecological-geochemical state was realised on 237.86 sq. km territory of the first sampling, while for stream sediments of Neris and Vokė in segments indicated by large circles (Fig. 1).

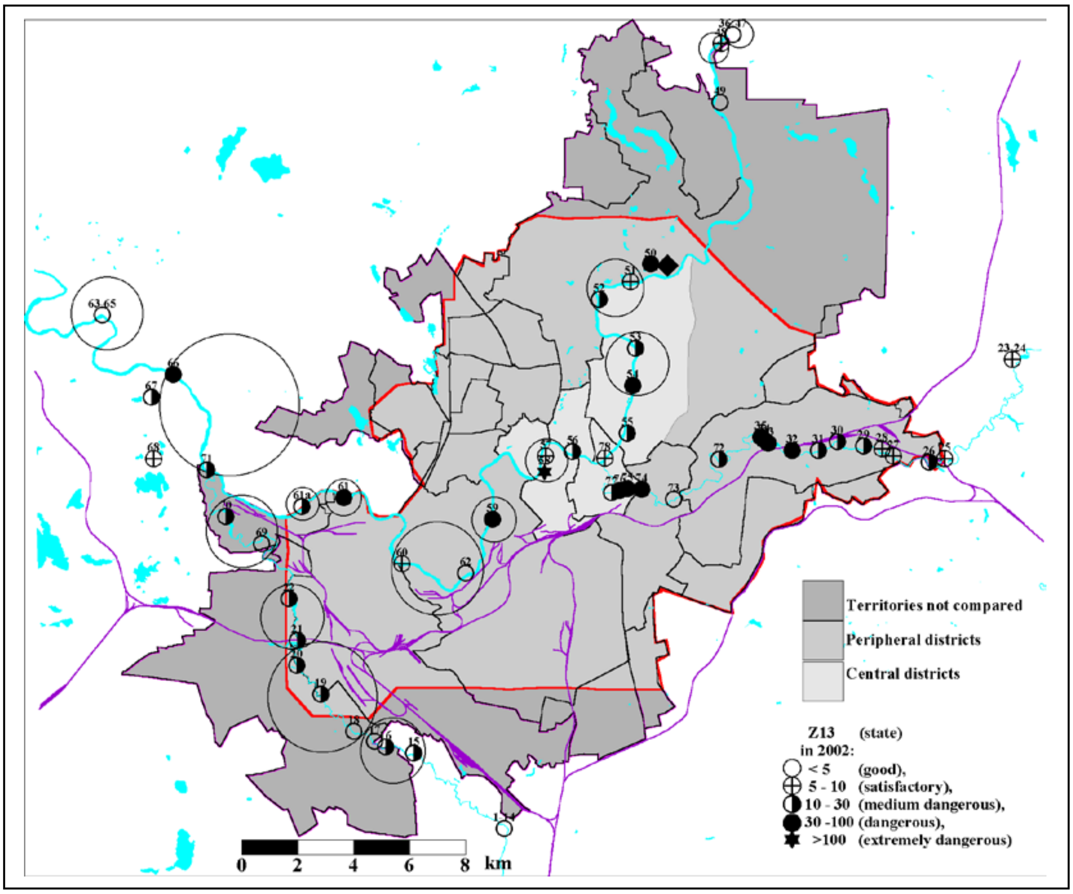


Fig. 1. **Study areas of topsoil contamination and stream sediment last sampling sites**

Note. Large circles indicate river segments, where contamination level in two periods was compared.
All samples were air-dried, sieved through nylon sieves (choosing fraction <1 mm). After burning at 450^{0}C and mechanical pulverisation they were analysed by DC arc emission spectrophotometry for determination of the total contents of Ag, B, Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, V, Zn. The international reference materials OOKO 153 and OOKO 151 were used for quality control. They were analysed in each batch of 10 samples. Since 1997 for quality assurance of analytical results the laboratory of the Institute of Geology and Geography

ISBN 9984 – 779 – 06 – 8

participates in “International Soil analytical exchange” subprogram organised by Wageningen University and international programs of inter-comparison [6].

Additive contamination indices Z13 for topsoil and stream sediments were calculated on the basis of Ag, Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, V and Zn contents for 2 different periods. Regional background values of these elements in soil were taken as the first approximation [7]. They were adjusted in a way described elsewhere [8]. Table 1 shows that for greater part of the elements, except Co, Sn, Pb, Ni, the adjusted local background values of the second sampling were slightly lower than for the first sampling. Median values of elements in bed sediments of Lithuanian streams depend on soil in the watershed [9]. Lithuanian streams draining dominant areas of sandy-loamy soil were chosen and anomalies of elements eliminated (values greater than 2*Md and lower than 0.5*Md, where Md is median value). The new medians after elimination of anomalies were taken as the background for element content in sediments of Neris, Vilnelė and Vokė. Table 1 shows that for most elements, except Pb, these background values are higher than for soil.

Table 1.

Background values (ppm) of elements in soil and stream sediments

Elements	**B**	**B_1**	**B_2**	**$RB=B_1/B_2$**	**BSS**
Ag	0.064	0.093	0.072	0.78	0.086
B	21.3	23.2	20.1	0.87	28.1
Ba	305	297	287	0.97	431
Co	3.70	2.64	2.88	1.09	4.9
Cr	24.3	25.8	24.3	0.94	34.9
Cu	6.80	7.64	7.60	0.99	10.8
Mn	436	544	395	0.73	888
Mo	0.64	0.74	0.64	0.86	0.84
Ni	9.6	9.4	9.4	1.00	12.2
Pb	15.0	15.1	15.4	1.02	13.7
Sn	1.95	1.93	2.05	1.06	2.3
V	25.7	25.0	24.3	0.97	30.0
Zn	24.9	27.2	23.1	0.85	47.2

B – regional soil background (South Lithuanian Plain), B1 – adjusted local background of the first sampling, B2 – adjusted local background of the second sampling, BSS – background for stream sediments**.**

Results and discussion

Table 2 indicates that during the first sampling the accumulating association of all investigated territory included only 5 non-ferrous metals. In central area it was wider and besides them contained also Ba, Cr, Ni and Mo, meanwhile in peripheral area it was narrower and consisted of the only element Zn. So during the first sampling the central part of Vilnius was affected not only by transport, corrosion of building material and household pollution, but also by industrial pollution of metal working plants (plants of boring machines, fuel equipment, etc.), meanwhile the pollution of peripheral part was actually only beginning. Therefore the median concentration coefficients of almost all elements, except B, Mn and V, were higher in the central part than in peripheral. The same concerns Z13 index: its median value in the central area was 2.5 times higher than in peripheral part and was already approaching the limit for allowable contamination (16).

During the period of the second sampling the same elements remained in accumulating association of central part, but the growth of contamination was observed only for part of them: Zn, Pb, Cu, Ag, Ba and Cr, i.e. mainly for those related to non-ferrous metals. Contamination level of Ni remained the same and of Sn and Mo even slightly decreased probably due to the fact than a lot of industrial enterprises (including metal processing) stopped functioning, part of

ISBN 9984 – 779 – 06 – 8

accumulated pollutants could be washed out of topsoil or removed with soil cover during reconstruction of separate quarters of the central districts. Despite decrease of accumulation level of Sn and Mo, the additive contamination in the central part has grown up and exceeded the limit for allowable contamination (16) indicating that the greater part of central districts are characterized by unfavourable conditions for life, most probably due to intensification of traffic, construction works, corrosion of building materials and growth of household pollution and further accumulation of pollutants in topsoil. New centres of pollution appeared near parking places and crossings with intensive traffic.

Table 2.

Temporal change of contamination indices in topsoil

In all investigated area (N_1=617, N_2=2453)					**In central area (N_1=117, N_2=2238)**					**In peripheral area (N_1=500, N_2=215)**				
Var.	**M_1**	**M_2**	**R**	**D**	**Var.**	**M_1**	**M_2**	**R**	**D**	**Var.**	**M_1**	**M_2**	**R**	**D**
Z13	5.28	18.24	3.45	12.96	Z13	12.22	19.61	1.60	7.39	***Z13***	4.88	9.32	1.91	4.44
Zn	**1.39**	**5.10**	3.68	3.71	**Zn**	**3.13**	**5.21**	1.67	2.08	**Zn**	**1.30**	**2.87**	2.21	1.57
Ag	**1.36**	**3.22**	2.37	1.86	**Pb**	**2.17**	**3.20**	1.48	1.04	***Cu***	1.24	**1.72**	1.39	0.48
Pb	**1.29**	**3.04**	2.35	1.75	**Cu**	**1.78**	**2.32**	1.30	0.54	***Pb***	1.21	**1.55**	1.28	0.34
Cu	**1.34**	**2.26**	1.68	0.92	**Ag**	**2.74**	**3.50**	1.28	0.76	*Ba*	1.21	**1.42**	1.18	0.22
Sn	**1.32**	**1.94**	1.47	0.62	**Ba**	**1.30**	**1.44**	1.11	0.14	***Ag***	1.28	**1.50**	1.17	0.22
Mo	1.17	**1.50**	1.29	0.33	**Cr**	**1.33**	**1.37**	1.03	0.04	*Mo*	1.13	**1.30**	1.14	0.16
Ni	1.20	**1.48**	1.23	0.28	Co	1.27	1.28	1.01	0.01	*Co*	1.16	**1.32**	1.14	0.16
Ba	1.22	**1.44**	1.18	0.22	**Ni**	**1.50**	**1.50**	1.00	0.00	*Cr*	1.21	**1.34**	1.11	0.13
Cr	1.24	**1.36**	1.10	0.13	**Mo**	**1.55**	**1.54**	0.99	-0.01	Mn	1.21	**1.34**	1.11	0.13
Co	1.18	1.28	1.09	0.10	Mn	1.09	1.08	0.99	-0.01	V	1.20	**1.31**	1.10	0.12
V	1.19	1.10	0.93	-0.08	B	1.08	1.05	0.98	-0.03	Ni	1.17	1.27	1.08	0.10
B	1.15	1.06	0.93	-0.09	V	1.15	1.09	0.94	-0.07	***Sn***	1.28	**1.34**	1.05	0.07
Mn	1.18	1.09	0.92	-0.09	**Sn**	**2.16**	**2.01**	0.93	-0.15	B	1.16	1.16	1.00	0.00

Note. Var. – variable (element or additive contamination index of all 13 elements), N_1 and N_2, – number of samples, M_1 and M_2 – median values of concentration coefficients of elements or their additive contamination index Z13 during the first and the second sampling, respectively. $R=M_2/M_1$, $D=M_2-M_1$. Elements belonging to accumulating associations (with median concentration coefficient higher than 1.3) are in bold.

The accumulating association in peripheral part became even wider and included not only all elements related to non-ferrous metals, but also to ferrous metals: Zn>Cu>Pb>Ag>Ba>Cr>Mn>Sn>Co>V>Mo. The highest rate of contamination increase is characteristic of Zn, Cu, Pb, Ba, Ag, i.e. elements related to transport and household pollution. The median value of additive contamination index in peripheral area of Vilnius exceeded 8, i.e. started to approach to the limit of allowable contamination. The relative growth of Z13 in peripheral districts (1.91) was even higher than in the central districts (1.60), but the absolute growth in the latter districts (7.39) exceeded the absolute increase of Z13 in periphery (4.44). Some of administrative districts in periphery are highly industrialized and therefore are characterized by high median contamination level. They are located mainly in the southwestern and southern part of Vilnius (Fig. 2), also in Naujoji Vilnia, which is in the eastern part. The sites, where ecological-geochemical state of topsoil has worsened are mainly related to motor and railway transport, industry and household pollution.

ISBN 9984 – 779 – 06 – 8

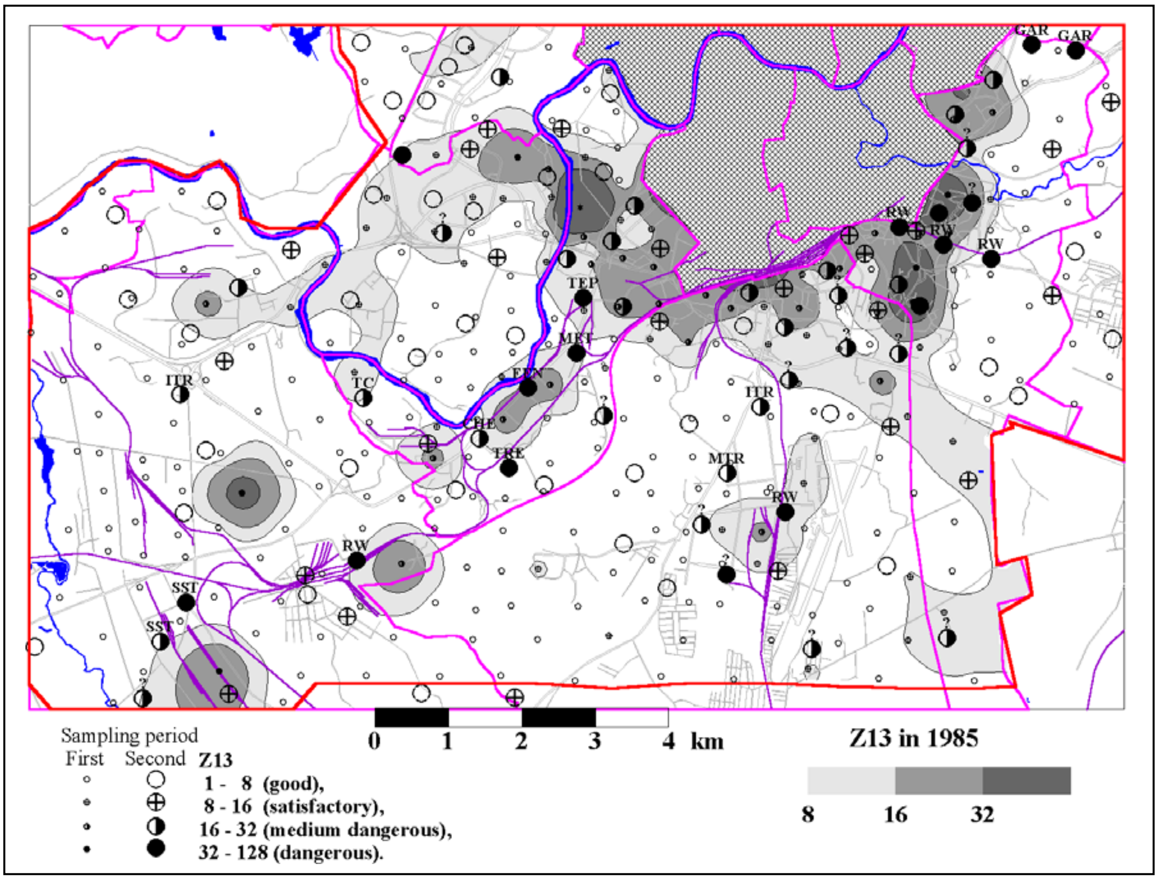


Fig. 2. **Temporal variability of topsoil contamination in southwestern part of Vilnius**

Note. New sites, which were revealed during the second period of sampling, where topsoil contamination exceeds the allowable level (16) and where the ecological-geochemical state became less favourable for life, are indicated by label, which explains the possible reason of contamination increase: ITR – intensive transport, GAR – garages, SST – service stations, RW – railway, MET – metal processing, MTR – metal trade, EEN – electrical engineering, CHE – chemical industry, TEP – thermoelectric power plant, HHP – household pollution.

The relative growth of topsoil contamination in all investigated territory was 3.45, while the absolute one was 12.96. The highest accumulation level was always characteristic of Zn due to variety of its different sources (metal processing, other industry, fuel burning, traffic, fertilizers, corrosion of roofs, etc.).

Median Z13 of Neris sediments in the whole Vilnius has 3.8 times decreased from 26 in 1981–1983 to 6.8 in 2002, i.e. from medium dangerous to satisfactory state. The number of accumulating elements with concentration coefficient (CC) exceeding 1.3 decreased from 9 in 1981–1983 to 4 in 2002, for most of them, except Mn and Pb, the accumulation level (CC) decreased from $Ag_{16}Cu_{3.6}Sn_{3.3}Cr_{2.8}Zn_{2.7}Mn_{1.5}Mo_{1.5}Pb_{1.4}Ni_{1.4}$ in 1981–1983 to $Ag_{4.5}Mn_{1.9}Pb_{1.5}Cu_{1.4}$ in 2002. Table 3 indicates that in most of the segments of Neris and Vokė Z13 index decreased. Almost everywhere (except segments V and VI, which are heavily polluted) the highest accumulation level (CC>2) is characteristic of non-ferrous metals (Ag, Cu, Zn, Sn and Pb), also Mn and Cr.

ISBN 9984 – 779 – 06 – 8

Table 3.

Temporal change of contamination and accumulating elements in stream sediments

River segment	Year	Z13	Accumulating elements	R	Increase of
I. Neris upstream of Vilnius (No 36-47)	1982	6.7	$Ag_{2.6}CuNiMnZnCrSn$	0.85	**Mn**Mo
	2002	5.7	$Mn_{4.3}AgMo$		
II. Neris downstream of Žalesa (No 48)	1983	3.0	$Mn_{2.7}$	1.22	Sn
	2002	3.6	$Mn_{2.5}Sn$		
III. Neris near Verkiai (No 51-52)	1981	1.2	-	2.14	MoMnCu
	2002	2.5	MnMoCu		
IV. Neris near Žirmūnai (No 53-54)	1981	4.6	$Ag_{3.3}Mn$	0.90	MoCu Pb**Mn**
	2002	4.2	$Mn_{2.1}CuPbAgMo$		
V. Neris near Žvėrynas (No 57-58)	1981	65	$Ag_{40}Zn_{7.6}Sn_{6.1}Cu_{5.9}Pb_{3.0}Cr_{2.8}Mo_{2.7}Ba_{2.3}MnNi$	0.35	Mn
	2002	23	$Ag_{17}Pb_{2.6}Zn_{2.5}CuMnSnMo$		
VI. Neris near „VELGA" (No 59)	1981	76	$Sn_{24}Cu_{18}Ag_{18}Zn_{8.2}Cr_{5.0}Mo_{3.3}Pb_{3.1}Mn_{2.2}Ni$	0.40	**CrNi**V
	2002	31	$Cr_{13}Ni_{7.2}Ag_{6.1}Cu_{4.4}ZnPbVSn$		
VII. Neris in Bukčiai (No 60, 62)	1981	21	$Ag_{10}Cu_{8.3}Zn_{2.1}CrSnPb$	0.20	Mn
	2002	4.1	$Ag_{3.3}Mn$		
VIII. Neris downstream of wastewater treatment pl. (No 61)	1983	30	$Ag_{17}Cr_{4.2}Cu_{3.4}Zn_{3.3}Sn_{2.5}MnMoPbNiBaCo$	0.52	**MnPb**
	2002	16	$Ag_{11}Mn_{2.4}Pb_{2.1}CuZn$		
IX. Neris near Sudervėlė (No 61a)	1983	10	$Ag_{4.6}Cu_{2.4}Cr_{2.3}Mn_{2.0}ZnNiSn$	1.28	**PbAg**
	2002	14	$Ag_{9.6}Pb_{2.3}ZnMnCu$		
X. Neris dowstream of Vokė (No 66, 71)	1981	34	$Ag_{22}Cu_{3.8}Sn_{3.8}Cr_{3.6}Zn_{2.5}MoMnNiPb$	0.40	PbMn **Zn**
	2002	13	$Ag_{7.5}Cu_{2.9}Zn_{2.7}PbMnNiSn$		
XI. Neris near Verkšnionys (No 63-65)	1981	34	$Ag_{23}Cr_{4.0}Cu_{3.5}Sn_{2.7}Zn_{2.4}MnMoNi$	0.11	–
	2002	3.7	$Ag_{3.7}$		
XII. Vokė in Vaidotai (No 15-17)	1984	2.9	AgSnZn	0.58	Mn
	2002	1.7	Mn		
XIII. Vokė in Naujakiemis (No 18-20)	1984	7.5	$Ag_{4.8}ZnSnMo$	0.80	MnCu **Pb**
	2002	6.0	$Zn_{2.2}Pb_{2.1}CuAgMnSn$		
XIV. Vokė in Trakų Vokė (No 21-22)	1984	7.3	$Ag_{3.6}Zn_{2.2}MoSnMnPb$	1.61	**SnCuPb** NiMn
	2002	12	$Sn_{6.2}Pb_{2.9}Cu_{2.2}MnZnNiAgMo$		
XV. Vokė in Grigiškės (No 69-70)	1981	3.1	AgSnMn	1.02	**Zn**
	2002	3.1	$Zn_{2.7}Ag$		

Note. River segments are shown in Fig. 1. Accumulating elements have CC>1.3. The subscript of element indicates its CC (only CC>2 are shown). R is the ratio of Z13 in the second period to Z13 in the first period. Elements with high increase are in bold.

In segment V near former tannery and leather processing plant Cr, Mo and Ba added to other common pollutants in 1981. However, when the plant was transferred to another place, the content of these elements decreased in sediments taken in 2002 and the ecological-geochemical state improved from dangerous to medium dangerous category.

It also improved in segment VI, where surface runoff from welding equipment plant comes: the Z13 decreased due to lower CC of Sn (tinning technology is no more used in the plant).

ISBN 9984 – 779 – 06 – 8

However, the ecological-geochemical state of the segment remained dangerous, because Cr and Ni are still used in technological processes and their pollution increases.

High water migration coefficient explains variability of Ag in bed sediments. Accumulation of Ag and Mn can be related to geochemical barriers (oxidation and sorption processes) in sediments in the places of groundwater discharge and inflow of unpolluted surface water. Increase of Pb and Ag downstream of wastewater treatment plant can be explained by general increase of transport and household pollution in the whole town. This can be the reason of Z13 increase in segment IX.

Paper mill in Grigiškės, where waste paper is processed, can explain the growth of Zn in Vokė (segment XV) and in Neris downstream of Vokė (segment X). However, Z13 increase is not essential in Vokė (segment XV). So the influence of this tributary on Neris pollution is not great and ecological-geochemical state of Neris downstream of Vokė has improved greatly.

Meanwhile the growth of Z13 and Sn, Cu, Pb pollution in Vokė sediments within segment XIV as well as increase of Pb accumulation in segment XIII is related to intensive railway and motor transport pollution in vicinity of storehouses and enterprises of southwestern industrial district. The relative growth of Z13 in Neris near Verkiai (segment III) is related to geochemical barriers, because Z13 indices of both periods are low.

Ecological-geochemical state of Vilnelė, which is other tributary of Neris, was analysed only in 2002 and differs in various segments. In some of them (i.e. in segment following metal processing plants in Naujoji Vilnia or near tannery and electrical engineering plant near central districts of Vilnius) the ecological-geochemical state of sediments is still dangerous (Fig. 1).

Acknowledgment

Credits. Late sampling of topsoil in 6 central districts of Vilnius and Valakampiai was funded by Vilnius Municipality, while in peripheral parts as well as sampling of stream sediments in 2002 by Lithuanian State Science and Studies Foundation. The authors would like to express their gratitude to these organizations.

Conclusions

During the period from 1985 to 2002 topsoil total contamination index has mainly increased in Vilnius indicating that this medium is accumulating pollutants over long period. Besides, new polluted areas have appeared in peripheral districts and especially near parking places. The growth of topsoil contamination by non-ferrous metals (Zn, Pb, Cu, Sn and Ag) was more intensive than by elements related to ferrous metals and can be explained mainly by increase of traffic intensity and household pollution. The relative growth of additive contamination level of topsoil in peripheral districts of town is higher than in the central districts, partly due to location of industry, railway and streets with intensive transport in peripheral areas. However, both the levels and absolute growth of total contamination index in central districts, which are older and more densely populated, is higher. These regularities can be observed also in other towns. Decrease of topsoil anomalies on local areas is possible due to disturbances of soil cover.

The tendency of improvement of ecological-geochemical state of river sediments is observed due to decrease of industrial emissions of the territories of industrial enterprises, lower enrichment of surface runoff with heavy metals, better treatment of wastewater and migration of pollutants with water flow. The highest accumulation level in stream sediments is characteristic of non-ferrous metals (Ag, Cu, Zn, Sn and Pb), also Mn and Cr, but their accumulation mostly decreases, except several segments near local emission sources of pollutants and downstream of them, also in places of geochemical barriers. Increase of Pb contamination can be related to rain sewage discharge to streams.

Geochemical monitoring is necessary in the areas, where topsoil ecological-geochemical state has worsened and exceeds the allowable level of topsoil contamination. The same concerns stream sediments, not only because it is necessary to monitor the influence of effluents, but also

ISBN 9984 – 779 – 06 – 8

because the sites heavily contaminated until now are potential secondary pollution sources for downstream segments.

References

1. Birke M., Rauch U. Geochemical investigation of the urban area of Berlin. Federal institute of Geosciences and Natural Resources, Berlin, 1994, p. 15-17.
2. Pasieczna A. Atlas zanieczyszczen gleb miejskich w Polsce. Panstvowy instytut geologiczny, Warszawa, 2003, 191 p. (in Polish).
3. Taraškevičius R. Heavy metals in topsoil of Naujamiestis, Senamiestis, Šnipiškės, Žirmūnai, Žvėrynas and Antakalnis districts of Vilnius (in Lithuanian). Aplinkos inžinerija (Environmental Engineering), vol. VIII, No. 3, Vilnius, "Technika", 2002, p. 137-145 (in Lithuanian).
4. Zinkutė R., Radzevičius A., Taraškevičius R. Ecological-geochemical state of topsoil and water sediments in Šiauliai. Environment. Technology. Resources. Proceedings of the 4th International Scientific and Practical Conference. Rezekne, June 26–28, 2003. Rezekne, 2003, p. 309–315.
5. Taraškevičius R., Zinkutė R. Geohygienical evaluation of topsoil in urban territories. Geografijos metraštis (The Geographical Yearbook), 36 (1), Vilnius, Institute of Geology and Geography, Lithuanian union of geographers, 2003, p. 161-170 (in Lithuanian).
6. Taraškevičius R., Zinkutė R. Microelement determination methods for mapping purposes. Environmental geochemical baseline mapping in Europe. Abstracts of the 2nd conference, Vilnius, Lithuania, September 1-4, 1999. Vilnius, 1999, p. 100-103.
7. Kadūnas V., Budavičius R., Gregorauskienė V., Katinas V., Kliaugienė E., Radzevičius A., Taraškevičius R. Geochemical atlas of Lithuania. Vilnius, 1999, 90 p.: 18 tables+162 maps (in Lithuanian and English).
8. Taraškevičius R., Zinkutė R. Geochemical characterization of topsoil in dwelling districts of Lithuanian urban territories. International workshop "Geosciences for Urban Development and Environmental Planning". September 13–18, 2003, Vilnius, Lithuania. COGEOENVIRONMENT, 2003. Extended abstracts. Vilnius, 2003, p. 97–99.
9. Radzevičius A. The influence of river basin soil mechanical composition on element concentration in river sediment. In: Lovejoy, D. A. (ed). Heavy metals in the environment: an integrated approach. Vilnius: Institute of Geology, Metalecology Society, 1999, p. 91–98.

ISBN 9984 – 779 – 06 – 8

VIDI SAUDZĒJOŠĀS TEHNOLOĢIJAS

ENVIRONMENTAL FRIENDLY TECHNOLOGIES

ISBN 9984 – 779 – 06 – 8

CONCEPT OF RISK ASSESSMENT FOR ESTONIAN OIL SHALE MINES
RISKA NOVĒRTĒŠANAS JĒDZIENS IGAUNIJAS DEGSLĀNEKĻA RAKTUVĒS

JYRI-RIVALDO PASTARUS, SERGEI SABANOV

Tallinn University of Technology, Department of Mining
5 Ehitajate tee St, Tallinn, 19086, Estonia
Phone: + 372 6203850, *fax*: + 372 6203696, *e-mail*: pastarus@cc.ttu.ee

Abstract. *The paper deals with the risk assessment problems in Estonian oil shale mines, where the room-and-pillar mining with blasting is used. This study addresses risks associated with the collapse of mining blocks, including environmental problems. Some of the various factors, which are relevant to Estonian oil shale mines, are determined. For risk estimation the event tree is used. Investigation showed that the likelihood and the consequences of the risk are not acceptable. Risk mitigation process reduces the likelihood. The used concept of risk assessment method is applicable for Estonian oil shale mines. It may be used for different purposes and levels. The results of the risk assessment are of particular interest for practical purposes.*

Keywords: *collapse, event tree, mining block, mitigation, probability, risk analysis, risk assessment, risk evaluation, risk management, surface subsidence.*

Introduction

The most important mineral resource in Estonia is a special kind of oil shale. It is located in a densely populated and rich farming district. Underground oil shale production is obtained by room-and-pillar method with blasting. This method is cheap, highly productive and easily mechanize.

Underground mining in Estonian oil shale mines causes a large number of technical, economical, ecological and juridical problems. The data, which have become available in the last 40…50 years, provide a foundation for the ideas recommended to be used in risk assessment.

This study addresses risks associated with the collapse of mining blocks, including environmental problems. Up to present, 73 collapses on the area of 100 km^2 (about 400 mining blocks) have been recorded. Application of risk assessment to Estonian oil shale mines raises a unique set of problems, because each mine and mining blocks is a unique system within its own distinctive environment.

The risk analysis is use of available information to estimate the risk to ground surface subsidence from hazards. Some of the various factors, which are relevant to Estonian oil shale mines, are determined. Probabilistic risk analysis is a more rational basis for evaluation. For the risk estimation the event tree is used. Having received the risk information, and knowing the risk valuation criteria, we come to a decision.

The primary interest in this study has been in evaluating the usability of the methodology and in evaluating the probability of failure without detailed assessment of consequences.

Analysis showed that the used concept of risk assessment method is applicable for Estonian oil shale mines. The concept of risk assessment may be used for different purposes and at different levels: at the mining block design stage; as bases for decision-making when selecting among different remedial actions for mined out area within time and financial restraints; to relate ground surface subsidence risk levels to acceptable risk levels established by society for other activities. The results of the risk assessment are of particular interest for practical purposes.

Concept of risk assessment

Risk assessment is the process of deciding whether existing risks are tolerable and risk control measures are adequate. It incorporates the risk analysis and risk evaluation phases. Risk assessment involves making judgment about the taking of risk and all parties must recognize that

ISBN 9984 – 779 – 06 – 8

the adverse consequences might materialize and owners will be required to deal effectively with the consequences of the failure event [1, 2, 3]. The primary steps of a risk assessment are presented in Fig. 1.

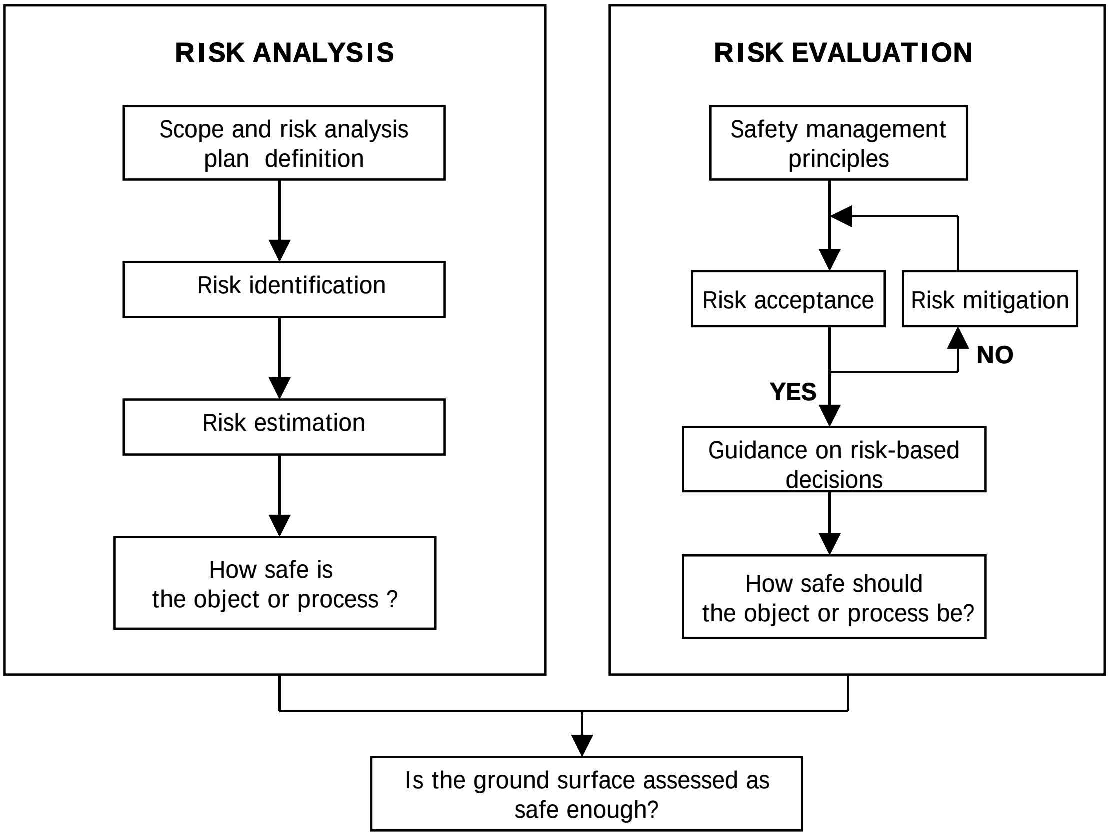


Fig. 1. **Risk assessment [3]**

Risk analysis

Risk analysis is used for performing safety assessment for many different technical systems. Many authors have described the sequential steps that comprise technical systems risk analysis. Concerning the varied terminology, most are in general agreement over the basic requirements [1, 2, 4]. Risk analysis includes (Figure 1):

1. Scope and risk analysis plan definition
2. Risk identification
3. Risk estimation

The description of the system, scope and expectations of the risk analysis should be defined at the outset. An iterative approach should be adopted with qualitative methods being employed at the early stages of the process. If more information becomes available, use of quantitative analyses is required.

Risk identification is the process of determining what can go wrong, why and how [3]. Failure can be described on many different levels. Conceptualization of the different possible failure modes for a technical system is an important part of risk identification. One should first take into account as many types of failure as possible. The initial list can then be reduced by eliminating those types of failures considered implausible.

Risk estimation entails the assignment of probabilities to the events and responses identified under risk identification. The assessment of appropriate probability estimates is one of the most difficult tasks of the entire process. Tools that are often used to help in risk estimation are fault trees and event trees [1, 2, 4]. Probability estimation can be grouped into three general approaches depending on the type and quality of the assailable data [3]:

1. Analytical approach uses logical models for calculating probabilities.

ISBN 9984 – 779 – 06 – 8

2. Empirical approach uses existing databases to generate probability.
3. Judgmental approach uses experience of practicing engineers in guiding the estimation of probabilities.

Attaining an exact value of probability for technical systems and processes is not a realistic expectation. Component event probabilities may be assessed using a subjective degree-of-belief approach (Table 1.).

Table 1.

Verbal description of uncertainty [5]

Verbal description of uncertainly	Uncertainty
1. Virtually impossible	0.01 (0.001)
2. Very unlikely	0.10
3. Completely uncertain	0.50
4. Very likely	0.90
5. Virtually certain	0.99 (0.999)

Risk evaluation

Risk evaluation is the process of examining and judging the significance of risk [1, 3, 6]. Risk evaluation stage is the point at which values and judgments enter the decision process, by including consideration of the importance of the estimated risks. Risk evaluation is fundamental to risk assessment and risk-based decision making. The principal role of risk evaluation in risk assessment is the generation of decision guidance against which the results of risk analysis can be assessed. It requires a statement of the owner's safety management principles and of the values and preferences of the public (prevailing financial, legal and regulatory conditions). The risk evaluation process should be clearly communicated to all interested groups. The extent, to which each of these basic principles apply depend on the nature of the risk assessment. Risk evaluation includes.

1. Risk mitigation
2. Risk acceptance

Risk mitigation is a selective application of appropriate techniques and management principles to reduce either likelihood of an occurrence or its consequences, or both [2, 3, 6]. Risk mitigation is a logical step following risk estimation. If the calculated risk of the existing system is judged to be too high, alternatives are proposed to reduce the risk of failure. These alternatives are incorporated into the risk model and re-evaluation is conducted to estimate their impact. After repeated study the decision makers can be provided with suitable alternatives and their estimated costs for consideration in improving overall technical system safety.

Risk acceptance is an informed decision to accept the likelihood and the consequences of a particular risk [1, 2, 3]. In some countries, there is a certain risk level that is defined as the limit of unacceptable risk. For failure events with no potential fatalities or irreparable damage to the environment, the target annual failure probability may be decided exclusively base on economic considerations and corresponding risk analysis. A target level of 10^{-3} … 10^{-2} rather than 10^{-6} … 10^{-5} may be a reasonable criterion [5].

Risk management

Risk management is the systematic application of management policies, procedures and practices to the task of identifying, analyzing, assessing, treating and monitoring risk [1, 2, 6]. Having received the risk information, and knowing the risk evaluation criteria, a decision-maker must come to a decision. The decision process includes consultations with stakeholders and community, insurance issues, legal defensibility of decisions, risk information to decision-maker and to the public [3].

ISBN 9984 – 779 – 06 – 8

Investigations in Estonian oil shale mines

Technical and geological aspects by underground mining can influence on collapse of a mining block and surface subsidence. Some of various factors which are relevant to Estonian oil shale mines are presented in Fig. 2.

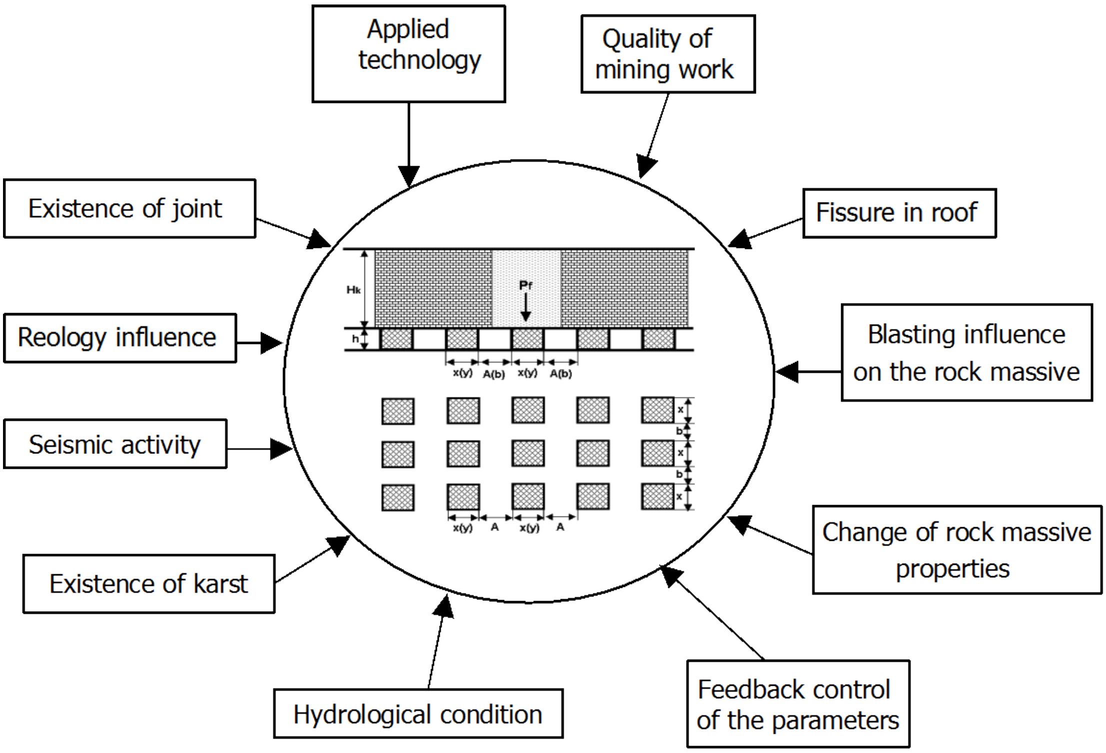


Fig. 2. **Contributing factors for mining block collapse and surface subsidence**

Main technical aspects, which can influence on the stability of a mining block, are quality of mining and blasting works. Investigation showed that room and pillars sizes in Estonian oil shale mines may deviate from project values. Maximum deviation is about ±1 m. It depends on quality of the applied machinery and miners. On the other hand the rock mass properties can change, caused by blasting works. In the roof and pillars appear supplementary cracks, which decrease the strength of the rocks.

Feedback control and adaptive design methods guarantee the stability of a mining block [7].

Influence of the geological parameters on the mining block stability is significant. Rheological behavior of rock was studied and taken into consideration by calculations [8].

Karst and fissure (joints) influence on the stability of a mining block is evident. These factors are determined for Estonian oil shale deposit and presented on the map of a mining block.

Especial attention must pay to hydrological conditions. Many old mines are completely flooded. It is not known, what will appear in the future, after 20 – 30 years.

Seismic activity in Estonia is at such low level that it has been considered in this study only to restricted extent. It is practically impossible.

The above mentioned technical and geological influence factors can lead to the damage of the ground surface. Importance of these factors in mining block collapse and surface subsidence process demands supplementary investigations.

ISBN 9984 – 779 – 06 – 8

Event tree presents the risk estimation. For the probability determination the judgmental and subjective degree-of-belief approaches are used (Table 1).

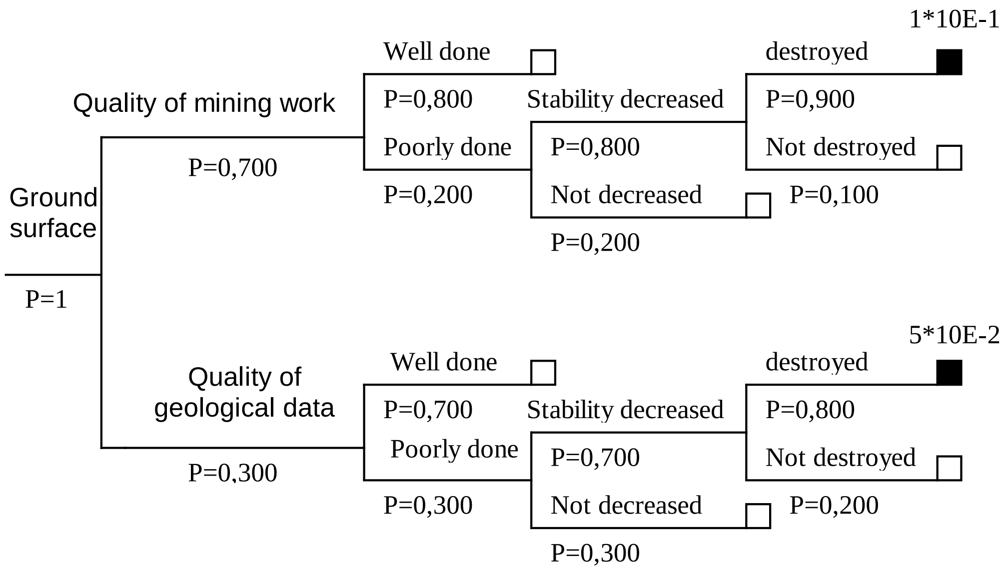


Fig. 3. **Event tree**

Presented event tree shows the ground surface damage form two factors: quality of mining works and geological data. In the case of quality of mining works the estimated probability of surface subsidence is 10^{-1}. The probability of surface subsidence when concerning quality of geological data is of $5*10^{-2}$. The summarized total probability of surface subsidence is of the order of $1.5*10^{-1}$.

The estimation probability of the surface subsidence exceeds 15 times the limit (10^{-3} … 10^{-2}). Consequently, the risk for mining blocks is not acceptable (Fig.3). Risk mitigation methods allow reducing either likelihood of the mining block collapse or its consequences, or both.

Design of mining block parameters based on the instruction, used in Estonian oil shale mines [8]. Analysis of the applicable mining block design method showed that the factor of safety is very large (1.2 – 1.8). Practically, it is impossible to determine the adequate factor of safety for a mining block. Consequently the factor of safety contains the unknown factors. Determination of the unknown factors is the task for the future.

On the other hand, the method of adaptive design can reduce the probability of a working mining block collapse [7]. It based on the monitoring system, which allows determining the potential collapse center in a mining block. Based on this data, it is possible to modify the pillar sizes. This method increases the stability of a mining block.

These above mentioned risk mitigation methods reduce likelihood of the mining block collapse and it consequences. In this case the risk will be acceptable. If not, alternatives will propose to reduce the probability of the collapse and surface subsidence. It demands supplementary investigation.

Conclusions

As a result of this study, the following conclusions and recommendations can be made.

1. Underground production in Estonian oil shale mines is obtained by room-and-pillar method with blasting. It causes a large number of technical, economical, ecological and juridical problems. The data, which have become available in the last 40…50 years, provide a foundation for the ideas recommended to be used in risk assessment.
2. This study addresses risk associated with collapse of mining blocks, including surface subsidence. The primary interest in this study has been in evaluating the usability of the

ISBN 9984 – 779 – 06 – 8

methodology and in evaluating the probability of the mining block collapse and surface subsidence without detailed assessment of consequences.

3. Some of the various factors, which are relevant to Estonian oil shale mines, are determined. For risk estimation the event tree is used. The probability of mining block collapse and surface subsidence is $1.5*10^{-1}$.
4. Investigation showed that the likelihood and the consequences of the risk are not acceptable. It exceeds 15 times the limit. Risk mitigation process reduces the likelihood.
5. Analysis showed that used concept of risk assessment method is applicable for Estonian oil shale mines. Presented method may be used for different purposes and at different levels. The results of the risk assessment are of particular interest for practical purposes.

Acknowledgment

Estonian Science Foundation (Grant No.5164, 2002-2005) supported the research.

References

1. Calow, P. Handbook of environmental risk assessment and management. Oxford, Blackwell Science. 1998.
2. DETR 2000.Guidelines for environmental risk assessment and management. London, TSO, 2000.
3. ICOLD 1999. Bulletin on risk assessment: Risk assessment as an aid to dam safety management. (Draft 24.08.99).
4. Graham, L. P., Bartsch, M. Risk analysis safety assessment for use at Swedish dams. Symposium: Research and development in the field of dams. Crans-Montana, Switzerland, 7-9 September 1995, p.12-19.
5. Hoeg, K. Performance evaluation, safety assessment and risk analysis for dams. Hydropower & Dams. Issue 6, 1996.
6. Kaplan, S., Garrick. On the Quantitative definition of risk. Risk analysis 1, 1981.
7. Pastarus, J.-R. Kamerno-stolbovaya sistema razrabotki mestorozhdenij i ee vliyanie na okruzhayushchuyu sredu. Scientific, Technological and Production Journal: Mine Surveying and Subsurface use. Moscow, 4 (10), 2003, p. 38-42. (in Russian).
8. Mining-law and legal regulation acts. Ministry of Environment, Ministry of Economy. Part II. Tallinn, 1998 (in Estonian).

ISBN 9984 – 779 – 06 – 8

ECOLOGICAL IMPACT OF BIODIESEL USE
BIODĪZEĻDEGVIELAS PIELIETOŠANAS EKOLOĢISKĀ IETEKME

VILNIS GULBIS, RUSLANS SHMIGINS

Latvia University of Agriculture, Motor Vehicle Institute
5 J.Cakstes blvd., Jelgava, LV-3001, Latvia
Phone: + 371 9151295, + 371 6872244, *fax*: + 371 3020762
e-mail: Vilnis.Gulbis@llu.lv, Ruslans.Smigins@llu.lv

Abstract. *The paper presents a study of biodiesel application and its ecological impacts. Our study is based on the comparison of exhaust emission composition produced by the combustion of rapeseed oil methyl ester (RME) and conventional diesel fuel (DD) and its blends in a direct injection diesel engine XD2P (YTT). The engine was tested in biofuels laboratory of LUA Motor Vehicle Institute. Fueling the engine with biodiesel and biodiesel/diesel blend reduced oxides of nitrogen by 17.5% (100RME) and by 5.6% (35RME) and carbon monoxide by 49.8% (100RME) and by 45.3% (35RME). Fueling the engine with biodiesel and different biodiesel/diesel blends reduced the absorption coefficient by 33.9% (5RME), by 44.3% (20RME), by 48.3% (35RME) and by 51.2% (100RME) on free acceleration regime. In these tests soot reduced by 28...76.7% at full opened throttle position with 100RME.*

Keywords: *renewable energy, biodiesel, exhaust emissions, smoke, test bench.*

Introduction

In Latvia now there are more than 173 000 diesel vehicles (CSDD, 2005), and the total number of them is increasing according to the diesel engine popularity. The widespread use of diesel powered vehicles and machines not only in Latvia, but also in all world, has caused many different environmental problems (acid rains, smog) and human health problems. Diesel exhaust is a complex mixture of gaseous constituents (including CO, NO_x, NO_2, CO_2) and particles, which have been classified as probable human carcinogen by International Agency for Research on Cancer (IARC, 1989). Due to this diesel widespread use, the possibilities to expose to diesel exhaust is not only to people whose work is directly connected with diesel equipment – railroad workers, truck and bus drivers and garage workers – but also to everybody who drive by car or go to work by bus every morning.

One of the possibilities to reduce environmental, economical and social problems caused by usage of fossil diesel fuel is to introduce biodiesel instead of fossil diesel fuel in diesel engines. Biodiesel can be made of such renewable resources as rapeseed oil, palm oil, waste cooking oil and others. These fuels have many characteristics, what makes them attractive for use in compression ignition engines, and the main advantage of biodiesel over fossil diesel is that it can be used in diesel engines without modification. These fuels also have some other essential advantages, what makes biodiesel more competitive to diesel. Biodiesel has higher flash point, what makes it safer for transport and storage; it reduces not only carbon dioxide, carbon monoxide, carcinogenic aromatic hydrocarbons (PAH) and others, but also sulfur dioxide emissions due to very low sulfur content in fuel.

Now biodiesel is applied in different areas: transport, commercial construction equipment and space heating. In Europe, U.S.A. and other countries biodiesel and its blends are used in diesel cars, light trucks and heavy trucks with few or no modifications. In some countries, such as U.S.A., biodiesel is used in different off-road equipment (bulldozers, excavators and cranes) and as heating oil for boilers operation or house heating. These application areas could be primary candidates for substitution of biodiesel due to a widely usage of high sulfur diesel fuel in these application areas.

Biodiesel is also successfully used in boats in many countries. For this application area there could also be some advantages noted. Firstly, the biodegradation rate of biodiesel is about twice as high as for diesel fuel; it degrades by 98.3% in 21 days (Williams, 2002). Secondly, the toxicity of biodiesel to plants and animals is lower compared with conventional diesel fuel. For

ISBN 9984 – 779 – 06 – 8

example, tests with larval forms of fish and shell fish showed that the toxicity of biodiesel is 20-40 times less than that of fossil diesel fuels (Zhou et al., 2003).

As the production of biodiesel (rapeseed methyl ester RME) is started now and is planned to grow rapidly, it is necessary to investigate the impacts of biodiesel and fossil diesel fuel blends on engine running and exhaust parameters. In this paper the results of biodiesel engine tests, which were carried out in engine testing and biofuels laboratory of the LUA Motor Vehicle Institute, are discussed.

Materials and methods

In the engine testing and biofuels laboratory of the Latvia University of Agriculture investigations of a commercial direct injection diesel engine XD2P (YTT) were carried out. It was a four-cylinder diesel engine with industrial application, manufactured by Ford CO., LTD. The engine was tested on the test bench VEM-100. The specification for this engine is shown in Table 1. The engine was operated on diesel fuel (DF), rapeseed oil methyl ester (100RME) and on its blends: 35% RME with 65% diesel (35RME), 20% RME with 80% diesel (20RME), 5% RME with 95% diesel (5RME). The exhaust emission characteristics were investigated at a variety of steady state engine speeds on full opened throttle position, namely 800, 1000, 1500, 2000, 2500 and 3000 rpm. The exhaust emission characteristics for DD and RME include smoke emissions (opacity) and gaseous emissions (NO_x, NO, CO, CO_2, O_2).

Table 1.

Engine Specifications

No. of cylinders	4
Bore	94 mm
Stroke	83 mm
Compression ratio	22:1
Max. power	49 kW/4200 rpm
Max. torque	139 Nm/2000 rpm

The exhaust emissions of NO_x, NO, CO, CO_2, O_2 were measured using the KM9104 exhaust gas analyser, but the PM related exhaust gas opacity (smoke) was measured using the gas analyzer BOSCH BEA-350 with opacimeter RTM 430. The diesel engine smoke opacity was measured at full opened throttle position at various engine speeds and than during free acceleration, but other exhaust emission components were measured at nominal rpm and only for DF, 5RME, 35RME and 100RME.

Results

The results showed that the smoke emissions obtained from the engine operated on biodiesel and on its blends with fossil diesel fuel were considerably lower than smoke emissions from conventional diesel fuel. Figure 1 shows soot concentration characteristics for biodiesel, conventional diesel and its 20% blend at engine full opened throttle position. As it is seen from the given characteristics by using biofuels soot concentration was reduced by 28% at engine speed 800 rpm to 76.7% at 3000 rpm. The measured smoke emissions were converted to the soot concentration (g/m^3) in exhaust gases by special correlation table (Грехов et al., 2004).

Figure 2 indicates the absorption coefficient of the tested engine running on free acceleration regime with different fuels: DF, 20RME and 100RME. All the measured absorption coefficient levels decrease with increasing the biodiesel percentage in the blend. Maximum reduction of the absorption coefficient (by 51.2%) has been recorded for 100% biodiesel usage. Quite good results have been almost recorded for 20RME, and it is 44.3% reduction of absorption coefficient compared to diesel fuel.

ISBN 9984 – 779 – 06 – 8

The results of the measured exhaust emission components are presented in Table 2.

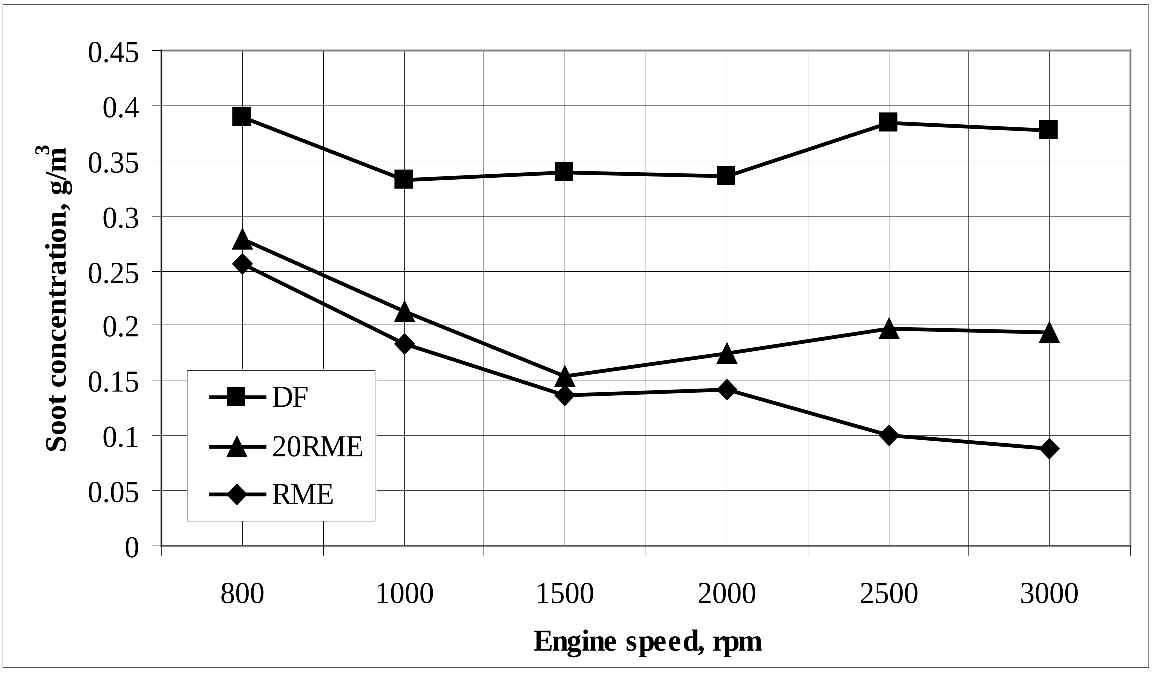


Fig. 1. **Soot concentration relationship with engine speed at full opened throttle position**

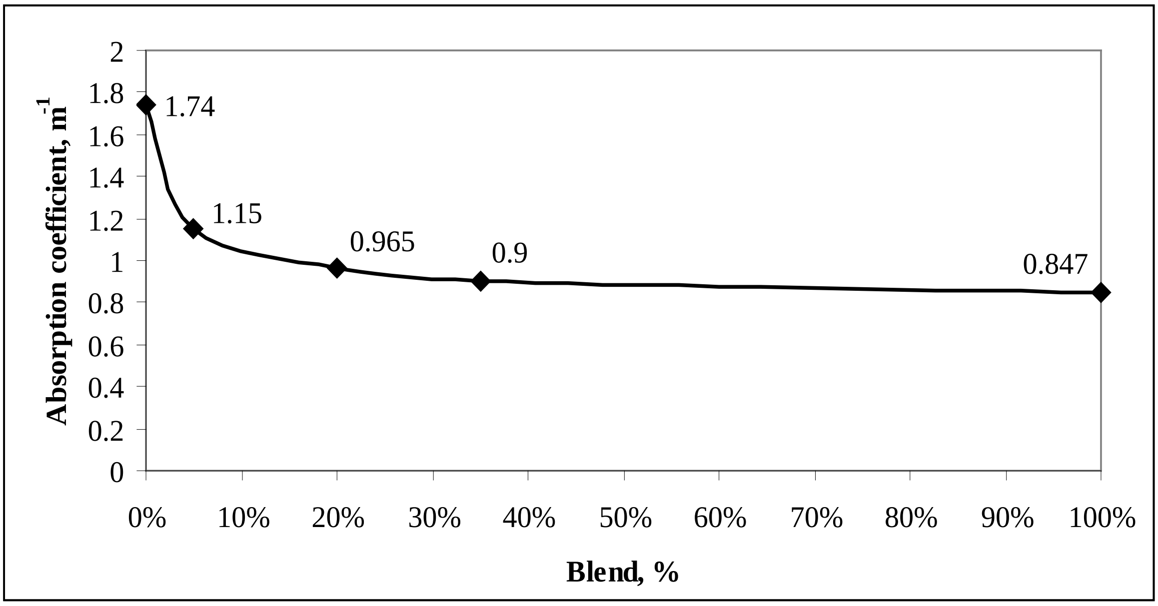


Fig. 2. **Absorption coefficient relationship with biodiesel quantity in the blend on free acceleration regime**

As it is seen from the Table 2, using biofuels carbon monoxide (CO) emissions were reduced by 49.8% (100RME) and carbon dioxide emissions (CO_2) – by 7.8% (100RME) in comparision with DF. This reduction could be related to the fuel composition – biofuels contain less carbon and more oxygen than fossil diesel. In summary the reduction of these components changed on the percentage basis of biodiesel.

Monoxides of nitrogen (NO) and oxides of nitrogen (NO_x) emissions (Table 2) from rapeseed oil methyl ester were generally slightly lower than those from the diesel fuel. NO_x emissions were

ISBN 9984 – 779 – 06 – 8

reduced by 17.5%, when the engine was fueled with 100% rapeseed oil methyl ester and only by 0.3%, when the engine was fueled with 5% biodiesel blend.
The values recorded for oxygen (O_2) for biodiesel and its blends were higher than those for conventional diesel fuel. It can also be expected due to the oxygen content of biodiesel fuels.

Table 2.

Exhaust emissions from a 2.3 liter direct injection diesel engine running on different fuels

Exhaust emissions components	Type of fuel used						
	DF	**5RME**		**35RME**		**100RME**	
			% +/-		% +/-		% +/-
CO, ppm	2203	*ND	*ND	1205	-45.3	1105	-49.8
CO_2, %	12.9	12.6	-2.3	12.5	-3.1	11.9	-7.8
NO, ppm	332	325	-2.1	317	-4.5	271	-18.4
NO_x, ppm	337	336	-0.3	318	-5.6	278	-17.5
O_2, %	3.1	3.8	+22.6	3.8	+22.6	4.8	+54.8

*ND – Not Detected

Discussion

The results of our investigation showed that the best advantage of biodiesel fuel is it capability to reduce emissions. To compare our results with the results of similar investigations of other authors the analysis of literature was carried out. For example, soot concentration in exhaust gases in our experiments was reduced by 28-76.7% and this agrees with other researchers studies, where a reduction of smoke with the use of biodiesel in vehicles was reported (Reece et al., 1993), (Scholl et al., 1993), (Graboski et al., 1998).
Researchers from the University of Limerick (Gonzalez Gomez et al., 2000) noted reduction in smoke density approximately by 48% when fueled with a WCOME (waste cooking oil methyl ester) as compared to conventional diesel. Researchers (Sams, 1997) found out that carbon from fuel combustion can be reduced in the order of 60-70% using biodiesel with the oxygen content 10-12%. Smoke opacity (absorption coefficient) reduction by 71% was noted fueling a 5.9L Cummins direct injection diesel engine (Peterson et al., 1995), but in our investigations maximum reduction of this coefficient was 76.7%.
Soot or smoke is a primarily component to which the service stations turn their attention. Diesel engine smoke opacity regulation (regulation 24-03) did apply in Europe at full load at various engine speeds and during free acceleration (Guibet, 1999). Nowadays in Latvia, this free acceleration test is applied in CSDD (Road Traffic Safety Department) to determine toxicity of diesel engine exhaust gases; the maximum opacity is at $2.5m^{-1}$ for all diesel vehicles (except turbodiesels, the maximum opacity for them is at $3.0m^{-1}$).
The main part of the experiments in world has shown that biodiesel fuels can significantly reduce exhaust emissions, including carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC) and particulate matter (PM). Some researchers (Niehaus, 1985) noted increases in carbon monoxide and hydrocarbon exhaust emissions, but decreases in oxides of nitrogen exhaust emissions. In other research work (Krahl et al., 1998) decreases in carbon monoxide, hydrocarbon, particulate matter and soot emissions were noted, but increases in oxides of nitrogen exhaust emissions fueling engine with rapeseed oil methyl ester (RME) compared to conventional diesel; Schäfer (Schäfer, 1996) also reported decreases in carbon monoxide, hydrocarbon and smoke emissions fueling the engine with palm oil methyl ester (PME) compared to conventional diesel; their data are presented in Table 3. Comparing dates from Table 3 for 100RME with our results, we can find that decrease of CO is in similar diapason, but NO_x remains higher.

ISBN 9984 – 779 – 06 – 8

Table 3.

Exhaust gases components average concentrations from diesel engines operating biodiesel compared with diesel fuel

Results by Krahl	**Components of exhaust gases**				
100RME	CO	HC	NO_x	Particulates	Soot
	90%[A] 100%[B]	70%[A] 80-90%[B]	110%	60-80%[A]	60%

Results by Schäfer	**Components of exhaust gases**			
	CO	HC	Smoke	NO_x
100PME	61%	91%	24%	104%
50/50 PME/DF	74%	90%	58%	99%
100RME	88-117%	50-53%	28-42%	106-119%

[A] – indirect injection
[B] – direct injection

Our results confirmed reduction in smoke opacity, CO, CO_2, NO and NO_x emissions, but it is not similar to those who fueled diesel engines with rapeseed oil, waste cooking oil or soybean oil methyl esters. Most of the reported studies show a difference in the results, which mostly depends on the employed engine technology and the type of the used emission test. These factors mainly have a significant effect on the difference of the emission composition reported by some authors and researchers.

Conclusions

1. For diesel engines running on biodiesel and its blends exhaust emissions tend to be lower for carbon monoxide, carbon dioxide, oxides of nitrogen, and monoxides of nitrogen in comparison with fossil diesel.
2. A compression ignition engine fueled on rapeseed oil methyl ester provides lower smoke opacity on full load and free acceleration regime.
3. Smoke emissions decrease as the biodiesel concentration increases, and the content of smoke for 20% blend is approximately 2 times lower than as it is for the conventional diesel fueled engine.

References

1. Graboski, M.S., McCormik, L. (1998) Combustion of fat and vegeteble oil derived fuels in diesel engines. Prog. Energy Comb. Sci., vol. 24, pp. 125-164.
2. Gonzalez Gomez, M.E., Howard-Hildige, R., Leahy, J.J., O'Reilly, T., Supple, B., Malone, M. (2000) Emission and performance characteristics of a 2 litre Toyota diesel van operating on esterified waste cooking oil and mineral diesel fuel. Env. Mon. and Assesment 65; 2000, pp. 13-20.
3. Guibet, J. (1999) Fuels and engines: technology, energy, environment. Institut Francais du Petrol. Paris: Technip, Volume 2, France – 1999, pp. 786.
4. IARC, International Agency for Research on Cancer (1989). Evaluation of carcinogenic risks of chemicals to human: diesel and gasoline engine exhausts and some nitroarenes. IARC monographs, vol 46. Lyon, pp. 41-185.
5. Krahl, J., Bünger, J. & Munack, A. (1998) Biodiesel exhaust emissions and determination of their environmental and health effects. In Plant Oils as Fuels. Proc. Symp., 1997. Springer-Verlag, 1998, pp. 104-122.
6. Niehaus, R.A., Goering, C.A., Savage, L.D., Sorenson, S.C. (1985) Cracked soybean oil as a fuel for a diesel engine. ASAE Paper No.85-1560. ASAE, St. Joseph, MI.
7. Peterson, C.L., Reece, D.L., Hammond, B., Thompson, J.C., Beck, S. (1995) Commercialization of Idaho biodiesel (HySEE) from ethanol and waste vegetable oil. ASAE Paper No. 95-6738, MI: ASAE.

ISBN 9984 – 779 – 06 – 8

8. Reece, D.L., Peterson, C.L. (1993) A report on the Idaho on-road vehicle test with RME and neat rapeseed oil as an alternative to diesel fuel. ASE Paper No.93-5018. ASAE, St. Joseph, MI.
9. Sams, T. (1997) Exhaust components of biofuels under real world engine conditions. In proceedings of the Symphosium on Plant Oils as Fuels – Present State of Science and Future Developments, Potstdam, Germany, 16-19 February 1997, pp. 64-77.
10. Schäfer, A. (1996) Biodiesel as an alternative fuel for commercial vehicle engines. In 2nd European Motor Biofuels Forum, Graz, Austria, 1996, pp. 233-244.
11. Scholl, K.W., Sorenson, S.C. (1993) Combustion of a soybean oil methyl ester in a direct injection diesel engine. SAE paper No.930934. SAE, Warrendale, PA.
12. Williams, J.B. (2002) Production of biodiesel in Europe - the markets. Eur. J. Lipid. Sci. Technol., 2002, 104 (6), pp. 361-362.
13. Zhou, P.L., Fet, A.M., Michelsen, O., Fet, K. (2003) A feasibility study of the use of biodiesel in recreational boats in the United Kingdom. Proc. Instn. Mech. Engrs. Vol. 217, Part M: Engineering for Maritime Environment, 2003, pp. 148-159.
14. Грехов, Л.В., Иващенко, Н.А., Марков, В.А. (2004) Топливная аппаратура и системи управления дизелей: Учебник для вузов. – М.: Легион-Автодата, 2004. – 344 с.
15. CSDD, Reģistrēto transportlīdzekļu sadalījums pēc degvielas veida uz 2005. gada 1. janvāri. URL: http://www.csdd.lv/?pageID=1098887752 (20.01.2005)

ISBN 9984 – 779 – 06 – 8

BIOMASU MAISĪJUMU FIZIKĀLI MEHĀNISKĀS ĪPAŠĪBAS
PHYSICAL PROPERTIES OF BIOMASS COMPOSITIONS

AIVARS KAĶĪTIS, IMANTS NULLE

Latvijas Lauksaimniecības universitāte, Mehānikas institūts
Čakstes bulv. 5, Jelgava, LV-3001, Latvija
Tālr.: + 371 3005671, *e-pasts*: Aivars.Kakitis@llu.lv

Abstract. *The main resources for biomass agro-ecotechnologies are cereal straw residues, energy crops and emergent vegetation from wetlands. The herbaceous biomass is a material with low density (20 – 60kg·m^{-3}) therefore new mobile equipment and technologies for biomass communition and densification have to be worked out. The storage, dosage and mixing before compacting is necessary. Because of this we must have a working knowledge of the bulk properties of materials. The angle of repose was investigated of straw, reed and peat particles. It was stated that angle of repose of straw and reed varies between 54 – 55 degrees. Angle of repose of peat particles varies between 40 – 60 degrees. In a bin filled with solid bulk material this material acts on the walls with the horizontal stress. The stress ratio between horizontal and vertical stress is important for equipment design. This ratio was investigated for different size particles of straw, reed and peat. Stress ratio of straw and reed particles varies between ~0.6 – 0.7.*

Keywords: *stalk materials, biomass conditioning, biomass briquettes, angle of repose, bulk properties.*

Ievads

Ekonomiskā un ekoloģiskā situācija pasaulē palielina atjaunojamo enerģijas resursu izmantošanas nepieciešamību. Attīstot enerģētisko augu audzēšanu un lauksaimnieciskās ražošanas atlikumu utilizāciju enerģijas ieguvei, samazinātos naftas cenu svārstību ietekme uz Latvijas ekonomiku un rastos jaunas darba vietas lauku apvidos. Apgūstot racionālas tehnoloģijas ekonomiskai aizaugušo platību un ezeru apauguma izmantošanai enerģijas ieguvei, tiktu sakārtota apkārtējā vide un samazinātos ar kūlas dedzināšanu saistīto nelaimes gadījumu skaits.

Izmantojamās biomasas – salmi, niedres un enerģētiskie augi - ir ar mazu blīvumu (20 – 60 kg m^{-3}), kas samazina biomasu transportēšanas efektivitāti lielos attālumos. Lai palielinātu stiebraugu biomasu kurināmā blīvumu, nepieciešams to kompaktēt briketējot vai granulējot. Iepriekš veiktie pētījumi parādīja, ka stiebraugu briketēšana nenodrošina standartiem atbilstošu brikešu blīvumu un noturību. Brikešu blīvumu un noturību var ievērojami palielināt pievienojot saistvielas (kūdru, sapropeli u.c.).

Salmu un niedru brikešu izturību var palielināt pievienojot masai kūdru. Izturības robežspriegums bīdē salmu-kūdras briketēm ar kūdras saturu 50% palielinās 2.2 reizes.

Lai veidotu biomasu maisījumus ar noteiktu sastāvu, nepieciešams nodrošināt to sastāvdaļu precīzu dozēšanu un vienmērīgu sajaukšanu. Briketējamās masas sastāvdaļas ir jāuzglabā tvertnēs un jāpadod uz tehnoloģiskajām iekārtām. Daudzas ražošanas problēmas saistītas ar masas plūsmu uzkrāšanas un dozēšanas iekārtās. Lai novērstu materiāla iesprūšanu un salipšanu jāveic pētījumi par iekārtu izmēru un formas atbilstību maisījuma īpašībām. Viena no tām ir iekšējās berzes leņķis jeb dabīgā nogruvuma leņķis. Dabīgā nogruvuma leņķis tiek ņemts vērā pie tvertņu konusa slīpuma leņķa izvēles. Tvertnē esoša birstošā materiāla īpašības iespaido arī virs tā esošā materiāla spiediens. No šī spiediena materiāls iegūst noteiktu izturību un, tvertnes iztukšošanas laikā, var veidoties velves. Lai noteiktu velvju sabrukšanas parametrus glabāšanas tvertņu konusos, jāzina birstošā materiāla vertikālo un horizontālo spriegumu attiecība. To var raksturot ar šķērsspriegumu koeficientu λ. Šī koeficienta noteikšanai eksistē vairākas metodes. Vienkāršākā no tām ir dabīgā nogruvuma leņķa metode. Uzskata, ka dabīgā nogruvuma leņķis raksturo iekšējos spriegumus materiālā, bet praksē ir pierādīts, ka iegūtie rezultāti ir visai aptuveni. Otra metode, precīzāka un sarežģītāka, ir tiešā šķērspiediena mērīšana.

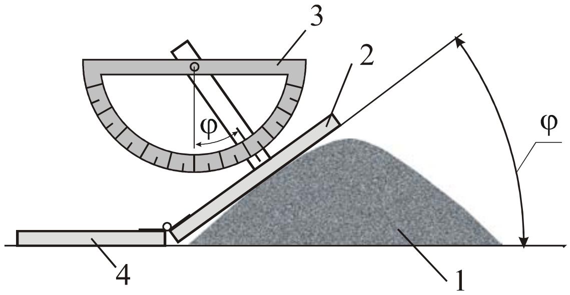
ISBN 9984 – 779 – 06 – 8

LLU Mašīnu mehānikas zinātniskajā laboratorijā noteiktas nobiruma leņķa φ un šķērsspriegumu koeficienta λ izmaiņas likumsakarības dažāda smalkuma salmu, niedru un kūdras daļiņām izmantojot abas iepriekšminētās metodes.

Materiāli un metodes

Salmu, niedru un citu stiebru materiālu brikešu blīvums un noturība lielā mērā atkarīga no materiāla sasmalcināšanas pakāpes. Lai iegūtu pietiekošu brikešu blīvumu un mehānisko izturību, salmu daļiņu izmēram jābūt mazākam par 1mm. Augsta smalcināšanas pakāpe palielina enerģijas patēriņu brikešu ražošanā un samazina to ekonomisko efektivitāti. Brikešu blīvumu un noturību var ievērojami palielināt pievienojot saistvielas (kūdru, sapropeli u.c.). Iepriekšējos eksperimentos tika noteikts kviešu salmu izturības robežspriegums stiepē (118.7 ± 8.63 $N \cdot mm^{-2}$), bīdē (8.47 ± 0.56 $N \cdot mm^{-2}$) un elastības modulis (13.1 ± 1.34 GPa).

Brikešu izgatavošanas procesā nepieciešams uzglabāt, dozēt un sajaukt saistvielas un sasmalcinātos stiebraugus. Lai varētu aprēķināt nepieciešamo iekārtu parametrus, jāzina masas īpašības, kuras nosaka tās mijiedarbību ar mašīnu daļām. Eksperimentāli tika noteikts nogruvuma leņķis un iekšējo spriegumu attiecība dažāda smalcinājuma stiebru daļiņām. Pētījumi tika veikti ar salmiem, niedrēm un kūdru. Stiebru materiāli tika sasmalcināti un, izsijājot caur sietiem, sadalīti smalkuma grupās ar daļiņu izmēriem 3-5, 2-3, 1-2, 0.5-1 un <0.5mm.



1.attēls. **Nobiruma leņķa noteikšanas ierīce**:
1 – materiāls, 2 - pieskares lineāls,
3 – leņķa mērīšanas skala, 4 – atbalsts

Stiebru materiāla nogruvuma leņķis tika mērīts ar laboratorijā izgatavotu ierīci, kura sastāv no pieskares lineāla 2 un leņķa mērīšanas skalas 3 (1. att.). Sasmalcinātais materiāls tika iepildīts cilindrā un, paceļot cilindru uz augšu, izbērts uz horizontālas plaknes (2. att.).

Eksperimenta rezultātu precizitāte tika nodrošināta izdarot pietiekošu mērījumu atkārtojumu skaitu (ne mazāk par 11 atkārtojumiem) un veicot datorizētu datu apstrādi.

2.attēls. **Nobiruma konusa veidošana**

Nogruvuma leņķis φ ir atkarīgs no materiāla iekšējās berzes koeficienta. Iekšējās berzes koeficientu f aprēķina no vienādojuma:

$$f = tg\varphi \,. \tag{1}$$

Ja birstošs materiāls atrodas noslēgtā telpā un tiek saspiests vertikālā virzienā, tajā rodas normālie spriegumi σ_v. Šie spriegumi izsauc perpendikulārā virzienā vērstus spriegumus σ_h (3. att.). Šo spriegumu lielums atkarīgs no spriegumu σ_v lieluma un masas plūstamības. Spriegumu attiecību λ aprēķina pēc Kezdi vienādojuma [1]:

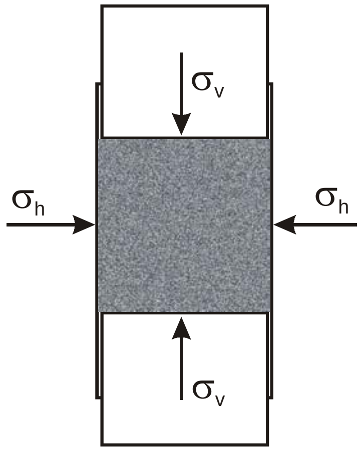
ISBN 9984 – 779 – 06 – 8

$$\lambda = 1 - \sin\varphi, \tag{2}$$

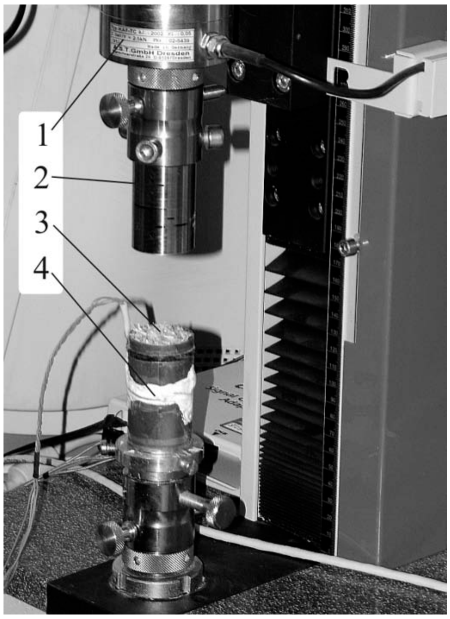
kur φ - materiāla iekšējās berzes leņķis.
Vācu standarts DIN 1055 (6. nodaļa, slodzes tvertnēs) [2] rekomendē vienādojumu (3), kas izveidots no vienādojuma (2):

$$\lambda = 1.2 \cdot (1 - \sin\varphi)\,. \tag{3}$$

Šāds pārveidojums izdarīts pamatojoties uz secinājumiem no prakses, kas pierāda, ka slodze uz tvertnes sienām ir lielāka, nekā aprēķināts pēc spriegumu attiecības λ [3, 4]. Neatbilstība izskaidrojama ar to, ka nosakot iekšējās berzes leņķi φ pastāvošās metodikas, netiek ņemti vērā daudzi faktori, kas darbojas reālā situācijā. ISO direktīva TC98/SC3/WG5 rekomendē spriegumu attiecību noteikt tieši izmērot radiālajā virzienā vērstos spriegumus centriskajā spiedē [5]. Eksperimentu veic izmantojot iekārtu, kas sastāv no plānsienu tērauda cilindra, kurā tiek saspiesta pētāmā biomasa. Cilindra deformācija tiek mērīta ar tenzorezistoriem 4 (4.att.). Izmantojot ZWICK materiālu testēšanas iekārtu pētāmā biomasa tika saspiesta ar noteiktu spēku vertikālā virzienā. Saspiešanas rezultātā masā rodas spriegumi σ_v, kas rada spriegumus σ_h (3.att.).



3. attēls. **Spriegumu sadalījuma shēma**:
σ_v – spriegumi, ko masā rada centriskās spiedes spēks, σ_h – spriegumi, kas rodas šķērsvirzienā.



4. attēls. **Horizontālo spriegumu noteikšanas** iekārta: 1 – spēka sensors, 2 – virzulis, 3 – materiāls, 4 – mērcilindrs ar tenzorezistoriem.

Tenzorezistoru tilta izejas spriegums tika reģistrēts izmantojot virtuālo mēriekārtu komplektu *PicoScope - 212*.
Eksperimenti tika veikti ar sasmalcinātām un frakcionētām salmu, niedru un kūdras daļiņām ar mitrumu 10%. Sasmalcinātais materiāls tika izsijāts un sadalīts smalkuma grupās ar daļiņu izmēriem 5 – 7, 3-5, 2-3, 1-2 un 0.25 - 0.5 mm.
Ierīce tika kalibrēta radot eļļas spiedienu mērcilindrā. Spriegumi σ_h tika aprēķināti izmantojot kalibrēšanas taisnes vienādojumu. Spriegumu attiecību λ aprēķina pēc vienādojuma 4:

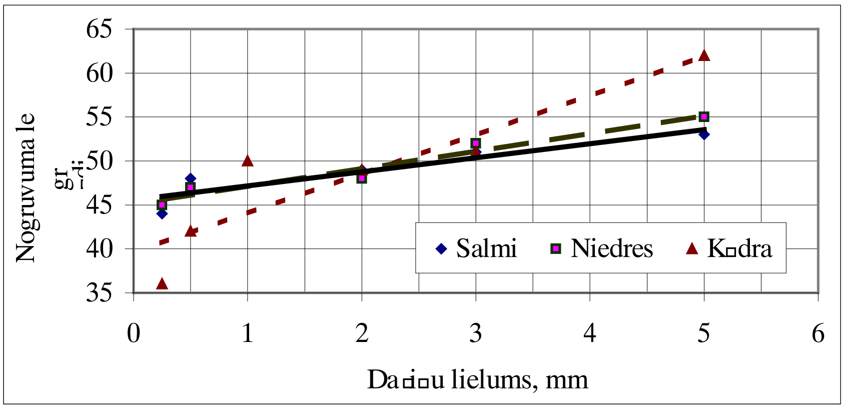
$$\lambda = \frac{\sigma_h}{\sigma_v}. \tag{4.}$$

Vertikālā spiediena σ_v izmaiņas robežas no 0.54 līdz 2.7 Mpa.

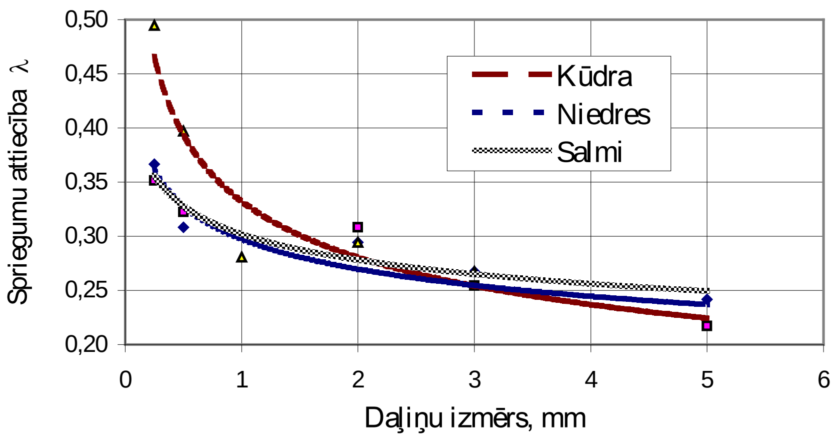
ISBN 9984 – 779 – 06 – 8

Rezultāti un to izvērtējums

Praktiski nosakot dabīgo nogruvuma leņķi φ redzams, ka gan salmu, gan niedru daļiņu lielums būtiski ietekmē tā vērtību. Daļiņas, kas smalkākas par 1 mm uzrādīja φ ≈ 45°, bet daļiņas, kas lielākas par 5 mm φ ≈ 55°. Salīdzinot vērtības redzam, ka salmu un niedru daļiņu dabiskā nogruvuma leņķis noteikta izmēra daļiņām ir aptuveni vienāds. Kūdras daļiņu izmēram palielinoties nogruvuma leņķis pieaug ievērojami straujāk un pārsniedz 60° kūdrai ar daļiņu izmēru 5mm. Pēc vienādojuma (3) aprēķinātā spriegumu attiecības λ izmaiņa atkarībā no daļiņu izmēra redzama 6. att. Redzam, ka daļiņu izmēram palielinoties virs 1.5 mm, šķērsspriegumu koeficients samazinās un kļūst aptuveni vienāds visiem pētītajiem materiāliem. Kūdras daļiņām ar izmēru <1 mm šķērsspriegumu koeficients pieaug straujāk nekā salmiem un niedrēm un sasniedz λ=0.5 daļiņām ar izmēru 0.25 – 0.5 mm.



5.attēls. **Dabīgais nogruvuma leņķa izmaiņa atkarībā no niedru daļiņu lieluma**



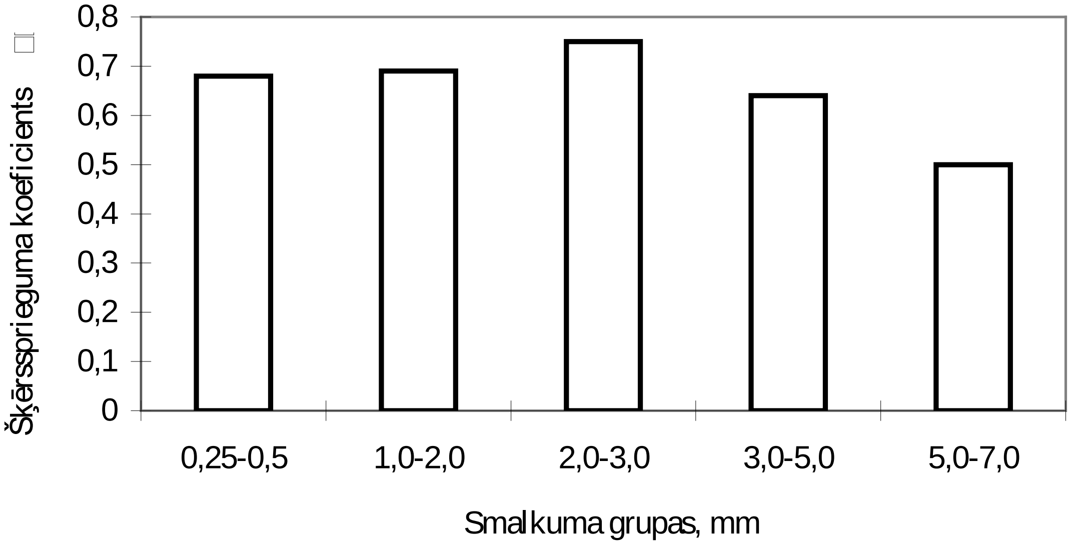
6.*attēls*. **Šķērssprieguma koeficienta λ izmaiņa atkarībā no stiebru materiāla daļiņu izmēra.**

Ņemot vērā ISO direktīvas TC98/SC3/W65 ieteikumus aksiālo un radiālo spriegumu attiecība tika noteikta izmantojot laboratorijā izgatavotu mēriekārtu. Iegūtie rezultāti parādīja, ka šķērssprieguma koeficienta vērtība mainās atkarībā no materiāla sasmalcināšanas pakāpes. Salmiem un niedrēm ar daļiņu izmēru 0.25 – 5 mm netika novērota būtiska šķērssprieguma izmaiņa. Tas atradās robežās no 0.62 – 0.71 (7.att.). Rupji smalcinātiem salmiem ar daļiņu izmēru 5 - 7 mm šķērsspriegumu koeficients samazinājās līdz λ=0.52.

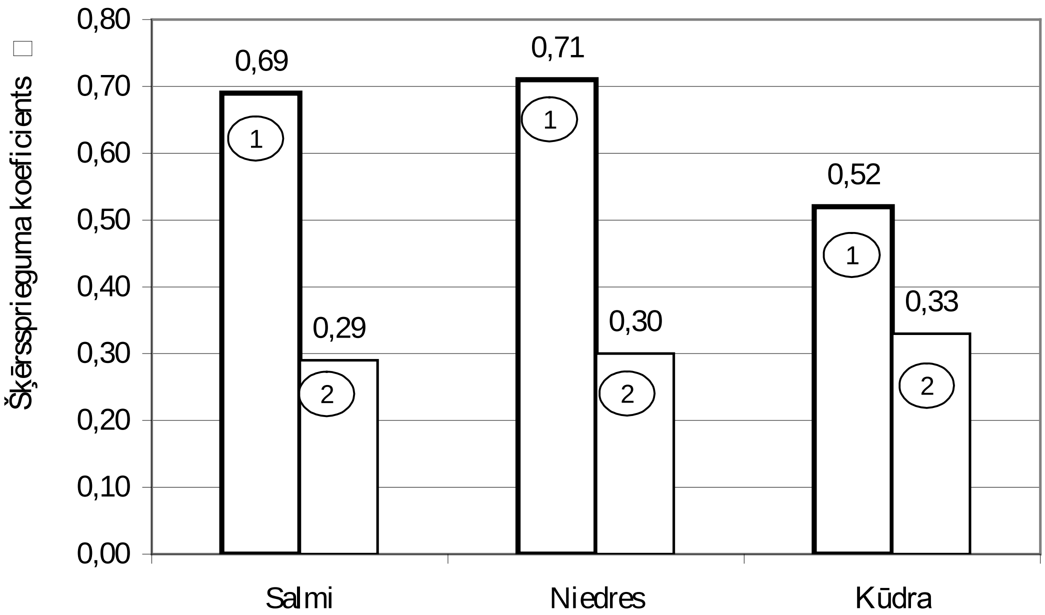
Salīdzinot λ-testā iegūtās šķērsspriegumu vērtības ar λ vērtībām, kas aprēķinātas pēc dabīgā nogruvuma leņķa (formula 3), redzam, ka iegūtā koeficienta vērtība, ir ievērojami lielāka nekā koeficienta vērtība, kas iegūta pēc nogruvuma leņķa metodes (8.att.). Rezultātu atšķirība bija

ISBN 9984 – 779 – 06 – 8

sagaidāma, jo par to liecināja literatūrā sastopamie citu zinātnieku pētījumu rezultāti dažādiem birstošiem materiāliem (smiltīm, graudiem un miltiem u.c.).



7.attēls. **Šķērssprieguma koeficienta izmaiņa sasmalcinātiem salmiem**



8.attēls. **Šķērssprieguma koeficients dažādiem materiāliem** (daļiņu izmērs 1 – 2 mm)

1. Mērot tiešā veidā (λ - tests)
2. Aprēķinot pēc dabīgā nogruvuma leņķa.

Veicot eksperimentu pēc nogruvuma leņķa metodes materiālā darbojas ļoti nelieli spriegumi, kas rodas masas pašsvara rezultātā. Ārpusē esošie materiāla slāņi ir ļoti irdeni un tieši tie formē nogruvuma leņķi (2.att.). Šajā gadījumā daļiņas kopā satur to savstarpējā saķeršanās nelīdzenumu un formas izciļņu dēļ.

Tiešā veidā mērot spriegumus radiālā virzienā, masā darbojas ievērojami aksiālie spriegumi, kas izsauc materiāla plūstamību deformācijai perpendikulārā virzienā. Tā rezultātā koeficienta λ vērtības ir ievērojami lielākas nekā iepriekšējā gadījumā. Fizikālie procesi, kas notiek

ISBN 9984 – 779 – 06 – 8

deformējamā materiāla slānī, precīzāk atbilst procesiem, kas norit tehnoloģiskajās iekārtās (presēs, transportieros, glabāšanas tvertnēs u. c.).
Dabīgā nogruvuma leņķim ir būtiska nozīme tvertnes iztukšošanas konusa aprēķinos, jo iztukšošanās beigās materiāla daudzums tvertnē ir neliels un tajā darbojas niecīgi aksiālie spriegumi.

Secinājumi

Dabīgā nogruvuma leņķis sasmalcinātiem stiebru materiāliem un kūdrai ir atkarīgs no smalcinājuma pakāpes un mainās robežās no 45° līdz 55° (salmiem un niedrēm) un no 40° līdz 60° (kūdrai).
Aprēķinot šķērsspriegumu koeficientu salmiem un niedrēm λ pēc dabīgā nogruvuma leņķa iegūst ~2.4 reizes mazāku vērtību nekā tā tiek iegūta tiešos mērījumos. Kūdrai λ vērtības atšķiras 1.58 reizes. Tiešos šķērssprieguma mērījumos salmiem un niedrēm ar daļiņu izmēru 0.25 – 5 mm iegūtās λ vērtības atrodas robežās no 0.62 – 0.71.
Tiešos mērījumos iegūtās koeficienta λ vērtības rekomendējamas izmantošanai smalcināto biomasu glabāšanas un apstrādes iekārtu konstrukciju aprēķinos.

Pateicība

Pētījumi veikti pateicoties LZP Fundamentālo un lietišķo pētījumu projekta 01.0790 "Biomasas resursi un mehanizācija kondicionēšanas procesos" finansējumam.

Summary

Development of energy crops and agricultural residue utilization for energy are important goals of the rural policy. Mainly heat and electricity energy production from dry solid biomass is planned using it as biofuel. As chemical fertilizer production and usage corresponds to the consumption of oil fuel, biomass usage directly for energy production or as fertilizer are activities with equal importance for fossil fuel substitution.
Previous analysis allow to conclude that in rural ecosystems herbaceous biomass as cereal crop straw (mainly wheat straw), common reeds, rape straw and reed canary grass are the most prospective stalk materials for solid biofuel production. The herbaceous biomass is a material of low density (20 – 60kg·m^{-3}) therefore new mobile equipment and technologies for biomass communition and densification have to be worked out. To guarantee the quality of biomass briquettes in the handling and usage process, sufficient durability of briquettes should be provided.
Former experimentally were stated values for wheat stalks [4] ultimate tensile (118.7 ± 8.63 N·mm^{-2}) and shear (8.47 ± 0.56 N·mm^{-2}) strength, modulus of elasticity (13.1 ± 1.34 GPa) and shear modulus (0.643 ± 0.043 GPa) in order to find methods for mechanical conversion with minimal energy consumption. Previously was stated that compacted with pressure 230 MPa compositions of straw particles from two fineness groups (2-3 mm and < 0.5 mm) have density > 1.0 g cm^{-3}, if fineness proportion (amount of particles < 0.5) exceed 25%. Density 1.0 g cm^{-3} has been obtained in densification of straw and reed stalk material particle compositions with peat, if peat proportion exceeds 20%.
Dependence of ultimate shear stress on wheat stalk material particle size in biomass briquettes was previously investigated. It was stated that ultimate shear stress increases for particle size in briquettes less than 0.5 mm. Peat additive improves the density and ultimate shear strength of briquettes, but peat in combustion process increases the ash content. Therefore it is not necessary to add peat more than 50% in briquetting composition.
Stalk biomass and peat is necessary to storage, load and dispense before the producing of briquettes. The loading, storage container discharging and automatic feeding process depends on internal stresses acting in biomass volume.

ISBN 9984 – 779 – 06 – 8

Knowledge of the stresses acting in chopped biomass is important for many applications:

- Storage container and hopper design for strength,
- Storage container and hopper design for flow,
- Loads on feeders and inserts,
- Driving torque of feeders.

Hoppers are used in industry for protection and storage of powdered and granulated materials. Hoppers must be designed such that they are easy to load. More importantly, hoppers must be designed such that they are easy to unload. The way the hopper is designed affects how much of the stored material can discharge and whether they're mixing of solid sizes or dead space that reduces the effective holding capacity of the hopper.

To design storage hoppers, the following material properties are needed:

- Internal friction coefficient,
- Wall friction coefficient,
- Permeability,
- Compressibility.

Other factors that should be considered include temperature and moisture content along phase diagram if caking may be a problem.

In contrast of pure fluids, the flow behavior of bulk solids cannot be described by only knowing the name and chemical structure of the material under consideration. This is obvious from the large number of additional parameters, besides the chemical composition, which have an influence on the flow behavior of the bulk solid. Some of these parameters are:

- Particle size distribution,
- Particle shape (e.g. spherical, rod-shaped),
- Particle surface (smooth, rough, sharp edges),
- Moisture content.

Mentioned before factors and properties of solid bulk material are referable to the compositions of granulated and chopped stalk materials and additives (peat) used for biomass briquettes.

Mechanical properties of stalk material were experimentally determinate in order to find methods for mechanical conversion with minimal energy consumption. These parameters of mechanical properties are necessary for mechanization equipment design.

To determine bulk properties of biomass chopped reed and straw particles with moisture content less than 10% was sieved and divided into fines groups: 3-5 mm, 2-3 mm, 1-2 mm, 0.5-1 mm and <0.5 mm.

Experimentally was stated two bulk properties of chopped stalk materials and peat: angle of repose and horizontal and vertical stress ratio.

The angle of repose is a characteristic of solids, which characterizes the pilling of stacking nature of the particles. The angle of repose is considered to be mostly a measure of the internal friction between the particles as a whole, but not between individual particles.

The angle of repose was investigated of straw, reed and peat particles. Experimental design for estimating of angle of repose is shown in Fig. 1 and 2. It was stated that angle of repose of straw and reed particles varies between 45 – 55 degrees. It depends on size of particles, increasing of particle size leads to increasing of angle of repose (see Fig. 5). Angle of repose of peat particles varies between 40 – 60 degrees.

The best use of angle of repose is to determine the size of a pile of chopped biomass. Angle of repose is not recommended to use for designing of bottom of a hopper to ensure proper discharge.

In a bin filled with solid bulk material this material acts on the walls with the horizontal stress. The stress ratio between horizontal and vertical stress is important for storage equipment design. Often the equation of Kèzdi (2) is used for the estimation of the stress ratio λ. The values of the stress ratio which are calculated according to equation (3) are not correct in any case because the stress ratio depends on a lot of parameters that are not taken into account in eq. (3). According to

ISBN 9984 – 779 – 06 – 8

ISO-guideline TC98/SC3/W65 stress ratio was measured directly from a uniaxial compression test. Experimental design for estimating of stress ratio λ is shown in Figure 4. Horizontal stresses were measured directly on the walls of cylinder 4 using strain gauges (see Fig. 4). This ratio was investigated for different size particles of straw, reed and peat. Stress ratio of straw and reed particles varies between ~0.62 – 0.71 for particle size 0.25 – 5 mm.
Obtained stress ratio values are recommended to use for chopped stalk biomass storage equipment design.

Literatūra

1. Kezdi, A.: Erddrucktheorien, Springer Verlag Berlin 1962.
2. DIN 1055, Teil 6 Lasten in Silozellen, Deutsche Norm, 1987.
3. Zachary, L. W., Lohnes, R. A.: A confined compression test for bulk solids, Proc. 13th Annual Powder & Bulk Solids Conf., May 1988, Rosemont, IL, USA.
4. Kwade, A., Shulze, D., Schwedes, J.: Determination of the Stress Ratio in Unaxial Compression Tests Part 1 and 2, Powder Handling & Processing 6 (1994) 1, pp. 61 – 65 and 2, pp. 199 – 203.

ISBN 9984 – 779 – 06 – 8

SIZE REDUCTION AND DENSIFICATION OF HERBACEOUS BIOMASS
AUGU BIOMASAS IZMĒRU SAMAZINĀŠANA UN KOMPAKTĒŠANA

ERIKS KRONBERGS, MAREKS SMITS

Institute of Mechanics, Faculty of Engineering, Latvia University of Agriculture,
J.Cakstes bulv. 5, LV-3001, Jelgava, Latvia
Phone: + 371 30 80674; *fax*: + 371 30 27238; *e-mail*: eriks@inka.cs.llu.lv

Abstract. *Herbaceous biomass can be obtained using delayed harvesting method with moisture content less than 15% and directly densified without drying. Size reduction experiments of common reed stalks as cutting, flattening and densification have been carried out. As the result of reed stalk flattening, more than 8 strips can be obtained from this tubular structure. Average energy consumption 273 – 380 J kg^{-1} had been stated for reed stalk flattening. Specific cutting energy E_{scq} value varies in 8 – 16 kJ m^{-2} in dependence of punch orientation angle according cross-section of reed specimen. Specific cutting energy for flattened stalk materials for reed density 600 kg m^{-3}, varies E_{sc}=13.3 – 27 J m kg^{-1}. Densification experiments of compositions from peat particles, coarse wheat stalk and reed material particles from (1 - 2 mm) group with pressure 230 MPa indicated influence of peat proportion. Density 1.0 g cm^{-3} has been obtained in densification of straw stalk material particle compositions with peat, if peat proportion exceeds 20%.*

Keywords: *herbaceous biomass, size reduction, densification.*

Introduction

Latvia as a European community country has the tasks for greenhouse gas (GHG) emission mitigation in future. Essential condition of the global sustainable development is the development of renewable energy resources. The more significant part (74%) of renewable energy sources in White Paper of European Union (1997) had been planned for Biomass energy. At the same time agricultural policy in Latvia should provide for the use of approximately 0.92 million ha of the unused now agricultural land and its sustainable development. Recent advances in biomass feedstock development and conversion technologies have created new opportunities for using agricultural land as a means of producing renewable fuels and raw materials.

Herbaceous biomass can be obtained with delayed harvesting method with moisture content less than 15% and used for densification without drying. This opportunity is important both for solid biofuel and construction material production. The main resources of herbaceous biomass for agro - ecotechnologies are cereal straw residues, herbaceous energy crops and emergent vegetation (mainly common reeds) from wetlands. In Latvia cereal crop residues that could be used for energy production are 171 000 t of straw annually. Only one part of straw residue (20-30%) is planned to use for heat production, but another part will be used as organic fertilizer. Common reeds (Phragmites Australis) can be used like straw material both for energy and fertilizer production and also as industrial raw material. More than 230 million tons of peat is available for bio fuel production in Latvia. Energy crops would be as the main basis for solid biofuel production in agricultural ecosystem in future. Total production of oilseeds in 2002 was 32.7 thousand tons. In proportion with this amount 21.8 thousand tons of rape seed cakes and 42.5 thousand tons of rape straw are available as solid bio fuel resources. As chemical fertiliser production consumes great amount of energy, biomass usage directly for energy production or as organic fertiliser are activities with equal importance in agriculture.

Mentioned agricultural ecosystem biomass can be denominated as resources only if there are mechanisation tools and equipment for collection and utilisation processes. Solid biofuel production chain includes size reduction operations and densification of herbaceous biomass with moisture content less than 15%. Mainly different plant stalks determine properties of agricultural biomass for solid biofuel production.

ISBN 9984 – 779 – 06 – 8

The main size reduction operations are stalk material flattening, cutting before densification (pelleting and briquetting). As additive materials in production of pellets and briquettes peat and rape seed cakes are most prospective.
The aim of the present study was to investigate interconnection between particle sizes of chopped stalk material and density obtainable before and after densification. Energy consumption in size reduction and densification operations had been determined and used for assessment.

Materials and methods

Experimentally earlier had been stated values of wheat stalk ultimate tensile (118.7 ± 8.63 N mm^{-2}) and shear (8.47 ± 0.56 N mm^{-2}) strength, modulus of elasticity (13.1 ± 1.34 GPa) and shear modulus (0.643 ± 0.043 GPa) in order to find methods for mechanical conversion with minimal energy consumption. Reed canary grass stalks (stems) are more useful with delayed harvesting for fuel production than leaf blades. Experimental investigation of common reed stalk conditioning properties as flattening and cutting can characterize maximum of energy consumption in these operations for all group of mentioned stalk materials because reeds have higher tensile strength (~200 N mm^{-2}) and accordingly another strength parameters.
Cutting and flattening of different length reed specimens with moisture content of 10% had been investigated by means of Zwick material testing machine TC-FR2.5TN.D09. Zwick material testing machine has force measurement accuracy 0.1 N, displacement measurement accuracy 0.01 mm and maximal force value 2.5 kN. Computer controls testing machine using software for force, displacement and other data collection. Software provides possibility obtain energy consumption data output.

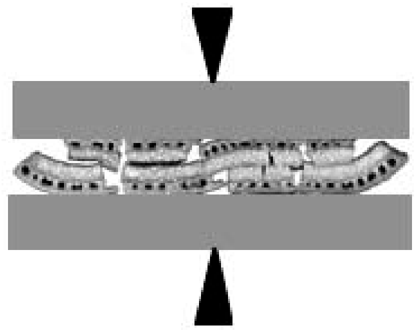


Fig. 1. **Reed stalk flattening**

During cutting operation with counter shear stalk flattening occurs at first. For this reason flattening of reed specimens with moisture content of 10% previously had been investigated. Different length reed specimens were flattened between two plates of material testing machine (Fig.1)

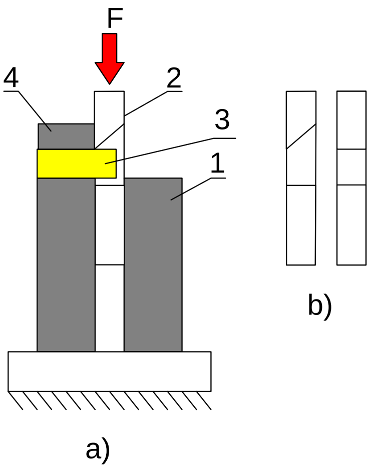


Fig. 2. **Flattened reed cutting device**

Cutting device was designed specially for flattened stalk material cutting. Cutting device (Fig. 2a) consists of die 1 and knife 2. Flattened reed specimen 3 is fastened with plate 4 to die. Cutting using two types of knives – with edge angles 20° and 90° (Fig. 2b) had been investigated. Displacement, stress and energy consumption data were collected on computer.
Stalk material size reduction by cutting is realised with aim to reduce biomass volume and increase density. Chopped to different length reed stalk biomass with moisture content less than 10% was used for density measurements. All chopped stalk material particles had been sieved and distributed to several fineness groups. Fineness of stalk material particles had been determined with diameter of sieve's openings

ISBN 9984 – 779 – 06 – 8

(round section). Every fineness group of particles is marked with diameter of opening on which particles retained and lower diameter of openings (in millimetres), which particles passed through. Thus marking 2-3 indicates particles larger than 2 mm and smaller than 3 mm. For density measurement had been used following fineness group particles: 2-3; 1-2; 0.5-1; 0.25-0.5 and <025. Measurements were realized filling determined volume (200 cm^3) container with particles and weighing it. The density was calculated on the basis of weighing results.

Densification experiments had been carried out in closed die by means of hydraulic press equipment. Wheat straw and reed stalk material biomass with moisture content of 10% were chopped to different length and had been used for densification. Experiments were carried out with particles from different fineness groups. Mixed peat and stalk material particles were used as briquetting compositions. Force and displacement had been recorded in densification process and the calculations let to find the energy requirement for it. Maximal pressure 230 MPa had been achieved in densification.

Results and discussion

As the result of reed stalk flattening, more than 8 strips can be obtained from this tubular structure. Average energy consumption 273 – 380 J kg^{-1} of DM had been stated for reed stalk flattening.

Specific cutting energy E_{scq} value was determinated with 90° edge angle knife and varies in 8 – 16 kJ m^{-2} mainly in dependence of reed specimen strength. Specific cutting energy of flattened reed stalk materials for density 600 kg m^{-3}, varies E_{sc}=13.3 – 27 J m kg^{-1}. It is the same order as alfalfa stem [1] cutting energy 38 J m kg^{-1}.

Cutting properties of knives with edge angles 20° and 90° were compared. It was not sufficient differences in the energy consumption values for single flattened reed stalk cutting ~0.2 J. For cutting two and three layers of flattened reed stalks the knife with edge angle 90° shows twice more energy consumption than knife with edge angle 20°.

Experimentally is stated, that density of evenly distributed in container reeds is ~ 0.11 g cm^{-3}. Density of chopped straw and reed particles from different fineness groups shows Fig.3.

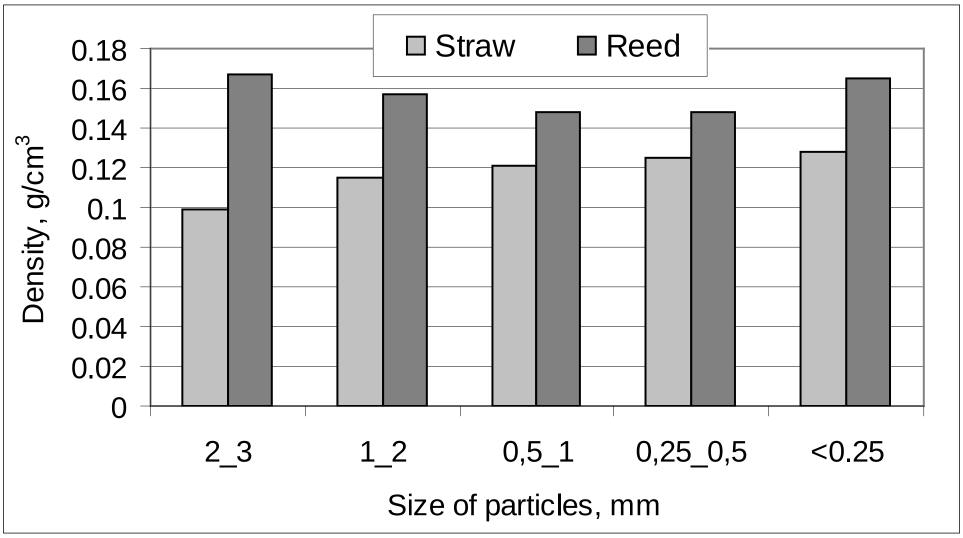


Fig. 3. **Density of biomass of particles**

ISBN 9984 – 779 – 06 – 8

Particle size reduction for chopped straw affects density insignificantly. It changes from 0.1 g cm^{-3} (2-3 mm particles) to 0.13 g cm^{-3} (particles <0.25 mm). For reed particles density varies between 0.15-0.17 g cm^{-3}.
Experimentally is stated that flattening of reed stalk material and father densification with very low pressure 0.002 Mpa let obtain density 0.22 g cm^{-3}.
Density obtained in densification different size wheat straw and reed stalk particles with pressure in closed die 230 MPa shows Fig. 4.

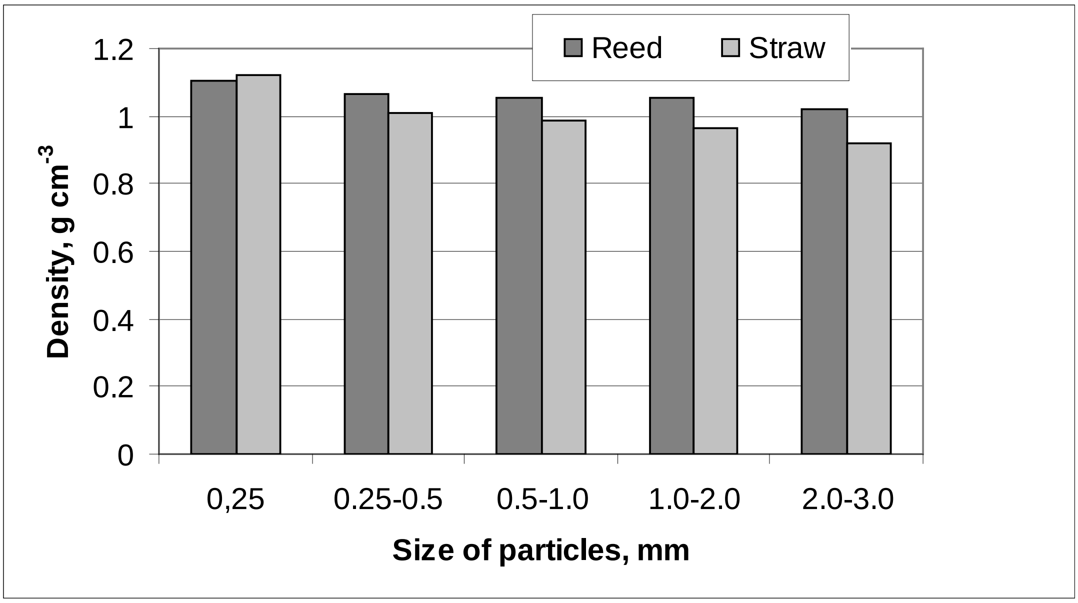


Fig. 4. **Density of compacted herbaceous biomass**

Density > 1.0 g cm^{-3} is recommend in standards (ŌNORM 7135, SS 18 71 20 and DIN 51731), concerned with wood pellet and briquette properties. This value had been used for evaluation of herbaceous material densification results. For reed particles with size <3 mm density > 1.0 g cm^{-3} can be obtained in densification. In densification of wheet straw particles with the same pressure 230 MPa density > 1.0 g cm^{-3} is obtained only for size <0.5 mm.
Ordinals briquettes in the production of wood sawdust briquettes develop pressure in biomass 100-160 MPa. For this reason size reduction of biomass particles is preferable. Another possibility to improve density of briquettes is using of binding additives. Peat can be used as such binding additive and biofuel at the same time. It is very very urgent problem, because more than 230 million tons of peat is available for biofuel production in Latvia
Densification experiments of compositions from peat particles, coarse wheat stalk and reed material particles from (1 - 2 mm) group with pressure 230 MPa indicated influence of peat proportion to density of briquettes. Density 1.0 g cm^{-3} has been obtained in densification of straw and reed stalk material particle compositions with peat, if peat proportion exceeds 20%.
Total energy grass production and pelleting energy analysis [2] converted in proportion illustrate possible positions for technology and equipment improvement (Fig. 5.). Canadian experience of switchgrass production as energy crop for biomass pellet production can be used for planning reed canary grass production for energy purposes in Latvia conditions. High level of fertilization and application energy input – 37% for energy grass production shows necessity to utilize biomass for fertilizer production. Low energy input for transportation is caused with calculation condition that switchgrass can be sourced within a 20 km radiuss of a pelleting plant. Density increasing of harvested herbaceous biomass let increase also this distance from field to pelleting plant. Energy input for pellet mill operation is rather high 19% with the major costs associated with hammer milling and pelleting. More efficient equipment creating is current task for herbaceous biomass size reduction.
Net energy output (18.5 GJ/t) to production input (1.27 GJ/t) is assessed with ratio 14.6:1.

ISBN 9984 – 779 – 06 – 8

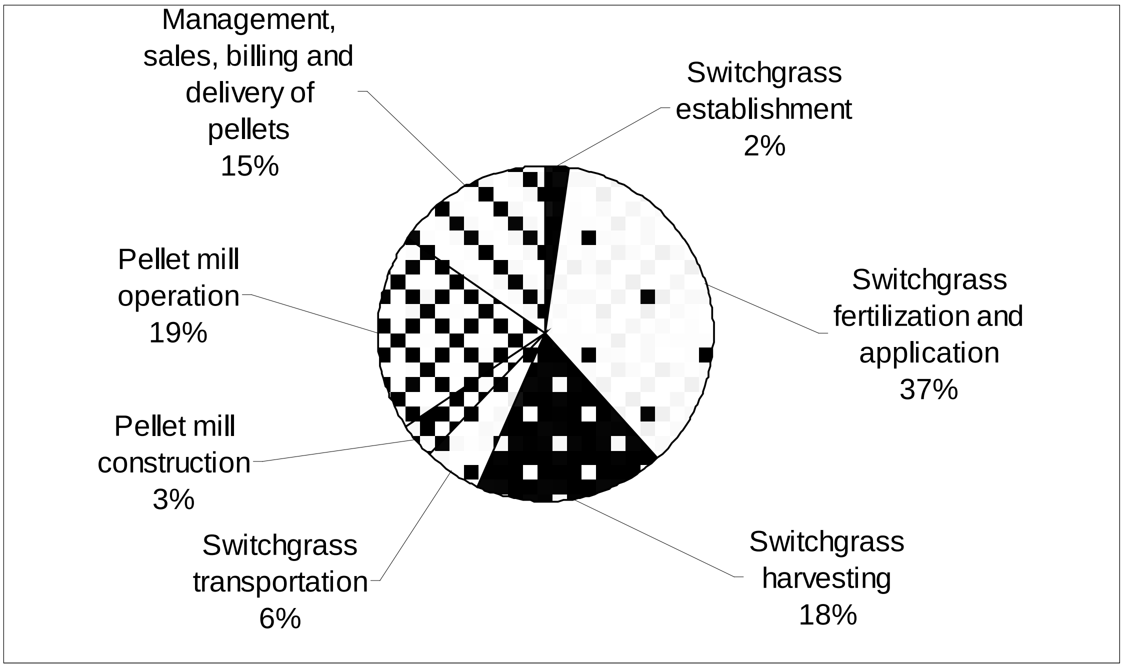


Fig. 5. **Energy input proportion for switchgrass pellets**

Conclusions

Delayed harvesting method let obtain herbaceous biomass with moisture content less than 15% and use it for densification without drying.

Average energy consumption 273 – 380 J kg^{-1} of DM had been stated for reed stalk flattening.

Specific cutting energy of flattened reed stalk materials varies E_{sc}=13.3 – 27 J m kg^{-1}.

There are not sufficient differences in the energy consumption values for single flattened reed stalk cutting ~0.2 J with knife edge angles 20° and 90°. Therefore thin herbaceous biomass layer cutting is recommended for shredder design.

Particle size reduction for chopped straw affects density insignificantly. Flattening of reed stalk material and futther densification with very low pressure 0.002 Mpa let obtain density 0.22 g cm^{-3}.

Density 1.0 g cm^{-3} has been obtained in densification of straw and reed stalk material particle compositions with peat, if peat proportion exceeds 20%.

More efficient equipment creating is current task for herbaceous biomass size reduction.

Acknowledgements

The authors gratefully acknowledge the funding from Latvia Board of Science this work under grant 01. 0790.

References

1. Persson, S., 1987. Mechanics of cutting plant material. An ASAE Monograph Number 7.
2. The use of switchgrass biofuel pellets as a greenhouse gas offset strategy/Samson R., Drisdelle M, Mulkins L. etc.//http://www.reap-canada.com/Reports/bioenergy2000Aug2.html

ISBN 9984 – 779 – 06 – 8

IMMEDIATE ROOF STABILITY ANALYSIS FOR NEW ROOM-AND-PILLAR MINING TECHNOLOGY IN "ESTONIA" MINE

TIEŠĀS SLĀŅVIRSMAS STABILITĀTES ANALĪZE JAUNAJĀ KAMERU STABU DEGSLĀNEKĻA IEGUVES TEHNOLOĢIJĀ „ESTONIA"RAKTUVĒS

OLEG NIKITIN

AS Eesti Põlevkivi, Development Department
Jaama str. 10, Jõhvi, 41533, Estonia
Phone: + 372 3364123, *fax*: + 372 3364803, *e-mail*: oleg.nikitin@ep.ee

SERGEI SABANOV

Tallinn Technical University, Department of Mining
Ehitajate tee 5, VII-202, Tallinn, 19086, Estonia
Phone: + 372 6203850, *fax*: + 372 6203696, *e-mail*: sergei.sabanov@mail.ee

Abstract. *This paper analysis the immediate roof (IR) stability by the deformation criteria for new room-and-pillar mining technology with modern machines in "Estonia" mine. The new mining technology based on a blasting method to move from packaged to emulsion explosives, from 2.0 m to 4.0 m boreholes (FRANZ SCHELL machine) and on new undercutting (SMAG machine) method. With such equipped new technology the entry advance rates reached 3.8 m. As a result of such greater advance rates the situations with unsupported room length up to 5.5 m with decreasing the stability of IR can be expected. The analysis of IR stability based on an in-site underground testing by the leaving bench-mark stations and convergence measurements. The main targets of this study to determine the main parameters for supported/unsupported IR deformation in areas with great entry advance rates and risk analysis concept elaboration.*

Keywords: *deformation criteria, room-and-pillar mining, immediate roof, stability, risk analysis.*

Introduction

For more than eighty years oil shale has been mined in Estonia. During that period about 950 million t from estimated four billion tonnes reserves have been extracted. About 99% of electric power and a large share of thermal power were produced from Estonian oil shale. Nowadays the oil-shale industry main goal is to preserve its competitive ability in the market of power resources for relatively cheap and high safety oil shale mining is capable to guarantee this competitiveness in the nearest future. In Estonian oil-shale mines the room-and-pillar mining system with blasting is used [1]. It gives an extraction factor of 70–80%. Loading and transportation of blasted mined rock is carried out by powerful LHD machines with diesel drive like TORO and WAGNER. The average productivity of such technology is 1500 m^3 of rock mass per day. The main problems are the great volume of blasting operations, low mobility and concentration of loading works due to the small entry advance rates (EAR), about 1.5-1.7m per blasting. One of the ways to improve the quality management system in nowadays situation is high safety drilling-and-blasting mining technology application with greater EAR and daily output.

Improved Technology Overview

The main operations carried out in rooms (6-7 m in width) include undercutting, drilling of blastholes, blasting, rock mass loading on the conveyor and roof bolting. The new mining technology based on improved drilling-and-blasting method (Fig.1., A.) to move from packaged to underground emulsion explosives (Nobelit 2000), from 2.0 m to 4.0 m boreholes (Fig.1.,B.) on new undercutting method (Fig.1.,C.) and to automatization of roof drilling-bolting process with roof bolting machine (Fig.1.,D.). The aim of undercutting is to gain additional free space in the oil shale bed which increases the effect of blasting. The old undercutting technology based

ISBN 9984 – 779 – 06 – 8

on bottom cutting with the help of the cutter (Ural-33) which gives horizontal cut into the bottom layer A, 15centimeters high and 1.7 to 1.8 metres deep. The new undercutting technology based on 6 large hole drilling with SMAG machine into the central oil-shale layer C, up to 4.7 metres deep with 3×280mm diameter. Roof bolter and face drilling machines are operating with remote controls that provide great safety conditions on a working place.

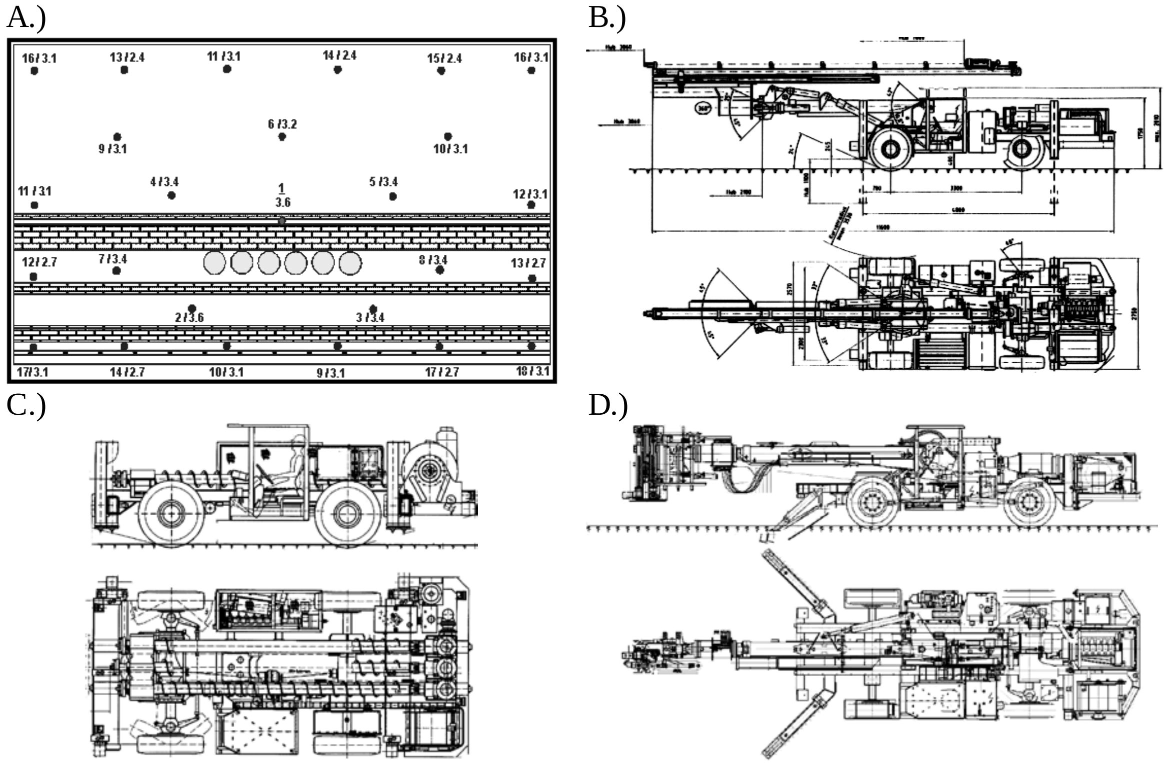


Fig.1. **New blasting pattern (A.); Franz Schell GmbH face drilling machine DHB-41-E-ZF (B.); SMAG undercutting machine GB 280 (C.); SMAG roof bolter FA523V (D.)**

The Study Targets

The width of the room is determined by the stability of the immediate roof. With such improved technology the entry advance rates reached 3.8 m. As a result of such greater EAR the situations with unsupported room width × length up to 7 × 5.5 m with decreasing the stability of IR can be expected. The main targets of this study are to determine:

- ✓ the main parameters for supported/unsupported IR deformation in areas with great entry advance rates, EAR>3.5m with chamber sizes ≥7×7m and excavation height h=3.8 m ;
- ✓ the main IR exfoliation levels by the optical geoperiscope – stratascope;
- ✓ dependence between IR deformation and loads in anchors (deflection rate);
- ✓ the main rates of risk analysis concept.

Geology and Measurement Equipment

During the last 2004 year period was tested new technology in two mining blocks 3103 and 3104 in "Estonia" mine [2]. The geological conditions were quite different. The commercial oil shale bed and immediate roof consist of oil shale and limestone seams. There are six commercial important oil-shale seams that are specified from the bottom to the top by the indexes from A to F (Fig.2.). The typically excavation height is about h=2.8 m, but on the case of weak IR conditions, like in our blocks, it can be up to 3.8–3.9 m. Roof support is to be achieved by usage of the Steeledale SCS roof bail type anchor bolts [3]. In this case expander plug (anchor lock) must be fixed in harder limestone layer G/H. It improves roof control significantly, reducing bolt-to-face distances and exposure of unsupported roof. The analysis of IR stability based on an

ISBN 9984 – 779 – 06 – 8

in-site underground testing by the leaving bench-mark stations (BMS) and convergence measurements (Fig.2.).

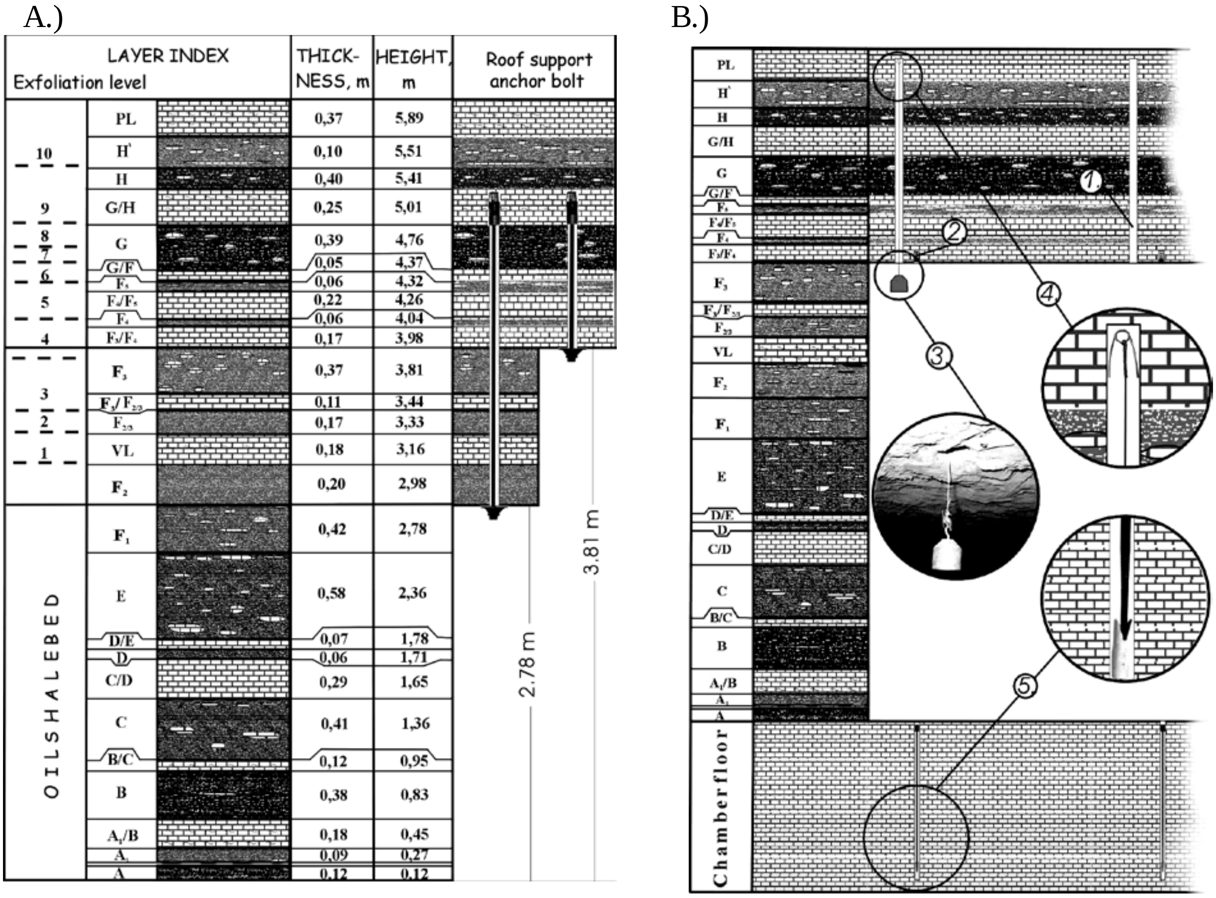


Fig. 2. **Structural cross-section with determined IR exfoliation levels (A.) and scheme of bench-mark stations in the roof/floor (B.)**

Where, ***1.****- bore hole for stratascop;* ***2.****-bench-mark station on the roof;* ***3.****-bob for rope-bench-mark station;* ***4.*** *- rope-bench-mark station;* ***5.*** *- bench-mark station in the floor.*

The deformation measurement was made by the DISTO classic[3] laser distancemeter [3] between two BMS installed in the room floor and on IR (for absolute deformation measurement). To prevent errors from floor (limestone) deformation the BMS (Fig.2.nr.5; Fig.3.A.) installation depth was 1.3m. The twin BMS-s was installed opposite on each other before the blasting, one pair (Fig.2.nr.2 and 5) near the pillar wall and at the room centre another one, no more than 0.5 m from pillar or face. The rope-bench-mark station (RBMS) was installed in the IR drilled bore hole on the depth 2.0 m for pillar deformation and IR absolute deformation on these depth measurements also (Fig.3.B). Absolute uncertainty of convergence measurement does not exceed 1.2 mm at the 95-% confidence level and the maximum relative uncertainty was 0.04%.

For IR exfoliation levels research and to estimate the thickness of exfoliation the optical geoperiscope – stratascope (10x zooming) with 0.12 mm measurement accuracy was used. For dependence finding between IR deformation and loads in anchors (deflection rate) during the experiment period the screwed anchor torque measurements was made also. The torque wrench accuracy is 4%.

ISBN 9984 – 779 – 06 – 8

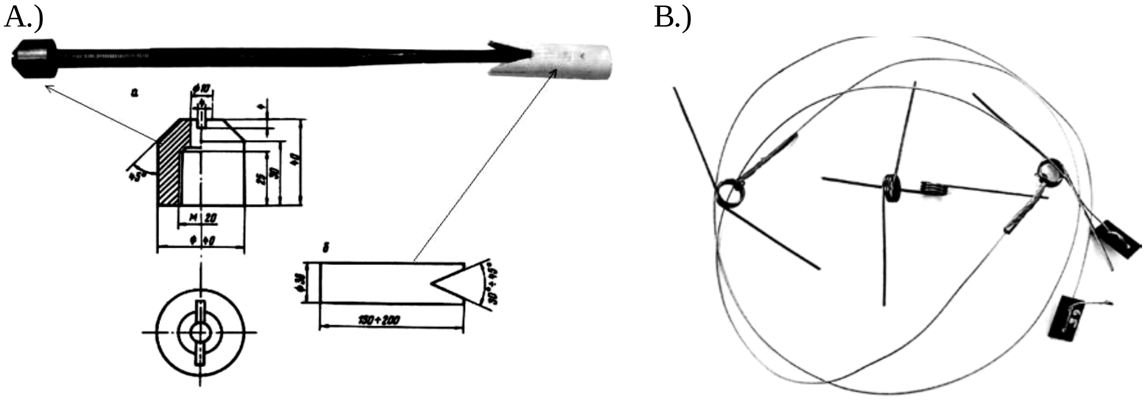


Fig. 3. **Bench-mark station (A.; Fig.2,nr.5) for installation in floor and rope-bench-mark stations (B.) for installation in roof (B.; Fig.2,nr.4)**

Where, a-metal head; b-wood cylinder

Prediction of Stability using Roof-to-Floor Convergence Data

The field of the oil-shale mine is divided into panels subdivided into mining blocks each approximately 300–350 m wide and 600–800 m long. A mining block consists usually of two semi-blocks [1, 2]. The pillars are arranged in a singular grid with cross-sectional area about 45-50 m^2 in "Estonia" mine. The service life of one room in practice is 2-3 months. During this period anchor bolting must support the roof. After this period the anchor bolts must be extracted and reinstalled in new formed rooms. Laminated roof deformation on the basis of plate's hypothesis by the experimental data of Institute of Mining Surveying (VNIMI) in St. Petersburg and Estonian filial of A. A. Skotchinsky Institute of Mining Engineering (IGD, Moscow, Russia) presented on figure 4.A. [4, 5].

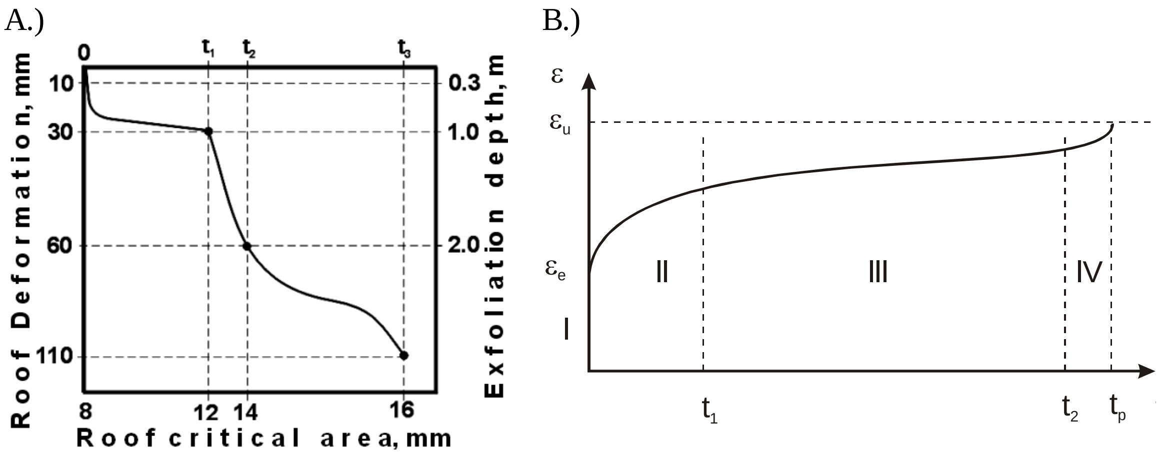


Fig. 4. **Roof-to-floor convergence curve by the VNIMI and IGD data (A.) and typical curve for long-term stability analysis (B.) [3]**

Where, t – time; t_p=t_3 – time at failure; ε – deformation; ε_u – ultimate deformation at failure; ε_e – elastic deformation; ; I – elastic deformation ε_e; II – transient creep $\acute{\varepsilon}$ <0 ($\acute{\varepsilon}$ – deformation rate); III – steady-state creep $\acute{\varepsilon}$ = const; IV – transient creep $\acute{\varepsilon}$ >0

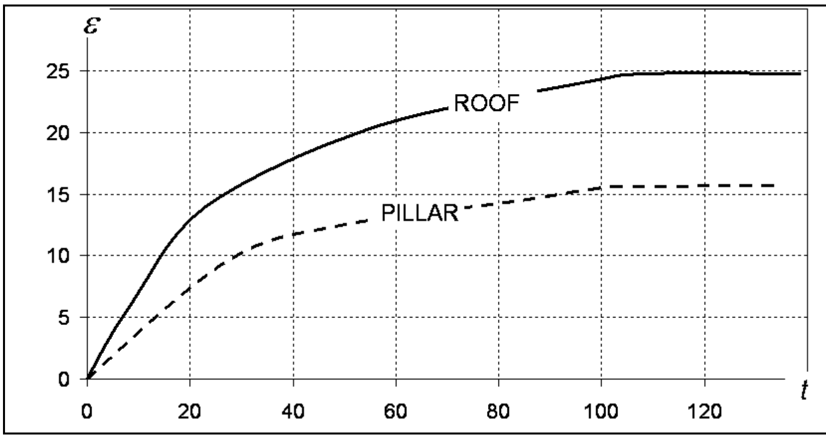
In general case for Estonian oil-shale deposit it is possible to allocate four stages in this process. During short time interval after the first blasting there are *instant deformations* (ID) up to 10 mm. Then during the time (duration depends on geological conditions) there are two processes: increase of *elastic deformations* (ED) due to reological processes, blasting work and entry advance, and also increase of *creep deformations* (CD) up to the cracks formation moment at t = t_1, when ε=20-30 mm. Then instead of a plate the arch on three hinges is formed completely. The time period from t_1- t_2 is a *transient creep* (TC) period due to a partial crushing of average and left/right hinges of an arch, till the moment of the crushing termination, when ε=60 mm. During

ISBN 9984 – 779 – 06 – 8

the period t_2-t_3 there is a *steady-state creep* (SSC) in hinges up to their full crush at the t_3, when ε=110 mm and full loss of the roof bearing capacity (full destruction up to depth 2-3,5 m) is happen. Duration of these time periods t_0-t_3 depends from many *geological* (loading, capacity, cracks, etc.) and *technological* (roof critical area, type of explosives initiation, advance rate, supporting and etc.) factors that present difficulties for dependence $\varepsilon=f(t)$ finding.
The *roof-to-floor convergence curve* method (Fig.4.B) is applicable also for the roof long-term calculations (for the period up to 100 years and more); its uncertainty does not exceed 10%.

Results

During in-site testing 16 pair of BMS-s was installed and 19 holes (Fig.6) were viewed by the stratascope in two mining blocks (3103 and 3104) with different geological conditions (with weak and average stable IR) [2]. The results of IR (on the center of the room) and pillars (S=45-50m^2) average deformation presented on figure below (Fig.5). The critical areas (L) of the rooms for our conditions were about 11-12 m.



PERIOD INDEX		*ε, mm* VNIMI + IGD	*ε, mm* 3103+ 3104
0	*ID*	10	*3-7*
I.	*ED + CD*	*20-30*	*15-28*
II.	*TC*	*60*	*29-40*
III.	*SSC*	*110*	—

Fig. 5. **Roof-to-floor convergence curves and comparison table for deformation by VNIMI+IGD and received experimental data**

By the VNIMI and IGD data the roof failure is happen (depth of failure ≈ 2.0-3.5 m) when deformation is $f_{max}=6.3L=8.84A+5.3$, mm, where A is room width. For our conditions, $f_{max}=8.84*7.0+5.3=67$ mm. From the comparison table on figure 5 you can see that received experimental data are much closed to the data of VNIMI and IGD. Its mean that the improved technology influences on immediate roof stability estimated by the deformation criterion is not greater than with old technology. Analysis of immediate roof failure cases during the experiment shown that depth of failure about 8-10cm when $\varepsilon=0.4f_{max}$ is possible. Then after IR unsupporting the failure on this depth can be expected with great probability.
By the way of exfoliation level (EL) or depth (h_v) and deflection rate (DR) determination we can estimate the effectiveness of anchor bolting and supporting pattern. Deflection rate of the system "anchor-roof" by the anchor torque (M, N*m) measurements was in average 1.3 mm/t, where loads on used anchors (N, t) was determined by the empirical formula N=0,2722M. On this case DR is a parameter of IR deformation after the vertical load on anchor increasing by one ton. Another very important parameter is exfoliation level of the roof, which was determined by stratascope inspection of 19 holes drilled in the roof. Sixteen of them were drilled in mining block nr.3104 and presented on figure below (Fig.6). The summarized result dependence $h_v=f(L)$ is showed on figure 7.

ISBN 9984 – 779 – 06 – 8

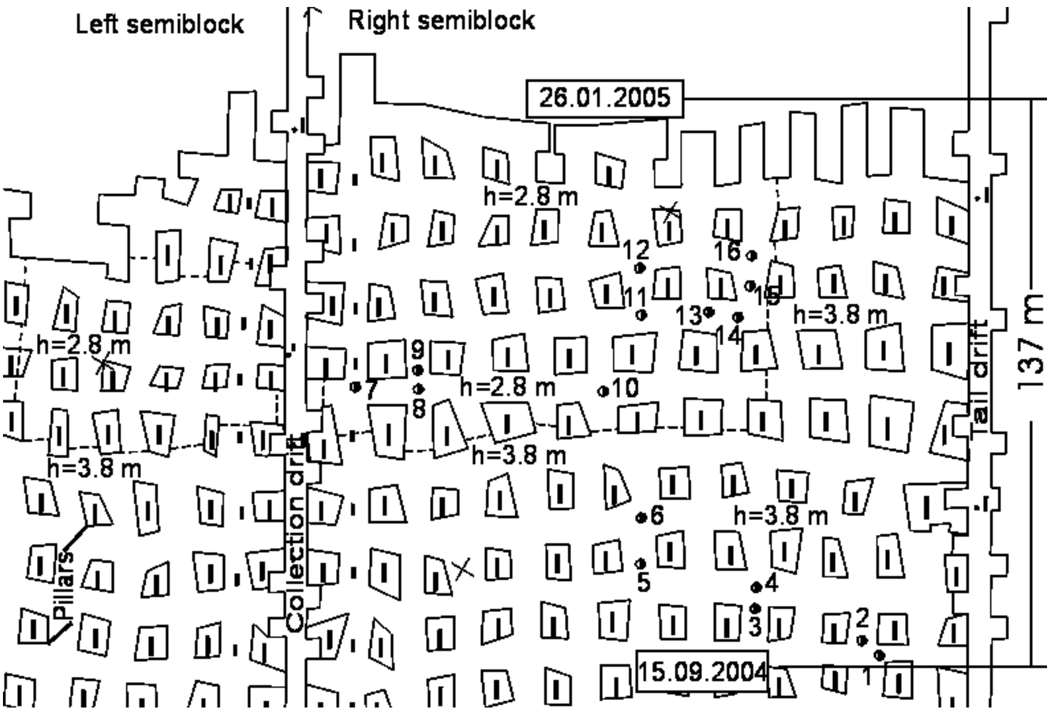


Fig. 6. **The part of mining block nr.3104 "Estonia» mine with places for stratascope inspection**

Where, □- boreholes for stratascope; 1-6 –boreholes equipped with BMS-s when h=3.8m; 7-16 –boreholes drilled in the rooms with exploration height=2.8m, without BMS-s

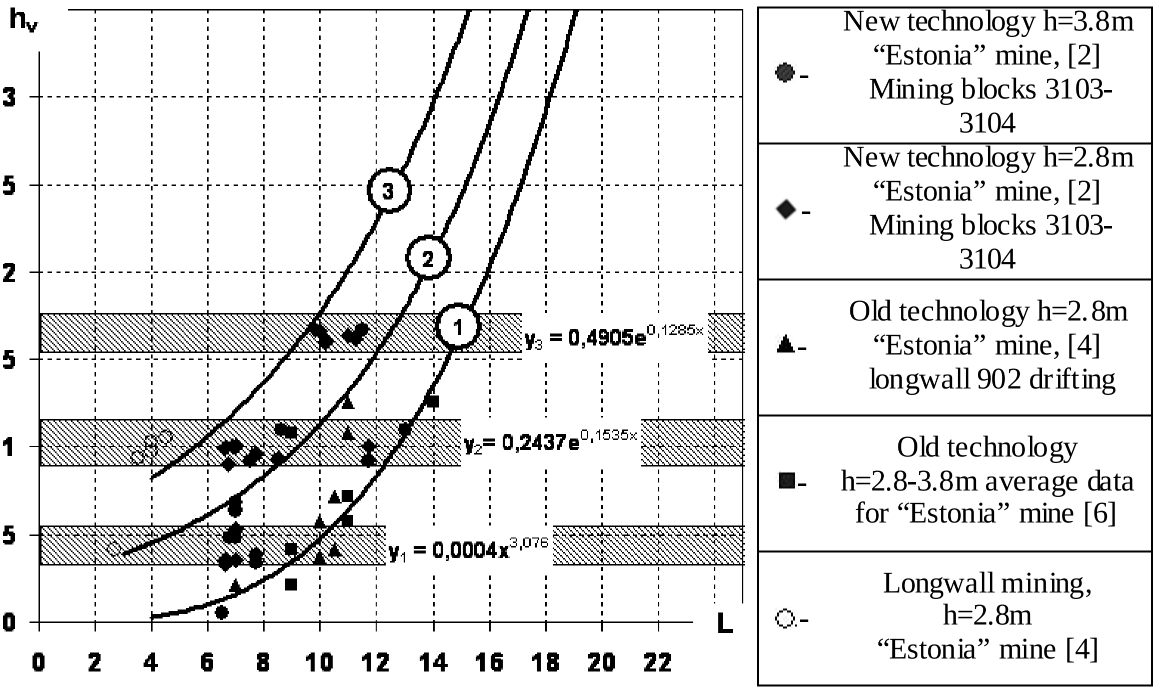


Fig. 7. **The exfoliation depth (h_v) dependence on the critical area (L)**
Where, geological conditions classification by the roof stability: ①-stable; ②- average; ③- weak.

For an obvious reason the EL-s depends on critical area of the roof (Fig.7). More than forty years ago by L.Talve, H.Arukula and A.Reier from Tallinn Polytechnic Institute (TPI, now TTU) was carried out analysis of IR exfoliation levels for Estonian oil-shale manes (old technology). According the results of their report [8] it is possible to summarized dependence $h_v=f(L)$ from the roof stability rate by curves presented on figure 7. The last data for EL-s research in

ISBN 9984 – 779 – 06 – 8

"Estonia" mine were presented in reports of IGD in 1987 [6, 7] and plotted as additional points on figure 7. As you can see there are three main exfoliation levels (h_{v1-3}=0.4-0.6; 0.8-1.2; 1.5-1.7m) which are depends from both factors like geological situation and roof critical area. These levels are suitable for both technologies with exploitation height h=2.8-3.8 m.
The risk evaluation of hazard for workers [9, 10] is carried out on the *Likelihood* of events, their *Consequence* and *Risk magnitude* and presented in Table 1.

Table 1.

Old and improved (new) technology risk evaluation

Hazard factors	**Hazard factors influence**	**Likelihood old(new)**	**Consequence old(new)**	**Risk magnitude old(new)**
Roof drilling and supporting	Immediate roof falling	3(1)	5(5)	15(5)
Roof unsupporting	Immediate roof falling	4(4)	5(5)	20(20)
Blasting work	Explosive substance	3(1)	5(3)	15(3)
Face drilling and undercutting	Moving parts of mechanisms, sharp and prickly subject	2(1)	4(2)	8(2)
Equipment Operating	High-altitude work, falling subjects, sliding surface	3(2)	3(2)	9(4)

Where, ***Likelihood*** *define as Very unlikely(1), Low probability(2), Likely(3), Very likely (4).* ***Consequence*** *- Harmless(2), Significance(3), Danger (4), Very danger(5).* ***Rick magnitude*** *are: (1-3)-Minimal. Not required special measures; (4-6)-Low. Special measures on reduction of risk are required; (7-10)-Moderate. Measures of organizational character are required. (additional instructing, training); (11-16)- High. The analysis of the reasons and existing security measures is carried out. Actions on prevention of similar cases are made. The information card is made; (17-20)-Catastrophic. Work stops. The analysis of risk is immediately carried out. Additional actions are developed. Additional instructing or training is carried out. Works cannot be begun while the risk is not reduced.*

Below there are some explanation for the rates of table 1. Old technology use a cutter machine "URAL 33" for face undercutting. The machine moves with the towrope. Rope is fixed by 3-4 meter stanchion, which putting between roof and floor. Typically there is a dangerous if the stanchion is falling. In some cases roof drilling and supporting can be made by manual bore machine only. Vibration and dust only two of the danger influences on miner health. Electricity cable breaking leads to loss of a life. For old equipment operation necessary work on high-altitude and beside dangerous subject that demand special skills. Especially big risk appears at roof supporting/unsupporting. The worker should have time to leave a place before roof falling. The risk minimization achieved by carefully and quality team work. From the table 1 it is visible, that the risk is much lower for the improved technology due to the high safety and remote controllable equipment.

Discussion

Estonian oil shale mines have seen total mining cost benefits when moving to emulsion explosives not in a reduction in powder factor within great advance rates but in the drill and blast productivity improvements achieved from improved logistics, faster transport & charging, improved advance, improved fragmentation, less damage, high safety (explosives preparation at working place), faster mucking and drill set ups.

ISBN 9984 – 779 – 06 – 8

Conclusions

During this study the following conclusions were made:

- Immediate roof stability estimated by the deformation criterion is not greater than with old technology.
- Analysis of immediate roof failure cases during the experiment shown that depth of failure about 8-10cm when $\varepsilon=0.4f_{max}$ is possible.
- There are three main exfoliation levels ($h_{v1\text{-}3}$=0.4-0.6; 0.8-1.2; 1.5-1.7m) which are depends from both factors like geological situation and roof critical area. These levels are suitable for both technologies.
- The risk evaluation of hazard for workers is much lower for the improved technology due to the high safety and remote controllable equipment.

Acknowledgments

We are indebted to the Head of Development department Eng. R.Kaarlep (AS Eesti Polevkivi), to technologysts of Development department S.Ovsjannikov, V.Gabets A.Bachmann and A.Mikhalchenkov, for their practical help in data collection. Special thanks to Prof. A. Adamson, Assoc. prof. J.-R. Pastarus and Eng. Lembit Uibopuu from TTU Department of Mining for their useful suggestions and unical equipment presentation. Our sincere thanks are addressed to all the persons who helped a lot during this study.

References

1. Pastarus, Yu.-R. V., Nikitin, O.V. Estimation methods for stability of mining excavations (on the example of oil-shale deposit in Estonia). Gornyj Zhurnal. Ruda I Metally, Moscow, 4-5. 2003, p.71-75.
2. Nikitin, O., 2004-2005. Immediate roof stability analysis for new technology with great advance rates in Estonia mine on example of mining blocks 3103-3104. *In:* Reports of Development department, AS Eesti Polevkivi, Johvi.
3. Mechanical Anchors, 2002. web page: http://www.steeledalescs.co.za/MechanicalAnchors.htm; Leica Geosystems, 2003. web page: http://www.leica-geosystems.com
4. Andreev, V., Reinsalu, E., Djachenko, Z., etc., 1987. Experimental working in underground mines for technological suggestion elaboration. *In:* Reports of IGD (Skochinski A.A.) nr. 0103018100.
5. Seleznev N., Zarkov S., Kuznetsov S., 1961. The main parameters determination for the main and immediate roof stability estimation for Estonian oil-shale new excavation technologies. VNIMI, St Petersburg.
6. Reinsalu, E., Toomik, A., Levin A., 1987. The analysis of harmful geological influences during the oil-shale mines “Estonia”, “Ahtme”, “Viru”, “Tammiku” exploitation. *In:* Reports of IGD (Skochinski A.A.) nr. 0192066000, Kohtla-Jarve.
7. Djachenko Z.K., Cheshin, A.J., and etc., 1985. The research of oil-shale bed full exploration by longwall mining. Kohtla-Jarve.
8. Talve L., Arukula H., Reier A. and etc., 1975. The roof supporting technological improvements for room-and-pillar oil shale mining. *In:* Reports of TPI, Tallinn.
9. Kaplan, S., Garrick, 1981. On the Quantitative definition of risk. Risk analysis 1, 1-27
10. Marilyn, R. Block, 1999. Identifying environmental aspects and impacts. Library of congress cataloging-in-publication data 1999 by ASQ. *In:* http://www.asq.org

ISBN 9984 – 779 – 06 – 8

IMPROVED UNDERGROUND MINING DESIGN METHOD FOR ESTONIAN OIL SHALE DEPOSIT

UZLABOTA APAKŠZEMES KALNRŪPNIECĪBAS DARBU PROJEKTĒŠANAS METODE IGAUNIJAS DEGSLĀNEKĻA ATRADNEI

JYRI-RIVALDO PASTARUS

Tallinn University of Technology, Department of Mining
5 Ehitajate tee St, Tallinn, 19086, Estonia
Phone: + 372 6203850, *fax*: + 372 6203696, *e-mail*: pastarus@cc.ttu.ee

Abstract. *The paper deals with the improved mining design method for Estonian oil shale mines, where the room-and-pillar mining system is used. Design of mining block parameters is based on the instruction used in Estonian oil shale mines. The factor of safety is very large. Consequently, the design method does not take into consideration all the influence factors. It is determined the supplementary influence factors and given the mathematical formulas. In this case the factor of safety is reduced up to 1.2. The improved mining design method is of particular interest for practical purposes.*

Keywords: *depth of excavation, design, factor of safety, fracture process, influence factor, influence zone, mining block, pillar cross-section area, room-and-pillar mining, stability.*

Introduction

The most important mineral resource in Estonia is a special kind of oil shale. It is located in a densely populated and rich farming district. Underground oil shale production is obtained by room-and-pillar method with blasting. This method is cheap, highly productive and easily mechanize.

Design of mining block parameters based on the instruction, used in Estonian oil shale mines [1]. Analysis of the applicable mining block design method showed that the factor of safety is very large. Consequently, it involves the unknown influence factors. In this case to determine the real factor of safety for a certain mining block is practically impossible, which may lead to the negative consequences. Up to present, 73 collapses have been recorded on the area of 100 km^2 (about 400 mining blocks). It takes about 18 % of the total number of mining blocks. The collapse of the pillars and the surface subsidence cause and will cause in the future a large number of technical, economical, ecological and juridical problems.

Determination of the supplementary influence factors and elaboration of the mathematical formulas was the main aim of the present work.

Investigation showed that there are four influence factors. Application of these influence factors will reduce the factor of safety up to 1.2.

The improved mining block design method is of particular interest for practical purposes.

Oil shale mining [2]

In Estonian oil shale mines the room-and-pillar mining system with blasting is used. It gives an extraction factor of 70 - 80 %. The field on the oil shale mine is divided into panels subdivided into mining block each approximately 300-350 m wide and 600-800 m long. A mining block consists usually of two semi-blocks. The oil shale bed is embedded at the depth of 40-75 m. Its height corresponds to the thickness of the commercial oil shale bed, approximately 2.8 m.

The width of the room is determined by the stability of the immediate roof. The latter is very stable when it is 6-10 m wide. In this case bolting must still support the immediate roof. The pillars are arranged in a singular grid. Actual mining practice has shown that pillars with a square cross-section suit best. Intra-chamber pillars are left to secure the solidity of the whole upper-laying rock mass and to eliminate surface subsidence. The cross-sectional area of the pillars is 30-40 m^2, depending on the depth of the oil shale bed.

ISBN 9984 – 779 – 06 – 8

Theoretical background

Design of mining block parameters is based on the instruction used in Estonian oil shale mines [1]. It bases on the long-term investigations during 30 – 40 years. Mining block design method takes into consideration nine general influence parameters. They are [1]:

1. k_o – coefficient of the karst influence (takes into consideration the distance from stope up to karst);
2. k_p – coefficient of the roof cracks (depends on the distance between the cracks and joints);
3. k_t – rate of the current rock strength (rock parameters depends on the time);
4. k_s – factor of the pillar easing (attenuation);
5. k_k – factor of the pillar form (depends on the pillar sizes);
6. n – given factor of the pillar and roof safety (n=1.2 … 1.8);
7. k_i – coefficient, depends on the importance of the supported object on the surface;
8. K, M – parameters, depending on the rock properties (K=7 m, M=0.54).

Roof and pillar design method analysis showed that the factor of safety is very large (maximum 1.8). Consequently, it includes the unknown factors. The investigation showed that since 1964 73 collapses on the area of 100 km^2 have been recorded. The reduction of the value of the factor of safety is possible, when to introduce the supplementary parameters. Investigation showed that they are:

1. Dependence of load distribution on different pillar cross-section area.
2. Dependence of pillar load on rock massive or barrier pillars influence.
3. Dependence of pillar strength on fracture process.
4. Dependence of pillar strength on excavation depth.

Dependence of load distribution on different pillars cross section area

The load on the pillars depends on the cross-sectional area of the pillars and on the stiffness of the roof. Investigation in Estonian oil shale mines showed that the roof is stiff enough and in this case a bigger pillar receives a greater load. Consequently, the failure begins from bigger pillars. Load distribution between the pillars of different cross-section area is given in Fig. 1.

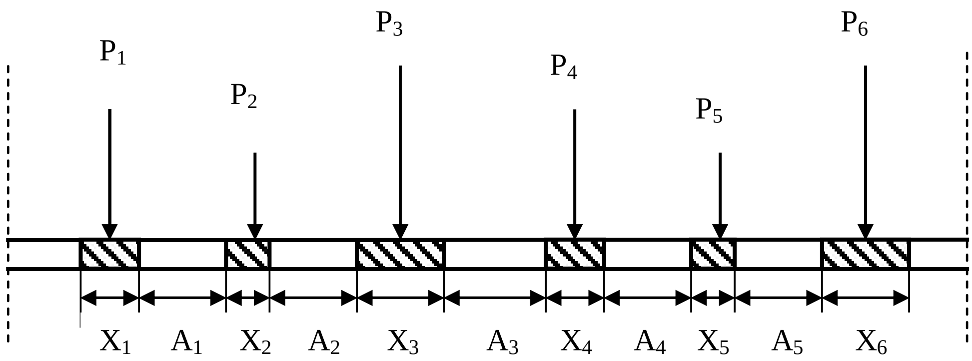


Fig. 1. **Load distribution between the pillars of different cross-section area**
P_1, P_2, … P_6 – load on the pillars; X_1, X_2, … X_6 – width of the pillars; A_1, A_2, … A_5 – width of the rooms.

For statistical analysis standard programs and a method based on the control of normal distribution of the cross-sectional area of the pillars were used. Investigation was held assuming that by normal distribution of the pillars cross-sectional area a potential collapse of a mining block is likely to be expected. Analysis was made for 12 mining blocks of Ahtme and Estonia mines [2, 3].

ISBN 9984 – 779 – 06 – 8

Investigation showed that if the pillar sizes differ less and they are stronger, if the normal distribution is not present [3].
The analysis was based on geometrical parameters of mining blocks. The method presented does not take into consideration the rheological rock parameters; and these problems required additional investigations.

Dependence of pillar load on rock massive or barrier pillars influence

Typically, full load to pillars take place close to the centre of a mining block. Towards the margin of a mining block, there appears a zone where the load on pillars is less than in the centre (Fig. 2). It is related to the influence of the rock massive and barrier pillars.

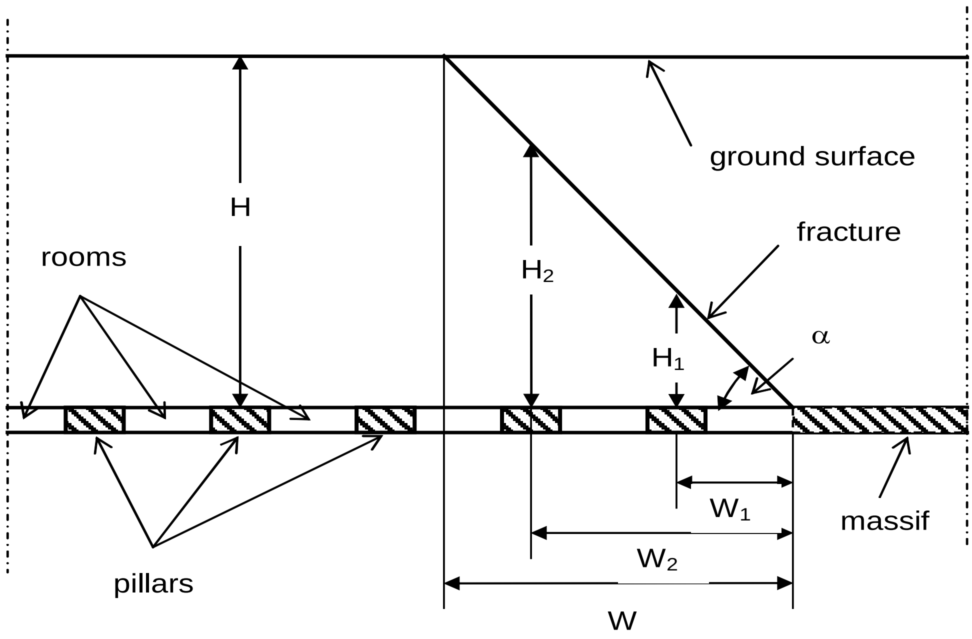


Fig. 2. **Geometrical interpretation of the influence zone in a mining block**
H – depth of excavation, m; H_1, H_2 – thickness of the overburden rocks, influences on the pillar; W – width of the influence zone; W_1, W_2 – pillar distance from the rock massive or barrier pillars; α - angle of major influence.

Theoretical investigation, modeling and experience of in-situ conditions show that the width of the influence zone equals to the half of the critical width [4, 5].

$$W = \frac{L}{2} = \frac{1.2H + 10}{2} \tag{1}$$

where W – width of the influence zone, m; H –depth of excavation; L – critical width, m.
The pillar load ratio in the influence zone is presented by the following formula:

$$K_w = \frac{W_i \tan\alpha}{H} \tag{2}$$

where K_w – pillar load ratio in the influence zone; W_i – pillar distance from the rock massive or barrier pillars, m; α - angle of major influence, deg (α=55^0).

ISBN 9984 – 779 – 06 – 8

Formula (2) is valid when the distance between the pillar and rock massive (barrier pillars) is in the range $0<W<H/\tan\alpha$, beyond the limit $K_w=1$.

Dependence of pillar strength on fracture process [6]

Based on the Mohr-Coulomb failure criterion, the theoretical and numerical modeling was performed. For the calculation on PC the FLAC – program was used. Towards the center of a mining block, the vertical load occurs on the top of the pillar, and the orientation of the fracture plan is inclined according to the Mohr-Coulomb's theory (compressional shear fracture). Towards the margin of a mining block, the inclined load occurs on the top of the pillar and the orientation of the fracture plane is vertical (axial fracture). The pillar is stronger by compression shear fracture. The results of theoretical investigations and modeling are close to those in in-situ conditions.

Uni- and bi-axial strength ratio of the pillar is [6]:

$$K_f = \frac{\sin\varphi}{1+\sin\varphi} \tag{3}$$

where φ - internal friction angle, deg.

In the case of the compressional shear fracture $K_f = 1$, in the case of axial $K_f < 1$ (Formula 3).

Dependence of pillar strength on excavation depth

A commercial oil shale bed (pillar) and immediate roof consist of oil shale and limestone seams and the main roof consists of carbonate rocks of various thicknesses. Practical experience evidences that some oil shale bed parameters are not constant and vary depending on the depth and geological conditions. The strength of the rock increases in the southward direction. The probable reasons for that is increase in the thickness of limestone seams and decrease the calorific value of the oil shale seams in this direction. The data of 258 boreholes of Estonian oil shale deposit were analyzed and compressive strength of pillars calculated.

Taking into consideration the 95 % confidence level, southward strength increase is about 1.35 ± 0.25 times and can be described by following dependence [2]:

$$K_d = 0.0068H + 0.72 \tag{4}$$

where $K_d \geq 1$ is rate of rock strength increase (for the depth $H \leq 40$ m $K_d = 1$) and deviation are 15 - 28% for the whole of Estonia oil shale deposit.

Acknowledgment

Estonian Science Foundation (Grant No.5164, 2002-2005) supported the research.

Conclusions

As a result of this study, the following conclusions and recommendations can be made.

1. In Estonian oil shale mines the room-and-pillar mining method with blasting is used. Design of the mining block parameters based on the instruction, used in Estonian oil shale mines.
2. Theoretical investigation and experiments of in situ conditions showed that by the calculations, the factor of safety is very large. It contains the unknown factors. Consequently, it is impossible to determine the optimum parameters of a mining block.
3. Theoretical investigation showed that the factor of safety contains four unknown factors. It is opened the physical background and given the mathematical formulas of these factors.
4. Application of these factors for design the mining block parameters improve the design quality. It will reduce the factor of safety up to 1.2.

ISBN 9984 – 779 – 06 – 8

References

1. Mining-law and legal regulation acts. Ministry of Environment, Ministry of Economy. Part II. Tallinn, 1988 (in Estonian).
2. Nikitin, O. Optimization of the Room-And-Pillar Mining Technology for Oil-shale Mines. Doctoral theses. Tallinn, TTU, 2003 .
3. Pastarus, J.-R. Improved method of predicting long-term stability of the mining blocks in Estonian oil shale mines. Proc. of the International Conference "Scientific achievements for wellbeing and development of society. Enabling environment for society wellbeing". (Noviks, G. ed.). Rezekne Augstskolas Izdevnieciba, Rezekne, Latvia, March 4-5, 2004, p.37-42.
4. Pastarus, J.-R., Toomik, A. Roof and pillar stability prognosis in Estonian oil shale mines. Rock Mechanics. Proc. of the ISRM regional Symposium EUROCK 2001 "Rock Mechanics a shallenge for society". Espoo, Finland, 4-7 June 2001, A. A. Balkema/Lisse/Abingdon/Exton (PA)/Tokyo, 2001, p.849-853.
5. Pastarus, Yu.-R. V., Nikitin, O.V. Estimation methods for stability of mining excavations (on the example of shailoil deposit in Estonia). Gornyj Zhurnal. Ruda I Metally, Moscow, 4-5. 2003, p.71-75. (in Russian).
6. Pastarus, J.-R. Fracture process in pillars. Proc. of the International Conference on Structural Integrity and Fracture (SIF 2002). Perth, Australia, 25-27 September 2002, p.343-346.

ISBN 9984 – 779 – 06 – 8

MĀJSAIMNIECĪBAS ATLIKUMU KOMPOSTĒŠANA KONTEINEROS
COMPOSTING OF HOUSEHOLD WASTES IN CONTAINERS

IMANTS PLŪME, BENITA PLŪME

LLU, Tehniskā Fakultāte, Čakstes bulv. 5 Jelgava, LV-3001, Latvija,
Tālr.: + 371 3080674, *fakss*: + 371 3027238, *e-pasts*: imants@llu.lv
I/U "Sandio", benitap@inbox.lv

Abstract. *Household wastes handling improperly leads to increasing of total amount of wastes deposited in landfills. Investigations of family (3 adults and 3 children) during 3 year period appeared, that average weight of kitchen wastes produced was 62,2 kg per habitant in year. Kitchen wastes have high moisture content 70 – 90% and high density 500 – 600 kg/m³. Investigated weight of liquid leached was 43,2%, if the kitchen wastes were composted without additional material and leakage was 15,4% if wastes was composted together with 10% dry bulking materials (straw5% + sawdust5%). Leakage was not observed, if kitchen wastes were co-composted with 25% lake rootfelt. Maximal temperatures in 1,2 m^3 container were 36 °C for compost of weeds and 61 °C for screened weed's compost. Non-treated with etch wheat grain's sprouts all perished after 40-day couching period in compost having maximal temperature 36°C during previous composting process and in same time survived 75% of sprouts in compost having maximal temperature 61 °C during previously performed composting process.*

Keywords: *household wastes, composting, insulated containers.*

Ievads

Planētas vidi piesārņojošo fosilā kurināmā dedzināšanas izmešu samazināšanai vispasaules nozīme ir Kioto līguma stāšanās spēkā 2005. gada 16. februārī, kas nosaka ierobežojumus siltumnīcas efektu īpaši veicinošo gāzu emisijai. Tomēr pat pilnīga minētā līguma prasību izpilde var tikai nedaudz palēnināt, bet ne apturēt straujo planētas vidējās temperatūras paaugstināšanās tempu, tāpēc katram iedzīvotājam aktīvi jāpiedalās minētā nelabvēlīgā procesa nobremzēšanā. Līdzšinējo egoistisko saimniekošanas veidu jānomaina ar ekosistēmas pieeju saimniekošanai, kas nosaka nepieciešamību ņemt vērā augsnes, ūdens, biomasu un visu dzīvojošo radījumu, ieskaitot cilvēku, savstarpējās attiecības. Mājsaimniecības bioloģiski sadalāmos atlikumus (virtuves atlikumi, zāģu skaidas, kūla, zālāju un dīķu apaugums u.c.) pieskaitāmas bioloģiski degradējamai biomasai, kuras noglabāšana izgāztuvēs tiks pakāpeniski ierobežota saskaņā ar izmaiņām ES likumdošanā. No izgāztuvēs noglabātajām biomasām anaerobo procesu rezultātā izdalītajam metānam salīdzinājumā ar ogļskābo gāzi ir 21 reizi lielāka siltumnīcas efektu izraisošā iedarbība uz atmosfēras ozona slāni. Ja biomasas anaerobo kompostēšanas procesu aizstāj ar aerobo procesu, tad apkārtējā vidē pārsvarā izdalās ogļskābā gāze, bet citu kaitīgo gāzu emisija krasi samazinās. Piemēram, kompostējot kūtsmēslus aerobos apstākļos, siltumnīcas efektu izraisošo gāzu metāna un slāpekļa oksīda emisija ir attiecīgi 9,6 un 1,5 reizes mazāka salīdzinot ar to kompostēšanu anaerobos apstākļos [1]. Nav ieteicama atbrīvošanās no mājsaimniecības organiskajiem atlikumiem tos sadedzinot, jo, piemēram, kūlas dedzināšanas rezultātā pakāpeniski samazinās augsnes organisko vielu daudzums. Bez tam augu atliekas satur hlora savienojumus, kas nekontrolētas degšanas procesā pie relatīvi zemas temperatūras tiek pārvērsti dioksīnu formā. Salīdzinot ar citiem organiskiem atkritumiem (notekūdeņu dūņām, rūpnieciskas izcelsmes organiskiem atkritumiem), virtuves atkritumos smago metālu koncentrācija nepārsniedz pieļaujamos normatīvus, bet mazos daudzumos esošos pesticīdus un konservantus iespējams sekmīgi degradēt kompostēšanas procesā. Veiktie pētījumi Čehijā parāda, ka pilsētas apstākļos uz vienu cilvēku tiek ražoti 49,4 kg virtuves atkritumu gadā [2]. Kompostējot individuālas mājsaimniecībā ražotus atlikumus (virtuves atlikumus, zālāju apaugumu, zāģu skaidas utt.) tiek ražots „uzticams" mēslojums ar nelielu smago metālu saturu. Virtuves un dārzu biomasu kompostēšanai piemērota ir firmas „Biolan" (Somija) rūpnieciski ražotā siltumizolētā tvertne, kurā iespējams nodrošināt iekšējo temperatūru vismaz 55^{o}C nezāļu

ISBN 9984 – 779 – 06 – 8

dīgstspējas samazināšanai un atkritumu ātrai biodegradācijai [3]. Bioloģiski sadalāmo mājsaimniecības atkritumu kompostēšanas mērķis var būt ne tikai augu barības vielu recirkulācijas nodrošināšana, bet arī biomasā esošās siltuma enerģijas utilizācija, jo 3 kg augu sausnas pēc siltumspējas ir ekvivalenta aptuveni 1 kg šķidrās kurināmās degvielas enerģijai. Bioloģiski degradētā organiskā viela aerobās kompostēšanas jeb "zaļās degšanas" procesā izdala tikpat lielu siltuma daudzumu, kāds izdalītos, ja šīs vielas sausnu sadedzinātu kurtuvē. Parasti kompostēšanas procesā izdalītais siltums nevajadzīgi izkliedējas apkārtējā vidē pastiprinot jau tā lielo planētas "piesārņojumu" ar siltumu. Pētījuma mērķis ir aktualizēt lietderīgu kompostēšanas siltuma izmantošanu. Viens no veidiem, kā lietderīgi izmantot šo siltumu, ir komposta temperatūras paaugstināšana, lai samazinātu augu slimību, patogēno baktēriju skaitu un paātrinātu biomasu konversiju par vērtīgu organisko mēslojumu. Pētījuma mērķis ir noskaidrot mājsaimniecības atlikumu daudzumu, īpašības un ieteicamās kompostēšanas metodes.

Materiāli un metodes

Vienas ģimenes saražoto virtuves atkritumu (VA) daudzums 36 mēnešu periodā tika noteikts nosverot ik pēc 3 – 5 dienām ražoto virtuves atlikumu porciju ar svariem, kuru kļūda nepārsniedz ±0,05 kg. Virtuves atkritumu, nezāļu, kūlas un citu biomasu mitrumu, organiskās vielas un pelnu satura noteikšanai tika izmantoti svari ar kļūdu ±0,00002 kg. Atsevišķu biomasu paraugu (VA, noteces, nezāļu komposti, zāģu skaidas) mitrums, organiskās vielas saturs un ķīmiskais sastāvs tika noteikts sertificētā agroķīmiskajā laboratorijā "Ražība". No komposta izdalīto noteču apjoms tika noteikts ar kļūdu ±0,0005 kg.

Virtuves atkritumu sastāvs un īpatsvars produktos tika noteikts divos 30 dienu periodos aprīlī-maijā un augustā 2001.g. Atkritumu mitruma un organiskās vielas vidējo rādītāju noteikšanai paraugu mērījumi tika atkārtoti 4 – 7 reizes.

Organiskās vielas satura sausnā noteikšanai tika izmantota sakarība:

$$\% O_v = \frac{100\ (1 - M_p)}{M_s} \qquad (1),$$

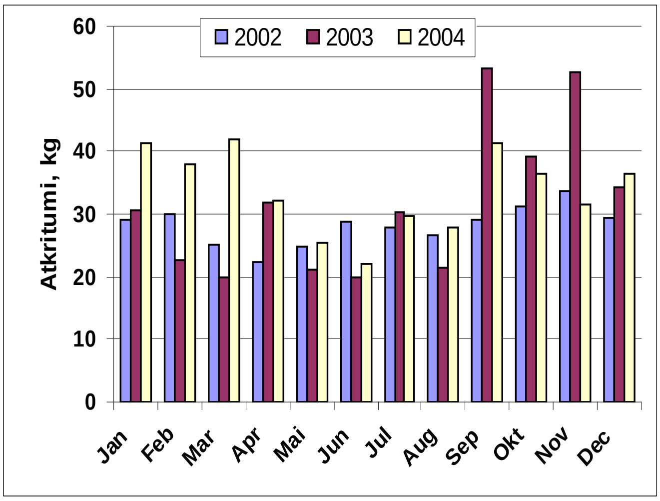
kur, M_p – parauga pelnu svars, kg; M_o – parauga sausnas svars, kg.

Virtuves atlikumu kompostēšanai tika izmantoti 0,02 un 0,20 m3 konteineri bez siltuma izolācijas un 0,47 m^3 konteiners ar 0,075 m biezu putupolistirola siltumizolācijas slāni. Konteineriem ar tilpumu 0,02 un 0,20 m^3 bija izveidotas atveres pasīvai aerācijai, bet 0,47 m^3 tilpuma tilpnei ventilators nodrošināja aktīvo aerāciju ar regulējamu gaisa padevi 0…0,006 m^3 stundā. Nezāļu, kūlas un apauguma kompostēšanai tika izmantots 1,2 m^3 tilpuma konteiners ar 0,05 m biezu putu polistirola siltumizolācijas slāni. Kompostēšanas laikā tika reģistrēta apkārtējās vides un komposta temperatūras. Konteinera pasīvās aerācijas pakāpi ir tika iestatīta ar ieplūdes caurulē ierīkoto ar roku regulējamu gaisa ieplūdes vārstu. Lai nodrošinātu labāku siltumizolāciju iestājoties vēsākam rudens periodam, tilpnes stūru zonas un jumts sākot ar novembra mēnesi tika papildus siltināts 0,03...0,05 m biezu putu polistirola slāni. Lai noteiktu dažādu nezāļu kompostu un zāģu skaidu (komposta komponentu) ietekmi uz augu attīstību, tika veikta 20 nekodinātu kviešu graudu izsēja katrā no 8 izmēģinājumu trauciņiem un tika novērota dīgstu garuma izmaiņa, izdzīvojošo dīgstu skaits, kā arī dīgstu svars pēc 40 dienu audzēšanas perioda. Dīgstu garuma un sausnas svara noteikšanai tika izmantots lineāls ar mērīšanas kļūdu ±0,001 m un svari ar mērīšanas kļūdu ±0,00002 kg.

Rezultāti un diskusija

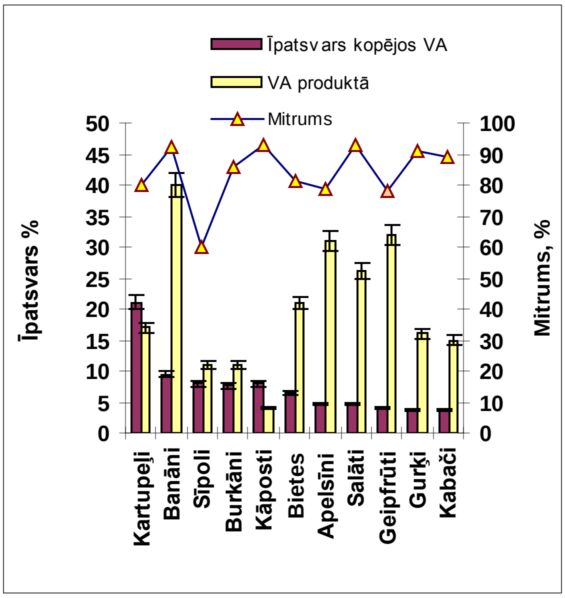
Virtuves atkritumus pamatā veido dārzeņu, augļu mizas un citu produktu atliekas. Trīs gadu periodā 6 cilvēku ģimenē (3 pieaugušie un 3 bērni) ražoto atkritumu daudzums parādīts 1. attēlā. Vienā gadā 6 cilvēku ģimenē ražotais virtuves atkritumu daudzums pieauga no 338 kg 2002 gadā līdz 404 kg 2004 gadā. Periodā no septembra līdz novembrim tika uzkrāts vidēji par 33% vairāk virtuves atkritumu salīdzinājumā ar periodu no maija līdz augustam.

ISBN 9984 – 779 – 06 – 8



1.attēls. **Trīs gadu periodā 6 cilvēku ģimenē saražoto virtuves atkritumu daudzums**

Mērījumu rezultātā aprēķināts, ka vidēji uz vienu cilvēku gadā minētajā gimenē tiek ražoti 62,2 kg virtuves atkritumu.
Noteikts, ka no virtuvē izmantotajiem produktiem atlikumu daudzums var mainīties no 0 līdz 40% no svaigā produkta masas. Noteiktais vidējais virtuves atlikumu daudzums sasniedz 19% no svaigo produktu masas. Noteikti produkti, kuriem ir vislielākā ietekme kopējā VA daudzumā, šo produktu atlikumu īpatsvars produktā, kā arī šo virtuves atlikumu relatīvais mitrums (2. attēls).
Praktiski visiem galvenajiem virtuves atlikumu komponentiem ir mitruma saturs ir robežās no 80 līdz 93% (sk. 2. attēlu), izņemot sīpolu, olu, riekstu čaumalas un maizes atlikumus, kuru mitrums bija robežās no 12 līdz 60%, bet kuru īpatsvars kopējā virtuves atkritumu masā ir relatīvi neliels.



2.attēls. **Virtuves atkritumu (VA) komponentu mitrums, īpatsvars produktā un kopējos virtuves atkritumos**

Pētot virtuves atkritumu kompostēšanas procesu bez mitrumietilpīgo materiālu piedevas, tika novērota ievērojama daudzuma šķidruma (komposta sulas) notece (3. attēls), kuras kopējais apjoms pēc trīs mēnešu uzglabāšanas perioda sasniedza 43.4% no komposta sākotnējā svara.

ISBN 9984 – 779 – 06 – 8

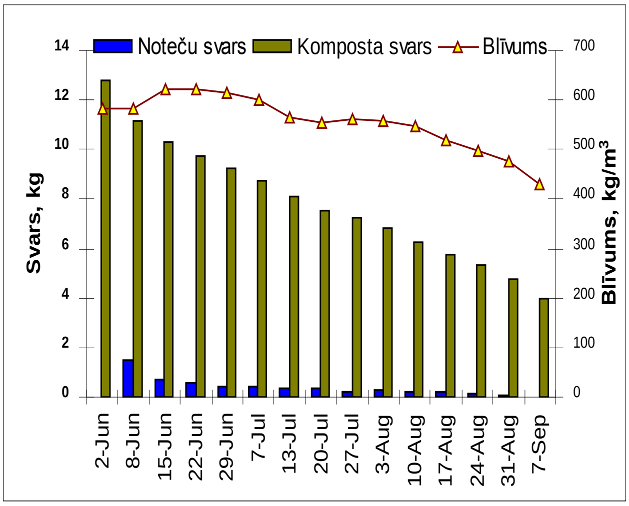
1.tabula

Virtuves atkritumu kompostu rādītāji

Komposta sastāvs*	Periods, dienas	Mitrums, sākumā, %	Maks. temperatūra kompostā, °C	Masas zudumi, %	Organiskās vielas zudumi,%	Noteces,%
VA100%	92	81	35	69	56	43,2
VA90%+Zs5%+S5%	102	75	43	34	43	15,4
VA75%+Ez.a.25%	18	61	53	38	53	-

*VA – virtuves atlikumi; Zs – zāğu skaidas; S - salmi; Ez.a – ezeru apaugums.

Virtuves atlikumu blīvums kompostēšanas sākuma periodā ir 550...600 kg/m^3, kas ir lielāks par ieteicamo 350.. 400 kg/m^3 blīvumu komposta masas optimālai aerācijai.
Virtuves atlikumu komposta mitruma, noteču un blīvuma samazināšanai, tajā pievienojami mitrumietilpīgie materiāli, piemēram, ezeru apaugums, salmi, kūla, zāğu skaidas u.c.



3.attēls. **Virtuves atlikumu blīvuma, svara un noteču izmaiņa kompostēšanas procesā**

Pievienojot virtuves atlikumiem 10% no to svara mitrumietilpīgos materiālus (salmus un zāğu skaidas, mitrums 10%), novērota būtiska noteču un masas zudumu samazināšanās, un masas noteču veidošanos nenovēro, ja palielina līdz 25% mitrumietilpīgā materiāla (ezeru apauguma sakņu pinums [4] ar mitrumu 10% un vidējo ūdens ietilpību 400%) īpatsvaru kompostā (1.tabula).
Kompostējot neapstrādātu nezāļu biomasu ar organiskās vielas saturu sausnā 12–14% kopā ar piedevu materiālu (zāğu skaidas, koku lapas) komposta K-1 maksimālā temperatūra sasniedza tikai 36 °C (2. tabula).
Mehāniski atdalot no nezāļu biomasas augsni, organiskās vielas saturs tika palielināts līdz 14–18% un sijātu nezāļu komposta K-2 temperatūra sasniedza 46 °C. Tvertnes pildījuma koeficients kompostiem K-1 un K-2 bija 0,8–0,85. Pilnīgi piepildot tvertni ar sijātām nezālēm vai zālāju apaugumu, kompostu K-3, K-4, K-5 un K-6 temperatūras pārsniedza 55 °C. Veicot maisījumu kompostēšanu rudenī, oktobra mēnesī, maksimālā temperatūra kompostā K-7 nepārsniedza 35°C. Pēc tvertnes stūru un jumta papildus siltumizolācijas, komposta K-8 temperatūra novembra mēnesī sasniedza 36 °C un starpība starp komposta maksimālo temperatūru un ārējo vidējo temperatūru palielinājās par 5 °C salīdzinājumā ar līdzīga sastāva komposta K-7 temperatūru oktobrī. Minētie novērojumi norāda, ka pie pietiekama siltumizolācijas slāņa biezuma (ne mazāk par 0,05...0.1 m) ir iespējama biomasu kompostēšanās procesu norise arī rudens mēnešos.

ISBN 9984 – 779 – 06 – 8

2.tabula

Nezāļu un zālāju apauguma kompostēšanas parametri

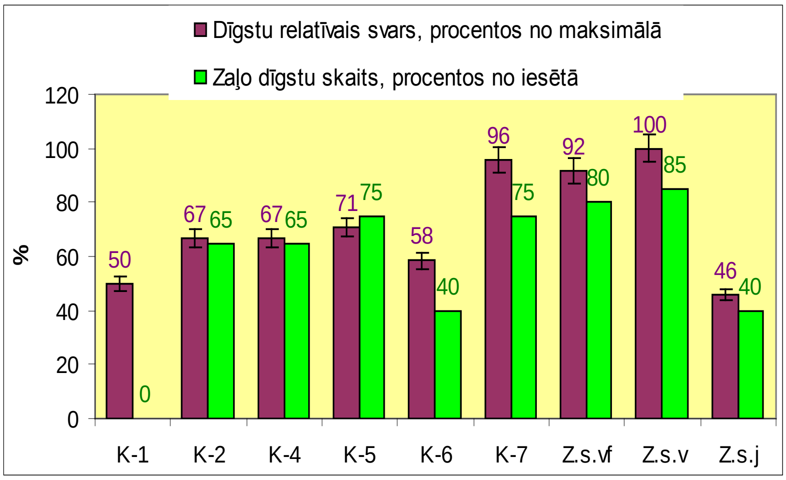
Komposta Nr.	Komposta sastāvs*	Kompos-tēšanas periods	Org. v. sausnā (sākums) %	Max. temp. °C	Temp. starpība Ti–Tā,°C	Piezīmes
K- 1	N85%+ Kl5% +Zs10%	21/06 30/06	12	36	15	Augsne nav atdalīta,
K- 2	N85%+Kl 5% +Zs10%	30/06- 16/07	15	46	25	Augsne daļēji atdalīta
K-3	N100%	16/07-30/07	17	55	36	Daļēji atdalīta augsne
K- 4	N100%	30/07-21/08	18	58	44	Daļēji atdalīta augsne
K-5	N100%	21/08- 16/09	18	63	52	Daļēji atdalīta augsne
K- 6	Za100%	16/09- 07/10	73	61	54	Samazināta aerācija, pelējums
K- 7	Za80%+Z s20%	07/10- 28/10	62	34	30	Zema ārējās vides temperatūra,
K- 8	Za80%+Z s20%	28/10-30/1	58	35	35	Pastiprināta termoizolācija

*N - nezāles; Kl – koku lapas; Za – zālāju apaugums; Zs – zāģu skaidas.

Izmēģinājumos ar nekodinātu kviešu sēklu dīgstiem noskaidrots, ka pēc 40 dienu kviešu dīgstu audzēšanas nokalta visi dīgsti substrātā, kas gatavots no nezāļu komposta ar maksimālo kompostēšanas temperatūru 36 °C un tai pašā laikā izdzīvoja 75% no iesēto graudu skaita substrātā, kas gatavots no komposta ar iepriekšējās kompostēšanas maksimālo temperatūru 63°C. Graudi, kuri tika audzēti komposta K-6 substrātā ir vāji attīstījušies, kā arī izdzīvojušo dīgstu skaits ir relatīvi neliels. To varētu izskaidrot ar komposta K-6 daļēji anaerobo kompostēšanas metodi, kuras rezultātā substrāts stipri iepelēja. Tātad kvalitatīva substrāta ieguvei, kompostēšanās procesam jānorit aerobā, ar gaisu pietiekami apgādātā vidē.
Kviešu sēklu dīgstu attīstība un saglabājamība aerobajā kompostēšanās procesā iegūtajā substrātā ir attiecīgi par 18% un 47% lielāka par dīgstu attīstību un saglabājamību daļēji anaerobajā kompostēšanas procesā iegūtajā substrātā ar lielu pelējuma sēnīšu saturu.
Kviešu graudi uzrādīja teicamu dīgstību un izturību pret slimību ierosinātājiem, ja tika iesēti zāģu skaidās, kuras agrāk bija apstrādātas ar slāpekļa minerālmēsliem un uzglabātas vairāku gadu periodā, kā arī, ja sēklas tika iesētas starp diviem 0,0005 m bieziem veco zāģu skaidu kārtām zālāju apauguma kompostā K-7 (sk. 4.attēlu) ar relatīvi zemu maksimālo iepriekšējās kompostēšanās temperatūru (35 °C). Var izvirzīt pieņēmumu, ka slāpekļa minerālmēslu klātbūtnē vairāku gadu periodā zāģu skaidas ir daļēji kompostējušās un tajās ir vielas, kuras aizkavē dīgstu sakņu saslimšanu ar augu slimībām. Bez tam komposta mikroorganismu darbības rezultātā rodas augu attīstību veicinošas bioloģiski aktīvas vielas.
Iesējot kviešu sēklas svaigās, ar slāpekļa minerālmēsliem neapstrādātās zāģu skaidās, novērojam vismazāko dīgstu sausnas pieaugumu, pie kam izdzīvojušo dīgstu skaits ir tikai 40% no iesēto graudu skaita. Tas ir izskaidrojams ar svaigo zāģu skaidu skābumu un augiem uzņemamo barības vielu trūkumu tajās. Lai samazinātu noteces no virtuves atlikumiem, ir ieteicama to kompostēšana kopā ar mitrumietilpīgajiem mājsaimniecības atlikumiem (pērno kūlu, apžāvētu zāli, salmiem, zāģu skaidām, koku lapām) pievienojot tos ne mazāk par vienu ceturto daļu no virtuves atlikumu masas. Siltumizolētu konteineru ar regulējamo pasīvo aerāciju izmantošana mājsaimniecības atlikumu kompostēšanai var nodrošināt „uzticama” un bioloģiski vērtīga komposta ražošanu, kā arī būtiski samazināt izgāztuvēs noglabājamo bioloģiski degradējamo

ISBN 9984 – 779 – 06 – 8

atkritumu daudzumu. Organisko atkritumu kompostēšana pietiekami augstā temperatūrā (50 - 60°C) nodrošina veselīgai augu attīstībai nepieciešamā organiskā mēslojuma ieguvi.



4.attēls. **Kviešu graudu dīgstu relatīvais svars un izdzīvojošo dīgstu skaits pēc 40 dienu audzēšanas perioda dažādu kompostu substrātos**

Secinājumi

1. Trīs gadu periodā vienā ģimenē (3 pieaugušie un 3 bērni) noteiktais vidējais virtuves atlikumu daudzums pilsētas apstākļos ir 62,2 kg uz vienu cilvēku gadā.
2. Noteiktā vidējā virtuves atlikumu masa ir 19% no svaigo produktu masas.
3. Virtuves atlikumu pamatkomponentu relatīvais mitrums ir robežās no 80 līdz 93%.
4. Virtuves atlikumu blīvums ir 550 - 600 kg/m^3, bet pēc trīs mēnešu aerobās kompostēšanas procesa blīvums samazinās līdz 400 – 450 kg/m^3.
5. Kompostējot virtuves atlikumus bez piedevu materiāliem vidē noplūst līdz 43,2% noteču no komposta svara, ja atkritumiem pievieno 10% mitrumietilpīgo materiālu noteces samazinās līdz 15,4%, un noteces netiek novērotas, ja virtuves atlikumiem pievieno 25% gaissausus mitrumietilpīgos materiālus ar vidējo ūdens ietilpību 300%.
6. Maksimālā temperatūra 1,2 m^3 siltumizolētā tilpnē sasniedza 36°C kompostējot nezāles, bet kompostējot nezāles, no kurām mehāniski atdalīta augsne, tā sasniedza 46 - 63°C.
7. Zālāju apaugumu kompostu maksimālā temperatūra vasaras mēnešos 1,2 m^3 siltumizolētā tilpnē sasniedza 58 - 63°C, bet rudens mēnešos (oktobrī novembrī) apauguma kompostu maksimālā temperatūra pazeminājās līdz 35 - 36°C.
8. Pēc 40 dienu audzēšanas nokalta visi nekodinātu kviešu sēklu dīgsti substrātā, kas gatavots no nezāļu komposta ar maksimālo iepriekšējās kompostēšanas temperatūru 36 °C un tai pašā laikā izdzīvoja 75% no iesēto graudu skaita substrātā, kas gatavots no komposta ar iepriekšējās kompostēšanas maksimālo temperatūru 61 °C.
9. Pēc 40 dienu audzēšanas nekodinātu kviešu sēklu dīgstu attīstība un saglabājamība aerobajā kompostēšanās procesā iegūtajā substrātā ir attiecīgi par 18% un 47% lielāka par dīgstu attīstību un saglabājamību daļēji anaerobajā kompostēšanas procesā iegūtajā substrātā ar lielu pelējuma sēnīšu saturu.
10. Ar slāpekļa minerālmēsliem apstrādātas zāģu skaidas pēc vairāku gadu kompostēšanas stirpās izmantojamas kā sēklu audzēšanas substrāts vai arī kā substrāta komponents.

Summary

Greenhouse gases emission can be partly limited by Kioto protocol coming in force since 16.02.2005, but fundamental prevention of global warming process can be achieved only by overall prevention of burning of fossil fuels as well as by limitation of burning of renewable biomass. For example, burning of yesteryear grass in fallows can cause emission of dioxins or other harmful gases, due to uncontrolled biomass firing at low temperature conditions.

ISBN 9984 – 779 – 06 – 8

Household wastes usage for compost production can save energy for production of mineral fertilisers and can to decrease the total amount of wastes deposited in landfills. Investigations are necessary to set proper mixture composition and to prevent leakages during composting process. Composting containers should be designed with volumes sufficient to contain all food scraps and bulking materials. Thickness of heat insulation layer for containers should be enough to provide compost temperature for elimination of weeds and pathogens. Household wastes (kitchen refuses, weed, grassland cutting, lake overgrowth, sawdust e.t.a.) composting in small containers with or without heat insulation layer were investigated. Kitchen refuses were composted in 0,022 and 0,2 m^3 volume containers without heat insulation layer and in 0,047 m^3 volume container having heat insulation layer made of foam plastic in thickness 0.075 m. Weed biomass composting (together with sawdust, leaves and grassland cuttings) was investigated in 1,2 m^3 container having heat insulation layer of foam plastic in thickness 0.05 m.

Weight of compost components were measured by scale with accuracy ±0,05 kg, for investigation of moisture and organic matter content scales with accuracy ±0,00002 kg were used and for leakage measurement scales with accuracy ±0,0005 kg was used. Compost maximal temperature and difference between outside and inside temperatures were measured. Growth rate of wheat sprouts was investigated by seeding of 20 grains per sample vessel containing compost after its composting in 1,2 m^3 container. Wheat grains were seeded also in 2 vessels having old sawdust and in one vessel having fresh sawdust. Wheat grains were not treated with etch, therefore impact of plant pathogens were foreseen. Weight of wheat sprout's biomass, number of perished and survived sprouts were registered for each of 8 sample vessel after 40 day growing period.

Investigations of family (3 adults and 3 children) during 3 year period appeared, that average weight of kitchen wastes produced was 62,2 kg per habitant in year (Fig.1). Kitchen wastes have high moisture content 70 – 90% and high density 500 – 600 kg/m^3. Investigated average weight of kitchen refuse was 19% of fresh product (Fig. 2). Weight of liquid leached from kitchen wastes was 43,2%, if the kitchen wastes were composted without additional material. Density of kitchen wastes without additives was 550...600 kg/m^3 in the beginning of composting period and density lowered to 350...400 kg/m^3 at the end of 3-month composting period (Fig.3). Leakage decreases to 15,4% of initial compost weight, if wastes were co-composted with 10% dry bulking materials (straw5% + sawdust5%). Leakage was not observed, if kitchen wastes were mixed with 25% lake rootfelt having average water absorptivity 400%. Maximal compost temperature was 46 °C, if kitchen wastes was composted in 0,2 m^3 container without heat insulation and maximal temperature was 53 °C, if kitchen wastes was composted in 0,047 m^3 container having heat insulation layer in thickness 0,075 m (Table 1).

Organic matter content rises from 12% for untreated weed to 15-18% for screened weeds having less soil particles. Organic matter content was 73% for dry overgrowth compost. Maximal temperatures in 1,2 m^3 container varies from 36 °C for weed's compost to 63 °C for screened weed's compost in summer period (Table 2). Maximal temperature in 1.2 m^3 container lowered to 35 °C during composting of grassland overgrowth in October. In a result of improvement of heat insulation, maximal compost temperature rises in November, compare to compost temperature in October, when container's roof was not provided with heat insulation layer. Couching of wheat grains, non treated with etch, in garden wastes compost substrates resulted in perishing of all sprouts after 40-day growing period in compost having maximal temperature 36°C during previously performed composting process. Percentage of sprouts survived in same period was 75%, if growing was provided in compost has been composted within maximal temperature 61 °C previously (Fig 4). Perishing of all sprouts in a low temperature compost can be explained due to less elimination of plant pathogens infecting sprouts. It is recommended co-composting of different household wastes in insulated containers to eliminate leakage, to keep proper moisture and temperature within whole compost medium. After composting period healthy growth substrate can be produced. Co-composting of household wastes widely can to reduce biomass deposition in landfills.

ISBN 9984 – 779 – 06 – 8

Literatūra

1. Amon, B., Amon,Th., Alt,Ch., Boxberger,J. Emission of NH_3, N_2O and CH_4 from milking cows in farmyard manure tying stall (housing, manure storage, manure spreading). Proceedings of the International conference "Trends in Agricultural Engineering". Czech University of Agriculture Prague, 1999, pp. 452-457.
2. Altman V. Model solution of salvage of biological share of the municipal Waste in the Czech Republic. Proceedings of the International conference "Trends in Agricultural Engineering", Czech University of Agriculture Prague, 1999, pp. 327-330.
3. Altrovs E. Komposts saudzē dabu un naudas maku. Žurnāls "Mājas & Dārzs", 2001, No. 11. 62-63 lpp.
4. Plume I. Pre-treatment of lake overgrowth. Proceedings of International conference **"**Traditions and innovations in sustainable development of society. Environment and society. Information technologies". Rēzekne, RA, 2002., pp.145–152.

ISBN 9984 – 779 – 06 – 8

BIOMASS AMOUNT RESEARCH IN BIOSORPTION PROCESS
BIOMASAS DAUDZUMA PĒTĪŠANA BIOSORBCIJAS PROCESĀ

VIKTORAS RAČYS, IRMANTAS VALŪNAS, DAINA KLIAUGAITĖ

Kaunas University of Technology, Department of Environmental Engineering
Radvilėnų pl. 19, Kaunas, LT-50254, Lithuania
Phone: + 370 37300182, *fax*: + 370 37300152, *e-mail*: Irmantas.Valunas@stud.ktu.lt

Abstract. *Rising environmental standards for treated waste water necessitates to improve current waste water treatment methods or to look for the new ones. Often this task is rather difficult because new or modified methods have to be investigated thoroughly and the main parameters for process modeling and effectiveness estimation have to be set. Biomass concentration in biosorption process is important technological parameter though there is no accurate technique for its estimation. Thermal dissociation technique to determine biomass concentration was developed as an alternative to the standard volatile suspended solids (VSS) method. Biomass content is important for the technological calculations of the system, estimation of the oxidation potential and for the evaluation of biomass growth in accordance to decomposed pollutants, etc. Thermal dissociation technique is based on the difference in the sorbent and biomass burn out temperatures. The biomass content research results are given for sand, gravel and for activated carbon BAS-A.*

Keywords: *biosorption, biomass amount, technological control, thermal technique.*

Introduction

One of the main technological parameters for the biological waste water treatment process control is the biomass amount variation during process time span. Biomass concentration is important for the technological calculations of the system, estimation of the oxidation potential and for the evaluation of biomass growth in accordance to decomposed pollutants, etc. Media of different types used in complex biological waste water treatment processes films over with biomass and it becomes difficult to estimate biomass content and present it using identifiable units. The agglomerate media - biomass (active sludge) makes it impossible to use common method for the biomass estimation. The problem is that the biomass cannot be properly separated from the media. Also small particles of the media in the sample of active sludge would determine substantial analysis errors.

In the scientific literature usually methods for approximate biomass estimation can be found. The fluorescence of a fermentation culture was studied for its application as an estimator of biomass concentration [1]. But it is difficult to estimate biomass concentration in identifiable units, like g/l. Many factors have influence to exactitude of the analysis: temperature, pH, medium chemical composition and cell activity. Other authors [2] developed technique to determine biomass concentration as chemical oxygen demand (COD) as an alternative to the standard volatile suspended solid (VSS) method. But even using very small amounts of sorbent for COD analysis, COD values are very high. That is why this method can not be used for control of biosorption process. The modified micro-Kjeldahl and Lawry method [3] is designed for estimating amounts of organic nitrogen and proteins in the sample. These two components are the main components in the living cell, so it is possible to estimate biomass concentration from the results of this method. However, this technique has following limitations: (1) total organic nitrogen is measured, not only that in the cells; (2) the method requires careful standardization for any particular application; (3) the colour is not strictly proportional to the concentration. German scientists try to work out this problem. A very promising way appears to be the impedance spectroscopy which enables a fast determination of the biomass concentration even at high optical densities [4]. It utilizes the properties of the membranes of living cells which exhibit a high polarization and contribute a significant amount of capacitance to the impedance. The different polarization states of the cell yields a characteristic curve of permittivity from which

ISBN 9984 – 779 – 06 – 8

the cell concentration can be derived. However this technology is in the initial stage yet and unique equipment is used. That is why another solution to solve this problem must be found.
The objective of our research was to develop and verify in practice accurate methodology for the determination of the biomass amount in the biosorption system, using fairly simple devices. The biomass amount in AC (active carbon), sand or gravel, and AS (active sludge) agglomerate - biologically activated system (BAS) - is the object of this research.
The research tasks are: 1) to determine thermal dissociation dynamics for active carbon A, sand and gravel in chosen temperature interval; 2) to determine thermal dissociation dynamics for active sludge in the same temperature interval; 3) to determine temperature points/intervals, when the mass of both components is unvarying; 4) to verify methodology in practice.

Materials and methods

The equipment needed for the experiment is muffle furnace, analytical scale, ceramic melting pots, desiccator. AC sample is dried for 1 hour at temperature 105 °C until the stable mass. Then AC is heated at: 200, 300, 400, 500, 600, 700, 800 and 900 °C temperatures. As too big mass changes were observed in temperature intervals 300-400 and 400-500 °C, these intervals were divided into smaller intervals and the temperature sequence for experiments was chosen: 200, 300, 350, 400, 430, 460, 500, 600, 700, 800 and 900 °C.
At each temperature AC is heated till stable weight is reached. Preparation and analysis of AS, sand and gravel is analogous to AC.

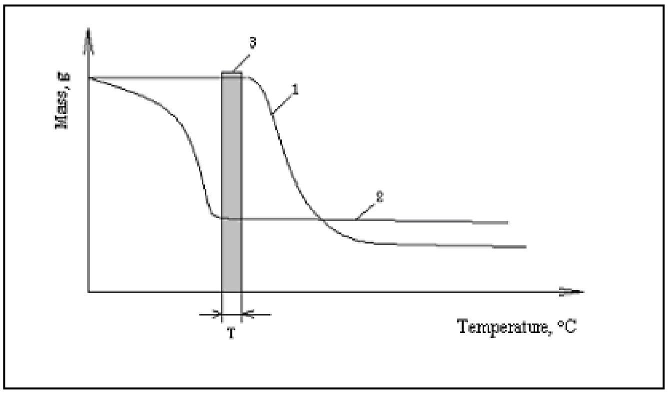


Fig. 1. **Theoretical thermograms: 1) thermogram of AC; 2) thermogram of AS; 3) the temperature range acceptable for agglomerate heating.**

Theoretical thermograms of activated carbon and active sludge are represented in fig. 1. The character of the thermograms of AC and AS was defined hypothetically, after preparative heating analysis. Their character was predicted before the experiment, i.e. it was premised that the curves would have three regions. These regions would represent temperature intervals when dissociation of both components does not take place, when dissociation takes place for both components and when both components are completely dissociated. The following model can be used to describe the dependency of dissociation and temperature:

$$\boxed{P(t) = \frac{A}{1 + e^{B \times (C - t)}}} \qquad (1)$$

Here A and B are the constants, t - temperature.

ISBN 9984 – 779 – 06 – 8

Results and discussion

The characters of plotted experimental data were analogous with the character of theoretical curves, fig. 2.

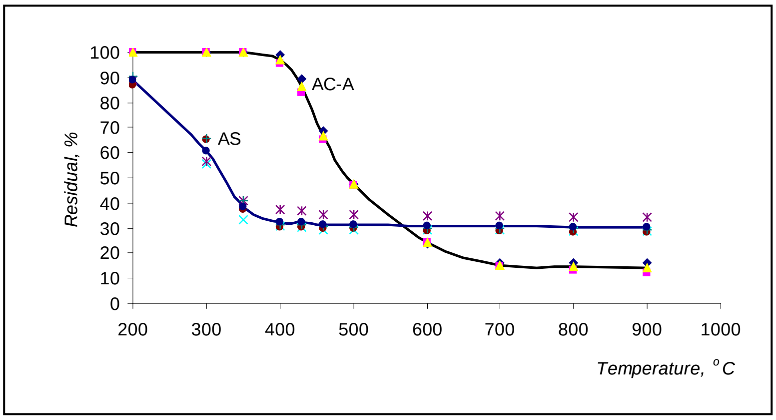


Fig. 2. **Experimental thermograms of AC-A and AS**

Mathematical dependencies for each component are:

For AC-A: $$P(t) = \frac{100}{1+e^{-1.5\times(5.1-t)}};\qquad (2)$$

For AS: $$P(t) = \frac{100}{1+e^{-1.7\times(3.2-t)}};\qquad (3)$$

The equation for the first region of curve of AC is:

$$y_1 = 3\cdot10^{-7}t^2 - 0.0002t + 100,\ R_1^{\,2} = 0.98 \qquad (4)$$

Where y_1 – residual of activated carbon, %, in temperature range 105-400 °C; t – temperature, °C.
The equation for the third region of curve of AS is:

$$y_2 = 2\cdot10^{-6}t^2 - 0.0045t + 31.93,\ R_2^{\,2} = 0.96 \qquad (5)$$

Where y_2 – residual of active sludge, %, in temperature range 350-900 °C; t – temperature, °C.
In every temperature, weight loss of active carbon A and biomass (%) is derived from 5 replicates. The values obtained at every temperature are similar within all 5 replicates, with the difference of ± 5 %. According to results, it can be assumed, that heated carbon A weight, calculated at different temperatures, is reliable and constant. Results are analogous with active sludge. These presumptions result in the following formulae that enable to calculate organic part of biomass in the sample:

$$m_{org} = m_{105}^{AS} - \alpha\cdot m_{900}^{AS}, \qquad (6)$$

Where m_{org} – organic part of biomass, g; m_{105}^{AS} - organic part of biomass in a sample after drying at 105 °C temperature, g; m_{900}^{AS} - residual of biomass (mineral part), after sample heating at 900 °C temperature, g; α - constant.

$$m_{105}^{AS} = m_{105} - D\times\frac{C\cdot m_{900} - m_{350}}{A - B\cdot C}, \qquad (7)$$

ISBN 9984 – 779 – 06 – 8

$$m_{900}^{AS} = \frac{m_{350}}{C} - \frac{B(C \cdot m_{900} - m_{350})}{C^2(A - B \cdot C)}, \quad (8)$$

Where $m_{105}, m_{350}, m_{900}$ - sample weight after heating at temperatures 105, 350 and 900 °C, respectively, g; *A, B, C, D* – constants.

By means of eqn (4) and (5) under accepted presumptions constants *A*, *C* and α can be calculated:

$$m_{105}^{AC} / m_{350}^{AC} = \frac{3 \cdot 10^{-7} \cdot 105^2 - 0{,}0002 \cdot 105 + 100}{3 \cdot 10^{-7} \cdot 350^2 - 0{,}0002 \cdot 350 + 100} = 1{,}002 \approx 1 = const. A, \quad (9)$$

$$m_{350}^{AS} / m_{900}^{AS} = \frac{2 \cdot 10^{-6} \cdot 350^2 - 0{,}0045 \cdot 350 + 31{,}93}{2 \cdot 10^{-6} \cdot 900^2 - 0{,}0045 \cdot 900 + 31{,}93} = 1{,}037 = const. C, \quad (10)$$

$$\alpha = \frac{m_{600}^{AS}}{m_{900}^{AS}} = \frac{2 \cdot 10^{-6} \cdot 600^2 - 0{,}0045 \cdot 600 + 31{,}93}{2 \cdot 10^{-6} \cdot 900^2 - 0{,}0045 \cdot 900 + 31{,}93} = 1{,}015 = const., \quad (11)$$

Constant *B* can be calculated using experimental data referring to presumptions mentioned above:

$$m_{105}^{AC} / m_{900}^{AC} = 6{,}580 = const. B, \quad (12)$$

Equation for constant *D* is get deriving eqn (7):

$$D = \frac{A \cdot B}{C}, \quad (13)$$

It must be stressed that the values of all constants are the same only for the same type of active carbon and active sludge.

The temperature range for thermal separation of AS and AC composite (BAS) can be apparently seen in the thermogram of active carbon and active sludge agglomerate, fig. 3. The first region of the curve (105-350°C) goes down because of dissociation of active sludge. The third region of the curve represents thermal dissociation of active carbon. The median horizontal region (350-400 °C) represents the range of temperature when the amounts of both components do not change, i.e. active sludge is dissociated already and thermal dissociation of active carbon has not begun yet.

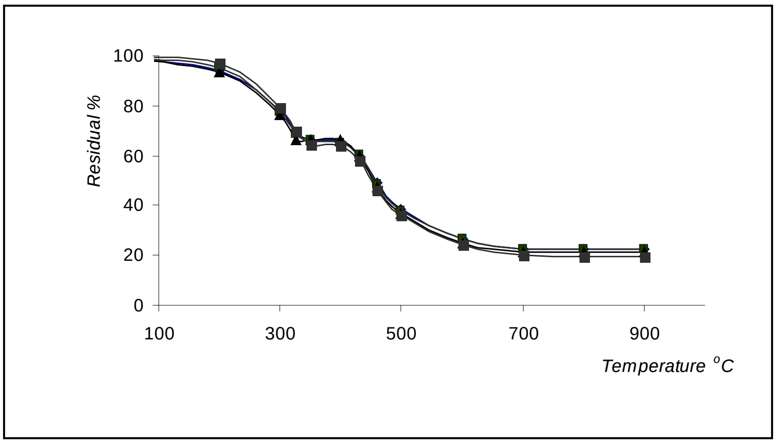


Fig. 3. **Thermogram of AC-A and AS agglomerate.**

It should be said, that all regions of all curves are arbitrary in conformity with experimental results.

In case of systems with sand or gravel (for example sand filters) biomass amount estimation is considerably simpler. The results of sand and gravel thermal dissociation are shown in fig. 4.

ISBN 9984 – 779 – 06 – 8

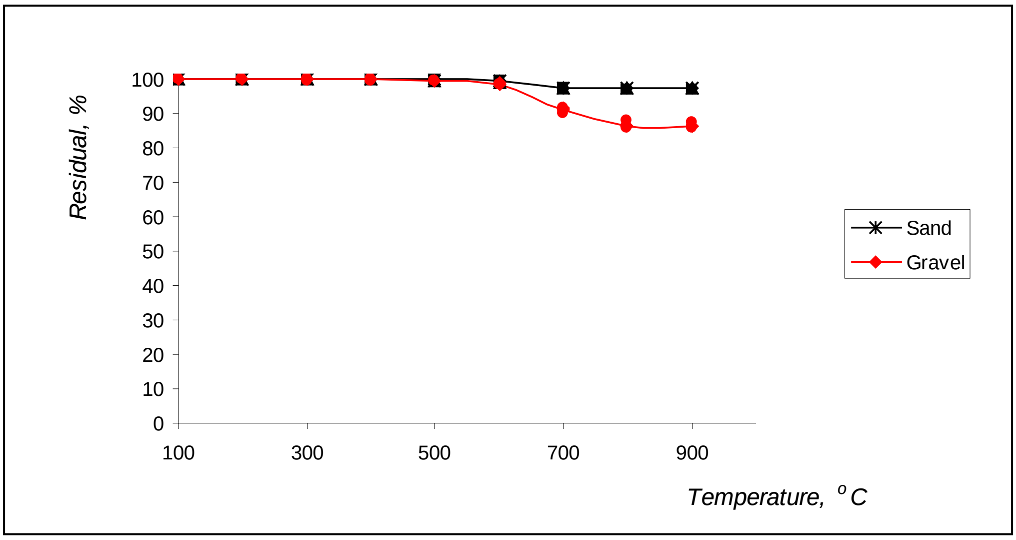


Fig. 4. **Thermogram of sand and gravel.**

It is evident that the mass of samples of sand and gravel remains almost the same in the temperature range 100 – 600 °C. The deviations from direct ratio of the burn out are inconsiderable, 0.70% and 1.40% for sand and gravel respectively. As this error does not exceed 5%, the thermal technique can be applied for the samples of sand and gravel without correction coefficients, i.e. after heating samples in 600 °C for two hours, the burnt out mass will represent organic part of the active sludge, which is responsible for the decomposition of organic pollutants.

Conclusions

1. It is experimentally proved that the heating process proceeds regularly. The relation between temperature and burnt out part of activated carbon at the temperature range 200-400 °C is strong and correlation coefficient is $R_1^2 = 0.98$. The relation between temperature and volatile organic part of active sludge at the temperature range 350 – 900 °C is strong and correlation coefficient is $R_2^2 = 0.96$.
2. The experimental research confirmed that organic volatile part of active sludge can be estimated after heating sample at the temperature of 350 °C. This value is used for calculating constants.
3. The ash content of the agglomerate active sludge - activated carbon is estimated at the temperature of 900 °C. This temperature is the final for heating samples.
4. Knowing weights of the samples after heating at the temperatures 105, 350 and 900 °C the organic part of biomass, the traditional (heated in 600°C) ash content of biomass and the mass of activated carbon in the sample can be estimated.
5. Organic volatile part of active sludge in the samples of sand and gravel can be estimated as mass difference after sample heating at the temperature of 600 °C. Correction coefficients are not calculated.

References

1. Zabriskie, D.W. & Humphrey, A.E., Estimation of fermentation biomass concentration by measuring culture fluorescence. *Applied and environmental microbiology*, 35(2), pp. 337-343, 1978.
2. Contreras, E.M., Bertola, N.C., Giannuzzi, L. & Zaritzky, N.E., A modified method to determine biomass concentration as COD in pure cultures and in activated sludge systems. *Water SA*, 28(4), pp. 463-467, 2002.
3. Sapan, C.V., Lundblad, R.L. & Price, N.C., Colorimetric protein assay techniques. *Biotechnology and applied biochemistry*, 29, pp. 99-108, 1999.
4. Hamburg – Harburg University of Technology (TUHH). Micro Systems Technology (former Semiconductor Technology) Web Site, Germany, http://www.tu-harburg.de/mst/english/forschung/muel_10.shtml

ISBN 9984 – 779 – 06 – 8

AUGU EĻĻAS KĀ IZEJVIELA DAŽĀDU VĒRTĪGU PRODUKTU RAŽOŠANAI

VEGETABLE OILS AS RAW MATERIAL FOR PRODUCTION OF SUITABLE PRODUCTS

RASMA SERŽANE, MAIJA STRĒLE, KRISTĪNE ZIHMANE, EMĪLIJA GUDRINIECE

Rīgas Tehniskā universitāte, Materiālzinātnes un lietišķās ķīmijas fakultāte,
Āzenes 14/24, Rīga, LV-1048, Latvija
Tālr.: + 371 7089220, *fakss*: + 371 7615765, *e-pasts*: mara@ktf.rtu.lv

Abstract. *Importance of vegetable oils in food industry is fast growing due to rising popularity of the wholesome food. Application of vegetable oils in different technical branches is connected with tendency to promote utilization of renewable raw materials and production of environmentally friendly products. Vegetable oils can be used for frying and salads as well as spices extracts, food additives, for massages, aromtherapy a.o. Wide field for utilization of vegetable oils is production of biodiesel fuel (fatty acid methyl- and ethylesters).*
Investigations about stabilization of pumpkin seed and oilseed pumpkin oils with BHT, ascorbylpalmitate and ascorbic acid were carried out. Investigations on oxidative stabilization of rape oil methyl- and ethylesters RME, REE (biodiesel fuels) with antioxidants at room and 60 ^{o}C temperature were carried out. Investigations about antioxidant properties of rosemary, basil and ginger extracts were carried out.

Keywords: *vegetable oils, rosemary extract, biodiesel fuel REE, RME, oxidative stability.*

Ievads

Pasaulē arvien vairāk rodas nepieciešamība pēc atjaunojamām izejvielām. Eiropas Komisijas pieņemtajā „*Baltajā grāmatā*” noteikts mērķis – līdz 2010. gadam divkāršot atjaunojamo izejvielu ražošanu.

Augu eļļas ir derīgas kā izejviela ļoti plaša spektra nozarēs. To nozīme pārtikas rūpniecībā pieaug sakarā ar strauji pieaugošo veselīga uztura popularitāti. Augu eļļas jau senatnē lietotas arī kosmētiskiem un ārstnieciskiem mērķiem. Tehnikas nozarēs uz augu eļļu bāzes tradicionāli ražo pernicas, smēreļļas. Pēdējā laikā, sakarā ar naftas resursu izsīkšanu un apkārtējās vides aizsardzības prasībām, arvien aktuālāka kļūst nepieciešamība pēc alternatīviem enerģijas resursiem.

Pieaugot transportam, krasi pieaug piesārņojuma līmenis atmosfērā, kura sekas jūtam jau šodien. Viens no alternatīvās enerģijas veidiem ir biodegviela, ko iegūst no augu eļļām. Biodīzeļdegvielu iegūst, eļļas pāresterificējot ar zemākajiem (metil-, etil-) spirtiem [1]. Tās iegūšana ir bezatkritumu process, jo radušies blakusprodukti – spraukumi, jēlglicerīns, nātrija vai kālija fosfāti – atrod plašu pielietojumu. Biodīzeļdegviela sniedz dubultu ekoloģisko efektu, t.i., gan izmantošanas zonas lokālajos mērogos, gan globālā mērogā, ierobežojot siltumnīcas efektu. Pastāv iespēja biodīzeļdegvielas ražošanai izmantot lietotas pārtikas eļļas vai to pārstrādes produktus [2]. Tas dod vēl papildus ekoloģisko efektu, jo šie produkti tiek izmesti kā atkritumi poligonos.

Pēdējā laikā liela vērība tiek veltīta hidraulisko šķīdumu, dzesējošo metālapstrādes šķidrumu, zāģeļļu u.c. smērvielu iegūšanai no augu eļļām [3]. Tās ir videi piemērotas smēreļļas, jo izgatavotas no atjaunojamiem resursiem, kas ātri noārdās, un kurām nav negatīvas iedarbības uz cilvēkiem, vidi un ekosistēmu.

Nākotnē paredzama augu eļļu, kā arī biodīzeļdegvielas blakusprodukta jēlglicerīna kā izejvielu avota izmantošana tādu polimēru ražošanai, kas ātri bioloģiski noārdās [4]. Rapšu spraukumus un salmus, tos briketējot, var izmantot cietā kurināmā ražošanai [5]. Augu eļļu katalītiskā krekinga rezultātā no tām var iegūt benzīnu [6].

Augu eļļu plašā lietošana pārtikā saistīta ar tajās esošo neaizstājamo taukskābju saturu, kā arī ar citu vērtīgu vielu – vitamīnu, antioksidantu u.c. klātbūtni.

ISBN 9984 – 779 – 06 – 8

Mūsu vairāk pētītās eļļas ir rapšu un linu, bet esam sākuši pētījumus arī par virkni citām augu eļļām [7]. Nosakot linu, kaņepju, ķirbju, magoņu, sarkanā āboliņa, vilkābeles sēklu un vīnogu kauliņu eļļu taukskābju saturu, redzams, ka tās satur daudz linol- un linolēnskābes (60-80 %). Tās ir neaizstājamās taukskābes, kas neveidojas cilvēka organismā un ir jāuzņem ar uzturu. Uzskata, ka linol- un linolēnskābes optimālās attiecības ir 70:30. Kaņepju eļļai šī attiecība ir tuva optimālai (74:26). Nepiesātinātās taukskābes viegli oksidējas eļļu glabāšanas laikā. Eļļu oksidēšanos var aizkavēt, lietojot antioksidantus. Rudzu un kviešu asnu eļļas ir dabiskā antioksidanta – E vitamīna – avots (~ 500 mg/100g), arī vīnogu kauliņu, ķirbju sēklu un riekstu eļļas ir bagātas ar antioksidantiem.

Esam veikuši rapšu, ripšu, linu un kaņepju eļļu stabilizēšanu ar antioksidantiem BHT (2,6-ditrešbutil-4-metilfenols), askorbīnskābi, askorbilpalmitātu. Oksidatīvās stabilitātes ziņā eļļas var sarindot: ripšu > rapšu > kaņepju eļļa, bet labākais antioksidants izrādījās askorbilpalmitāts un askorbīnskābe [7].

Pēdējā laikā lielu interesi izraisa dabīgo antioksidantu, piemēram, augu ekstraktu lietošana eļļu stabilizēšanai. Laba antioksidanta efektivitāte konstatēta salvijas [8], mārsmilgas, kalnumētras [9], sezama sēklu [10], propolisa ekstraktiem [11].

Rapšu eļļas metil- un etilesteri RME, REE, tāpat kā eļļas, ir pakļauti oksidēšanās procesiem, jo satur tās pašas taukskābes. Iepriekš [12] veikti stabilitātes pētījumi. Labākais antioksidants RME stabilizēšanai izrādījās askorbilpalmitāts 0,5 % no esteru masas.

Mūsu pētījumu mērķis bija turpināt dažādu augu eļļu, kuras satur daudz nepiesātināto taukskābju, kā arī rapšu eļļas metil- un etilesteru RME, REE stabilizēšanu, kā arī pētīt dažādu augu, kas satur dabīgos antioksidantus, eļļas ekstraktu antioksidantu īpašības.

Materiāli un metodes

Augu eļļu stabilitātes pētījumiem izvēlējāmies divu šķirņu ķirbju eļļas: ķirbju *Cucurbita pepo* un eļļas ķirbju *Cucurbita pepo L.* sēklu eļļas. Eļļas iegūtas SIA *DUO AG* ar auksto spiešanas metodi 40 °C temperatūrā. Tās ātri oksidējas, jo satur daudz nepiesātināto taukskābju (eļļas ķirbju eļļā – 83,8 %, ķirbju eļļā – 90,4 %). Ķirbju eļļa ir vērtīga eļļa, to nosaka augstais linolskābes saturs: eļļas ķirbju eļļā 35 %, ķirbju eļļā – 82,6 %. Kā zināms, tā ir polinepiesātinātā ω-6 neaizvietojamā taukskābe. Ķirbju eļļu lieto ārstniecībā iekaisumu, īpaši prostatīta, ārstēšanai.

Augu ekstraktu antioksidantu īpašību pētījumiem izmantojām rozmarīna, bazilika un ingvera ripšu eļļas ekstraktus. Šie augi satur dabiskos antioksidantus, un tos iespējams audzēt Latvijas klimatiskajos apstākļos. Ripšu eļļa ir piemērota garšaugu ekstraktu iegūšanai, jo tā ir bez specifiskas smaržas un garšas. Lietoti 0,5 % augu ekstrakti, rēķinot uz ripšu sēklu masu. Ekstrakti iegūti SIA *DUO AG* pēc īpašas tehnoloģijas [13].

Rapšu eļļas metil- un etilesteru RME un REE stabilizēšanai lietojām SIA *Delta Rīga* ražotnes RME un RTU laboratorijā iegūtus REE paraugus.

Kā antioksidantus lietojām BHT, askorbilpalmitātu un askorbīnskābi. Augu eļļām pievienojām 0,02 % antioksidanta, rēķinot uz eļļas masu, rapšu eļļas esteriem RME, REE – 0,5 % antioksidanta, rēķinot uz estera masu.

Paraugus gatavo: ķirbju eļļām un rapšu eļļas esteriem RME, REE antioksidantus BHT un askorbilpalmitātu izšķīdina 100 ml eļļas (estera), maisot 10 min 80 °C temperatūrā. Lai pievienotu askorbīnskābi ķirbju eļļām, to izšķīdina destilētā ūdenī (0,02 g askorbīnskābes 0,08 ml ūdens), pievieno eļļai un intensīvi maisa 10 min 60 °C temperatūrā. Sagatavotos paraugus, kā arī rozmarīna, bazilika un ingvera ripšu eļļas ekstraktus ielej 20 mēģenēs (5 ml), pievieno arī kontrolparaugu bez antioksidanta.

Oksidatīvo stabilitāti augu eļļām nosakām, uzglabājot paraugus paaugstinātā temperatūrā, lai paātrinātu tajos esošos oksidācijas procesus. Paraugus uzglabā termostatā 60 °C temperatūrā. Rapšu eļļas esteriem RME, REE oksidatīvā stabilitāte, pievienojot antioksidantus, 60 °C temperatūrā noteikta iepriekš [12]. Veicām salīdzinošus pētījumus, uzglabājot RME, REE istabas temperatūrā, noslēgtos stikla traukos, nepiekļūstot saules gaismai.

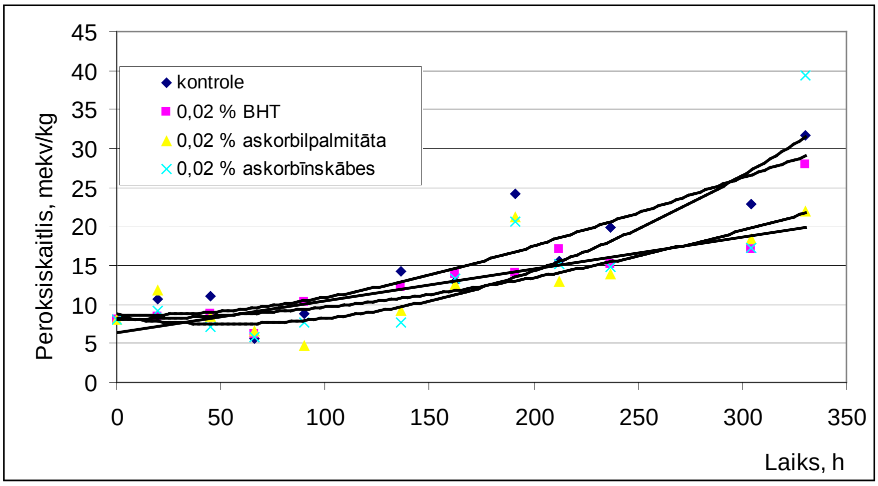
ISBN 9984 – 779 – 06 – 8

Paraugus analizējām, regulāri nosakot peroksiskaitli pēc ISO 3690 metodes un skābes skaitli pēc EN ISO 660 metodes. Augu eļļu un to esteru oksidatīvo stabilitāti raksturo indukcijas periods, kura laikā eļļai peroksiskaitlis ir ≤ 20, esteriem ≤50 mekv/kg.

Rezultāti un to izvērtējums

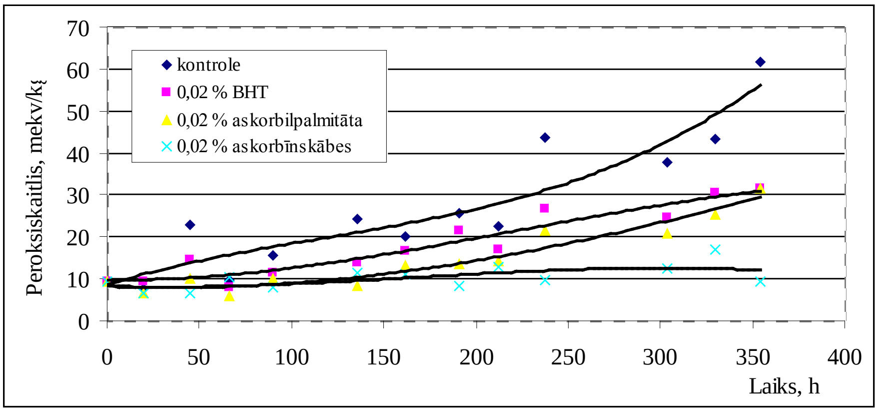
Ķirbju eļļas satur daudz nepiesātināto taukskābju, tādēļ mums likās interesanti noteikt to oksidatīvo stabilitāti. Iepriekš noteicām [7], ka ķirbju sēklu un eļļas ķirbju sēklu eļļas taukskābju saturs ir šāds: palmitīnskābe 9,5 % un 10, 2%; stearīnskābe – 0,1 un 6,0 %; oleīnskābe – 7,8 un 49,3 %; linolskābe – 82,6 % un 34,5 %. Eļļu oksidēšanu veicām 60 ^{o}C temperatūrā, jo temperatūrās, augstākās par 100 ^{o}C, notiek hidroperoksīdu sadalīšanās, līdz ar to peroksiskaitli nav iespējams noteikt [10].

Ķirbju sēklu eļļas stabilizēšanas rezultāti attēloti 1. att. Pievienoto antioksidantu iedarbība uz eļļu ir gandrīz vienāda: BHT – 1,3, askorbilpalmitāts –1,4 un askorbīnskābe –1,2 reizes pagarina eļļas oksidatīvās stabilitātes periodu.



1.attēls. **Ķirbju eļļas oksidatīvā stabilitāte 60 ^{o}C**

Eļļas ķirbju sēklu eļļas stabilizēšanas rezultāti redzami 2. att. Antioksidanti uz šo eļļu iedarbojas dažādi. BHT un askorbilpalmitāta piedeva palielina tās oksidatīvo stabilitāti 1,7 un 2,2 reizes, turpretī askorbīnskābe palielina eļļas stabilitāti 3 reizes, pie kam ar askorbīnskābi ir ļoti garš indukcijas periods – 350 stundās eļļas peroksiskaitlis nepārsniedz 12 mekv/kg. Salīdzinot ķirbju sēklu un eļļas ķirbju sēklu eļļas oksidatīvo stabilitāti bez antioksidanta piedevas, redzams, ka ķirbju sēklu eļļa ir gandrīz 2 reizes stabilāka par eļļas ķirbju eļļu, t.i., peroksiskaitli 20 mekv/kg tā sasniedz 225 stundās, bet eļļas ķirbju eļļa – 125 stundās.



2. attēls. **Eļļas ķirbju eļļas oksidatīvā stabilitāte 60 ^{o}C**

Pārbaudījām iegūto garšaugu ekstraktu antioksidantu īpašības. Garšaugu – rozmarīna, bazilika un ingvera ekstraktu iegūšanai kā bāzes eļļu izvēlējāmies ripšu eļļu, jo tā ir neitrāla eļļa, bez īpašas smaržas un garšas. Lai eļļa ekstraktu iegūšanas procesā nebūtu jākarsē, garšaugus

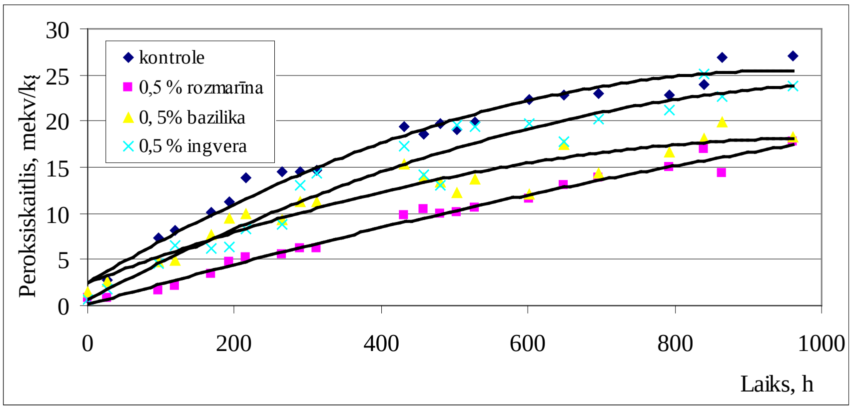
ISBN 9984 – 779 – 06 – 8

pievienoja ripša sēklām (0,5 % sausa auga uz sēklu masu) eļļas spiešanas procesā (*SIA DUO AG*).

Dabisko antioksidantu – rozmarīna, bazilika un ingvera – ietekmi uz ripšu eļļas stabilitāti skat. 3. att. Vislabākās antioksidanta īpašības uzrāda rozmarīns. Rozmarīna, bazilika un ingvera pievienošana ripšu eļļai palielina tās oksidatīvo stabilitāti 3, 1,8 un 1,5 reizes, attiecīgi.

Salīdzinot dabisko augu ekstraktu antioksidantu īpašības ar iepriekš lietotajiem BHT, askorbilpalmitātu un askorbīnskābi [7], redzam, ka rozmarīns ir 2 reizes efektīvāks antioksidants, kā askorbilpalmitāts, askorbīnskābe un BHT.

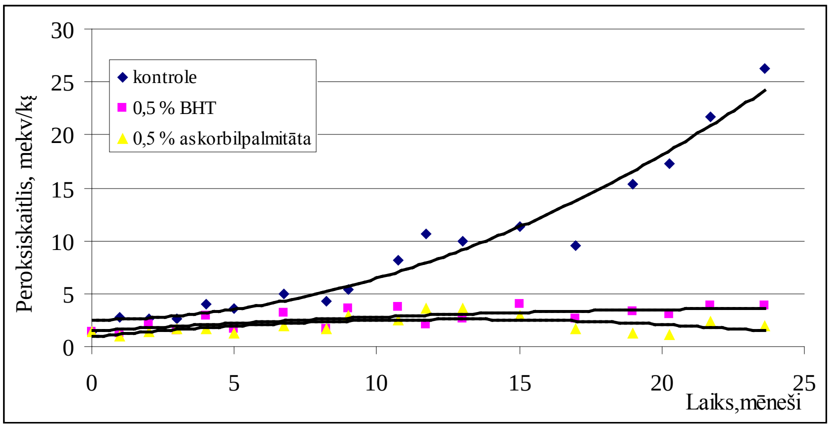
Ingveram ir tādas pašas antioksidanta spējas kā askorbīnskābei, bet bazilikam – kā askorbilpalmitātam.



3.attēls. **Rapšu eļļas oksidatīvā stabilitāte 60 °C**

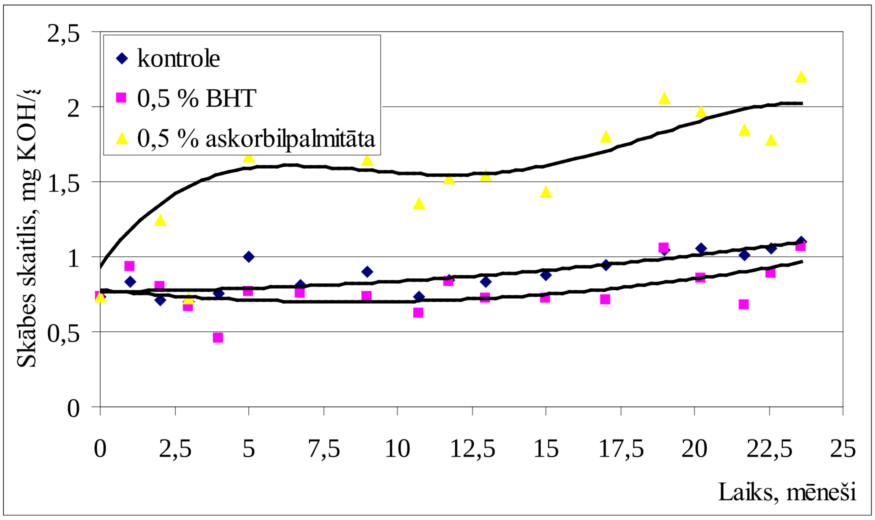
Iepriekš [12] ir noteikta RME un REE oksidatīvā stabilitāte paaugstinātā (60 °C) temperatūrā, pievienojot antioksidantus BHT un askorbilpalmitātu. BHT uzlaboja RME un REE stabilitāti, attiecīgi, 1,8 un 2,1 reizes, bet askorbilpalmitāts ~ 4 reizes. Šajos pētījumos RME un REE oksidatīvo stabilitāti noteicām, uzglabājot paraugus istabas temperatūrā 2 gadus un periodiski nosakot tiem peroksi- un skābes skaitļus. RME oksidēšanās pētījumu rezultāti istabas temperatūrā atspoguļoti 4. un 5.att.; redzams, ka oksidatīvās stabilizēšanas norise šādos apstākļos nedaudz atšķiras no paātrinātās oksidēšanas rezultātiem [12]. Istabas temperatūrā esteru oksidēšanās antioksidantu klātienē tiek aizkavēta efektīvāk – abu antioksidantu iedarbības rezultātā RME indukcijas periods praktiski nav beidzies – 2 gadu laikā peroksiskaitlis nepārsniedz 4 mekv/kg, kamēr bez antioksidanta piedevas RME straujāka oksidēšanās sākas jau pēc 18-20 mēnešiem.

Skābes skaitlis RME oksidēšanās procesos mainās maz, vienīgi askorbilpalmitāta klātbūtnē tas ir nedaudz paaugstināts – 1,5-2,0 mgKOH/g, kamēr RME bez antioksidanta un ar BHT piedevu ir robežās 0,5-1,0 - mgKOH/g.



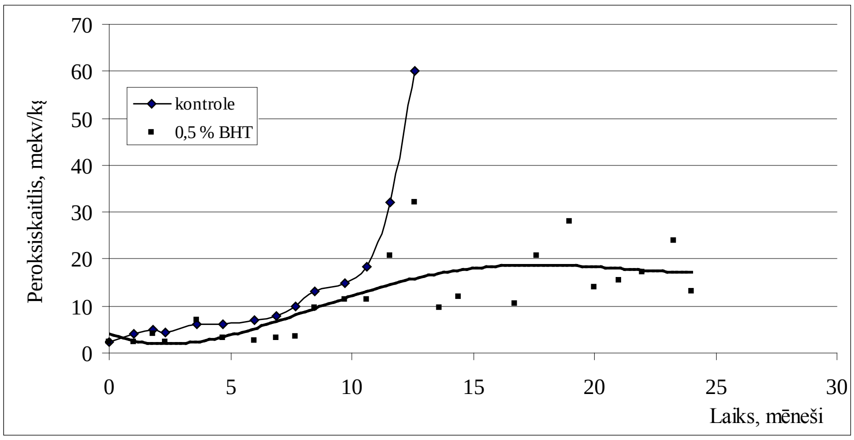
4.attēls. **RME oksidatīvā stabilitāte istabas temperatūrā**

ISBN 9984 – 779 – 06 – 8

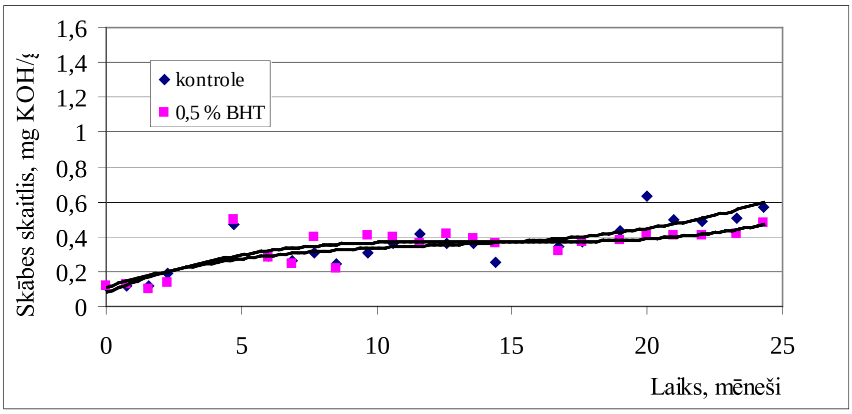


5.attēls. **RME oksidatīvā stabilitāte istabas temperatūrā**

REE oksidatīvās stabilitātes pētījumi istabas temperatūrā veikti, pievienojot antioksidantu BHT. Rezultāti atspoguļoti 6. un 7. att. Atšķirībā no RME, REE istabas temperatūrā bez antioksidanta oksidējas ātrāk, jau pēc 12 mēnešu uzglabāšanas notiek straujš peroksiskaitļa pieaugums. Indukcijas periods abiem paraugiem ir līdzīgs, t.i., ~ 12 mēneši, lai gan pēc tam BHT ietekmē oksidēšanās tiek efektīvi kavēta – 2 gadu garumā peroksiskaitlis praktiski nepārsniedz 20 mekv/kg.



6.attēls. **REE oksidatīvā stabilitāte istabas temperatūrā**



7.attēls. **REE oksidatīvā stabilitāte istabas temperatūrā**

ISBN 9984 – 779 – 06 – 8

Arī REE skābes skaitlis, līdzīgi kā RME, 2 gadu laikā bez antioksidanta, gan ar BHT piedevu mainās maz, robežās 0,3-0,6 mgKOH/g, kas ir vēl mazāks lielums, salīdzinot ar RME.
Salīdzinot REE stabilizēšanu, glabājot paraugus istabas un 60 ^oC temperatūrā, redzam, ka, tāpat kā RME stabilizēšanas pētījumos, istabas temperatūrā esteru oksidēšanās antioksidantu klātbūtnē tiek aizkavēta efektīvāk.
Pētījumu rezultāti rāda, ka antioksidanti BHT un askorbilpalmitāts stabilizē rapšu eļļas etilesterus RME un REE. Oksidēšanās procesa novērtējumu izmantotā pētījumu metode – stabilitātes noteikšana istabas vai paaugstinātā temperatūrā – būtiski nemaina.

Secinājumi

1. No augu eļļām iegūti produkti:
   - ķirbju sēklu eļļas (2 šķirnes), kas derīgas kā pārtikas piedevas ar ārstniecisku iedarbību,
   - ripšu eļļas garšaugu (rozmarīna, bazilika, ingvera) ekstrakti ar antioksidantu īpašībām, derīgi gan kā garšvielu ekstrakti, gan eļļu stabilitātes uzlabotāji,
   - rapšu eļļas metil- un etilesteri, derīgi kā biodīzeļdegviela.
2. Veikti ķirbju sēklu eļļas stabilizēšanas pētījumi. Atrasts, ka:
   - bez antioksidanta ķirbju sēklu eļļa ir stabilāka par eļļas ķirbju sēklu eļļu,
   - 0,02 % (masas %) BHT, askorbilpalmitāta un askorbīnskābes uzlabo ķirbju eļļas oksidatīvo stabilitāti 1,3, 1,4 un 1,2 reizes, bet eļļas ķirbju eļļas – 1,7, 2,2 un 3 reizes.
3. Veikti garšaugu ekstraktu antioksidantu īpašību pētījumi. Atrasts, ka labākās antioksidantu īpašības piemīt rozmarīnam. Rozmarīns uzlabo ripšu eļļas oksidatīvo stabilitāti 3, baziliks – 1,8 un ingvers – 1,5 reizes.
4. Veikti rapšu eļļas metil- un etilesteru RME, REE oksidatīvās stabilitātes pētījumi antioksidantu BHT un askorbilpalmitāta klātbūtnē, uzglabājot šos paraugus istabas temperatūrā. Atrasts, ka 0,5 % (masas %) antioksidantu piedeva nodrošina esteru stabilitāti ilgāk kā divus gadus.
5. Salīdzinot oksidatīvās stabilitātes noteikšanas metodes, uzglabājot paraugus istabas un paaugstinātā (60 ^oC) temperatūrā, atrasts, ka stabilitātes pētījumos veiksmīgi var lietot paātrināto metodi.

Summary

Following valuable products were obtained from vegetable oils:
- pumpkin seed oils (2 varieties), suitable as food additives with medicinal effect,
- colza oil extracts of rosemary, basil and ginger with antioxidant properties, suitable both as spice extracts and as antioxidants for oils,
- rapeseed methyl- and ethylesters, suitable as biodiesel.

Investigations stability of pumpkin seed oil were carried out. It was found, that:
- without antioxidant pumpkin seed oil is more stable than oil pumpkin seed oil,
- 0.02 % (m/m) BHT, ascorbylpalmitate and ascorbic acid improve oxidative stability of pumpkin seed oil 1,3, 1,4 and 1,2 times, but oilseed pumpkin oil – 1,7, 2,2 and 3 times, correspondingly.

Investigation of antioxidative properties of spices extracts was carried out. Rosemary improved oxidative stability of colza oil 3 times, basil – 1,8 and ginger – 1,5 times.
Oxidative stability of methyl- and ethylesters (RME, REE) of rapeseed oil in the presence of antioxidants BHT and ascorbylpalmitate was studied at room temperature. It was found, that 0.5 % (m/m) additive of antioxidants prologed stability of esters more than two years.
It turned out that results obtained by two methods of determination of oxidative stability – at room temperature and at elevated (60 ^oC) temperature – are similar comparable and the fast method (at elevated temperature) can be successfuly applied for investigation of stability.

ISBN 9984 – 779 – 06 – 8

Literatūra

1. Ballerini D., Hillion G. Methanolysis of vegetable oils. Actualite Chimique, 11-12. 2002, p.64-69.
2. Kumars S., Gupta A.K., Naik S.N. Conversion of non-edible oil into biodiesel. Journal of Scientific & Industrial Research, 62, No.1-2, 2003, p.124-132.
3. Norrby T., Kopp M. Environmentally adapted lubricants in Swedish forest industry – a critical review and case study. Industrial Lubrication & Tribology, 52. 2000, p.116-124.
4. Haasmaa K., Paronen T.P., Urtti A.O., Peltonen S., Heikkila M.E., Vuorenpaa J. Solventless hydrophobic biodegradable polymer dispossions, their manufacture and uses. Pat. WO 9749, 762 (31.12.1997).
5. Kronbergs E., Šmits M. Biomasu pētījumi kondicionēšanas procesu mehanizācijai. IV Starptautiskās zinātniski praktiskās konferences „Vide. Tehnoloģija. Resursi" materiāli. 26-28. jūnijs, 2003, RA: Rēzekne, 145.-149.lpp.
6. Furrer R.M., Bakhshi N.N. Catalytic conversion of tall oil and plant oils to gasoline range hydrocarbons using shape selective catalyst HZSM-5. Proc. of the Symposium „Energy from Biomass and Wastes", Chicago, 13-17 February, 1989, p.897-914.
7. Strēle M., Seržane R., Zihmane K., Gudriniece E. Investigations of the stability of vegetable oils. Vagos, Kaunas, 66, No.19, 2005 (in print).
8. Bandonienė D., Gruzdienė D., Venskutonis P.R. Antioxidant activity of sage extracts in rapeseed oil irradiated with UV-rays. Nahrung/Food, 2, No.45, 2001, p.105-108.
9. Kazernaviciute R., Venskutonis P.R., Gruzdienė D. Application of plant extracts and synthetic antioxidants for rapeseed oil stabilization. Food Technology and Quality Evaluation, 2003, p.203-208.
10. Suja K.P., Abraham J.T., Thamizh S.N., Jayalekshmy A., Arumughan C. Antioxidant efficacy of sesame cake extract in vegetable oli protection. Food Chem., No.84, 2004, p.393-400.
11. Nagai T., Inoue R., Inoue H., Suzuki N. Preparation and antioxidant properties of water extract of propolis. Food Chem., No.80, 2003, p.29-33.
12. Strele M., Serzane R., Zihmane K., Rabkevica S., Gudriniece E. Antioxidants in the stabilization of biodiesel fuels RME and REE. Proc. of the International Conference „New methods, means and technologies for applications of agricultural products", 18-19 October, 2003, Kaunas, p.43-46.
13. Poišs G. Vairākkomponentu augu eļļu ražošana ar aukstās izspiešanas paņēmienu. Pat. LV 13200 B (20.06.2004).

ISBN 9984 – 779 – 06 – 8

AR PRETUGUNS AIZSARGLĪDZEKĻIEM (ANTIPIRĒNIEM) APSTRĀDĀTAS KOKSNES TERMISKĀS DEGRADĀCIJAS ANALĪZE

THERMAL DEGRADATION ANALYSIS OF WOOD TREATED WITH FIRE-RETARDANTS

IGORS URBANOVIČS

Latvijas Valsts Koksnes Ķīmijas Institūts
Latvija, Rīga, Dzērbenes iela 27, LV 1006
Tālr.: + 371 7545142, *fakss*: + 371 7550635, *e-pasts*: gdobele@ edi.lv

PĒTERIS MEKŠS

Latvijas Valsts Universitāte, Ķīmijas Fakultāte
Latvija, Rīga, Kr. Valdemāra ielā 48, LV 1013
Tālr.: + 371 7377436, *fakss*: + 371 7378731, *e-pasts*: p.mekss@lu.lv

GAĻINA DOBELE

Latvijas Valsts Koksnes Ķīmijas Institūts
Latvija, Rīga, Dzērbenes iela 27, LV 1006
Tālr.: + 371 7545142, *fakss*: + 371 7550635, *e-pasts*: gdobele@ edi.lv

Abstract. *Fire hazard control in wooden constructions is very important. For this purpose, fire retardants are used, which change the thermodestruction of wood and reduce combustion.*
The aim of the present research project was to study and compare the fire–protective properties of fire-retardants and to explain the chemical process of pyrolysis, namely, degradation in treated and untreated wood.
The influence of fire-retardants on the wood thermal stability and the amount of volatile products was estimated on the basis of thermal analysis results. The volatile products (above 50%) of the pyrolysis process were identified, and the mechanism of the influence of fire-retardants on wood thermodestruction was studied.The presence of toxic compounds, formed by pyrolysis, was evaluated.
The results of the study have shown that analytical pyrolysis is a modern, precise method for identifying the toxic compounds of volatile products in processes of both wood pyrolysis and combustion.
The application of analytical pyrolysis enables a prompt determination of the fire protection degree of building wood constructions.

Keywords: *fire-retardants, wood, analytical pyrolysis, fast pyrolysis, products of pyrolisis.*

Ievads

Koksne, kā celtniecības materiāls, ir viegli apstrādājama, salizturīga, tai ir zema siltumvadītspēja un augsta rezistence pret daudziem ķīmiskiem reaģentiem. Taču koksnei ir arī trūkumi – neviendabīgums (anizotropisms), higroskopiskums (maina koksnes izmērus), spēja deformēties, plaisāt, pūt, degt. Koksnes paaugstināto degšanas spēju nosaka organiskais sastāvs. Lai pasargātu koksni no uguns iedarbības un mazinātu zaudējumus ugunsgrēku dēļ, plaši tiek pielietoti ugunsaizsargājošie sastāvi, kuru pamatā ir antipirēni [1].

Ugunsaizsargājošs efekts balstās uz dažādiem fizikāli – ķīmiskiem procesiem, kuri:
samazina koksnes uzsilšanas ātrumu;
termodestrukcijas mehānisma izmaiņām, kas ved uz koksa palieku palielināšanos un deggāzu izdalīšanās daudzuma samazināšanos;
antipirēni inhibē kondensētās un gāzes fāžu degšanu.

Ugunsaizsargājošiem sastāviem ir jābūt ar šādiem kritērijiem:
ar augstām ugunsaizsargājošām īpašībām;

- tie nedrīkst pasliktināt koksnes mehāniskās īpašības;
- tiem nav jāietekmē uznesamās lakas un krāsas;
- tie nedrīkst ietekmēt koksnes konstrukciju līmējamās vietas;

ISBN 9984 – 779 – 06 – 8

- tie nedrīkst būt indīgi un toksiski koksnei termiski sadaloties un degot.

Pateicoties pretuguns aizsarglīdzekļu pielietošanai, ir ievērojami samazinājušies ugunsgrēkos izraisītie materiālie zaudējumi un bojā gājušo cilvēku skaits.

Antipirēnu pielietošana dod lielu ieguldījumu koka konstrukciju pasargāšanā no uguns iedarbības, taču maz izpētīta ir to ietekme uz apkārtējo vidi. Svarīgi ir izpētīt kādas toksiskās vielas izdalās koksnes termiskās degradācijas procesā, kā arī salīdzināt apstrādātas un neapstrādātas koksnes termiskās degradācijas produktus. Rezultātā būtu iespējams sintezēt apkārtējai videi nekaitīgus pretuguns aizsargsastāvus.

Zināms, ka visu organisko materiālu degšanas pamatā ir pirolīze – materiāla termodestrukcija bez skābekļa klātbūtnes ar šķidro, gāzveida un cieto vielu veidošanos. Detalizēta pirolīzes procesa un gaistošo savienojumu izpēte var dot daudz informācijas par materiāla pārvērtībām ugunsgrēka laikā.

Koksnes ugunsaizsardzībai izmanto dažādus organiskos un neorganiskos savienojumus. Daudzu mūsdienās lietojamo antipirēnu sastāvā ietilpst fosforskābe un viņas sāļi. Tika veikti pētījumi, kuru rezultātā tika konstatēts, ka orto-fosforskābe veicina palielināta ūdens daudzuma izdalīšanos pirolīzes procesā [10]. Ir dati, ka koksnes gadījumā [10], kad tā ir impregnēta ar fosforskābes sāļiem, 2 – 3 reizes palielinās ūdens un karbonizēta atlikuma iznākums, pie kam degradācijas pamatprocesa maksimums tiek nobīdīts uz zemo temperatūru apgabalu.

Kā antipirēnus izmanto arī dažu sārmu metālu (K, Na) savienojumus un amonija sāļus. Šie savienojumi savādāk ietekmē koksnes termisko degradāciju. Termiskās degradācijas mehānisma pamatā ir ogļūdeņražu komponentu glikozīdu saišu saraušanas inhibēšana un lignīnu koksnes komponentu starpmolekulāro dehidratācijas reakciju katalīze. Karbonizētajā produktā šo reakciju rezultātā uzkrājas stabilas dubultsaites, samazinās pirolīzes šķidro gaistošo produktu daudzums un palielinās ogles iznākums.

Lai izpētītu koksnes gaistošo pirolīzes produktu sastāvu, darbā tika izmantota Latvijai unikāla metode - analītiskā pirolīze [2]. Šī metode pamatojas uz ātro pirolīzi (uzkarsēšanas ātrums – 600°C sekundē) un vienlaicīgu gaistošo produktu hromatogrāfisko analīzi. Ātrais pirolīzes process notiek inertās gāzes - nesēja plūsmā un reakcijas produkti tiek momentāli pārnesti ar nesējgāzi kolonā, kas ļauj būtiski samazināt otreizējo pirolīzes produktu pārvērtības. Realizējot šo ātro koksnes parauga uzkarsēšanu pirolītiskajā šūnā, var noteikt šķidro gaistošo produktu iznākumu 70 - 80%. Šo procesu praktiski var pielīdzināt koksnes sašķidrināšanai. Ātrā parauga uzkarsēšana un augstā detektora jutība ļauj eksperimentam izmantot ļoti mazus parauga daudzumus, kas, savukārt, pazemina difūzijas barjeras un ļauj pēc produktu sastāva raksturot pat niecīgas izmaiņas paraugos.

Dotā darba mērķis ir ar dažāda darbības mehānisma pretuguns sastāviem apstrādatas koksnes termiskās degradācijas procesa un pirolīzes gaistošo savienojumu sastāva izpēte, lai salīdzinātu to darbības efektivitāti un identificētu iespējamus toksikus pirolīzes produktus.

Materiāli un metodes

Materiālu sagatavošana.

Priedes koksnes paraugu sagatavošana:

priedes koksnes paraugu sagatavoja saskaņā ar LVS 238 – 99 “ Koksnes aizsarglīdzekļu testēšanas metodes” [4] prasībām. Izgatavoja taisnstūra brusas veidā ar izmēriem 150×60×30 mm. Koksnes parauga mitruma saturam jābūt (8 ± 1,5) %. Sagatavoto priedes koka paraugu sasmalcināja un samaļa. Izmantoja frakciju 0,1 mm.

Koksnes pretuguns aizsarglīdzekļu sagatavošana:

a) koksnes pretuguns aizsarglīdzekli “ FAP “ sagatavoja atbilstoši ražotāja SIA “ FIRMA LATAKVA “ tehniskajiem noteikumiem LV TN 000329664 – 03 – 02 [5];
b) koksnes pretuguns aizsarglīdzekli “ ВАНН - 1 “ sagatavoja atbilstoši ražotāja ZAS “ НЕОХИМ “ tehniskajiem noteikumiem TN 2332 – 001 – 35471523 – 97 [6].

ISBN 9984 – 779 – 06 – 8

Analītiskā pirolīze.
Pirolīzes process tika realizēts piroinžektorā " Pyrojector " SGE system. Pirolīzes process tika veikts pie 500˚C 15 sekundes. Pēc pirolīzes procesa kopā ar nesējgāzi hēliju pirolīzes produkti nonāca hromatogrāfa kolonnā. Gaistošo produktu noteikšanu veica izmantojot gāzu – šķidrumu hromatogrāfu " Agilent 6850 Series GC System ". Hromatogrāfa kolonna bija kapilāra tipa ar fāzi DB – 1701, tās garums bija 60 m ar diametru 0,25 mm. Nesējgāzes ātrums bija 32 ml/min. Hromatogrāfijas process tika veikts režīmā, sākot no 60˚C (4 minūtes noturēja doto temperatūru nemainīgu), tad temperatūru paaugstināja ar ātrumu 3˚C/min līdz tika sasniegti 270˚C, tad 10 minūtes noturēja doto temperatūru. Liesmas – jonizācijas detektora (FID) temperatūra - 280˚C, ūdeņraža plūsma – 30 ml/min, gaisa plūsma – 250 ml/min.
"Ātrā" pirolīze gaisa plūsmas klātbūtnē.
Koksnes paraugus sagatavoja analoģiski analītiskās pirolīzes procesam (aprakstīts 2.1 nodaļā). Vienīgā atšķirība - tika veikta visa sagatavotā materiāla tabletēšana. "Ātro" priedes koksnes pirolīzi veica vertikālā reaktorā ar gaisa plūsmu (ātrums – 5 l/min). Pirolīzes process bija realizēts reaktorā. Pirolīzes temperatūra – 340°C. Apstrādātas un neapstrādātas koksnes paraugus ievietoja uzkarsētā reaktorā. Izdalījušos kondensāta veidā gaistošos savienojumus savāca kolbā, kas pastāvīgi tika dzesēta ledus vannā. Kondensātu izšķīdināja acetonā un analizēja gāzu – šķidruma hromatogrāfā.
Termogravimetriskā analīze.
Termisko analīzi veica izmantojot derivatogrāfu – " DERIVATOGRAPH Q – 1500D " SYSTEM Paulik - Paulik – Erdey. Termiskās degradācijas process notika slāpekļa plūsmā, temperatūru intervālā no +20 °C - +1000°C. Temperatūras augšanas ātrums - 10°C/min, parauga iesvars – 0,1 g. Kā etalons izmantots līdz 1200°C pārkarsēts Al_2O_3.

Rezultāti un to izvērtējums

Ar pretuguns aizsarglīdzekļiem neapstrādātas un apstrādātas koksnes termiskā analīze.
Termiskās analīzes dati parāda, ka neapstrādātai priedes koksnei aktīvās termodestrukcijas process notiek 235 - 385°C temperatūru intervālā (3.1.tabula). Maksimālo ātrumu process sasniedz 340°C temperatūrā. Aktīvās termodestrukcijas procesā veidojošos gaistošo produktu daudzums sastāda 57% no kopējās parauga masas un to daudzums palielinās līdz 70,4% pie 500°C.
Salīdzinot ar neapstrādātu koksni, koksnei, kas apstrādāta ar antipirēniem termodestrukcijas maksimālais ātrums tiek sasniegts divās stadijās pie zemākām temperatūrām un ar mazākiem masas zudumiem. Karbonizētais atlikums, kas veidojas aktīvās termodestrukcijas procesā ir vairāk termiski stabils koksnei, kas apstrādāta ar antipirēniem. Temperatūrai sasniedzot 500˚C, apstrādātai ar antipirēniem koksnei kopējais gaistošo produktu daudzums samazinās un palielinās nedegošā karbonizētā atlikuma iznākums.

1.tabula

Neapstrādātas un ar antipirēniem „FAP" un „BAHH-1" apstrādātas priedes koksnes termiskās analīzes dati

Paraugs	Aktīvās destrukcijas sākums		Aktīvās destrukcijas beigas		Aktīvās destrukcijas max temperatūra	Masas zudumi pie 500˚C (%)	Pelni	
	t˚C	%	t˚C	%	t˚C	%	t˚C	%
Neapstrādāta koksne	235	2,1	385	59,1	340	70,4	900	0
FAP apstrādāta koksne	205	2,4	360	53,7	250, 310	69,7	875	3,1
BAHH apstrādāta koksne	225	2,6	375	52,1	265, 310	64,1	909	1,9

ISBN 9984 – 779 – 06 – 8

Ar pretuguns aizsarglīdzekļiem neapstrādātas un apstrādātas koksnes analītiskā pirolīze.
Izpētot analītiskās pirolīzes metodē identificēto gaistošo produktu sastāvu, kurā ietilpst kā viegli gaistošie gāzveida savienojumi, tā ogļūdeņražu un lignīna depolimerizācijas monomērie produkti, ir iespējams izsekot koksnes kompleksa ķīmisko saišu saraušanas mehānismiem.
Analītiskas pirolīzes rezultāti rāda, ka koksnes pirolīzes procesā izdalījušos gaistošo savienojumu sastāvā ietilpst visu triju galveno koksnes komponentu monomērie savienojumi – celulozes (hidroksiacetaldehīds, 1,6-anhidroglukosaharides-piranoze un - furanoze, oksimetilfurfurols, u.c.), lignīna (gvajakols un viņa atvasinājumi, karbonilsavienojumi) un hemiceluložu (furfurols, etiķskābe, formaldehīds) (3.2. tabula).
Ar antipirēniem apstrādātas koksnes pirolīzes procesā mainās gaistošo produktu sastāvs un daudzums. Antipirēna “ FAP “ ietekme analītiskās pirolīzes procesā izpaužas celulozes destrukcijas produktu daudzumu samazināšanā.

2.tabula

Neapstrādātas un apstrādātas ar antipirēniem koksnes analītiskās pirolīzes (inertā atmosfēra)/ „ātrās” pirolīzes (gaisa klātbūtne) aptākļos veidojošies gaistošie produkti

N.p. k.	Savienojuma nosaukums	Savienojuma izdalīšanās laiks (min)	Relat., vielu daudzumi neapstrādātai koksnei (%) *	Relat., vielu daudzumi FAP apstrādātai koksnei (%) *	Relat., vielu daudzumi BAHH-1 apstrādātai koksnei (%) *
1.	Oglekļa dioksīds	4,9	2,9 / 0	4,6 / 0	3,6 / 0
2.	Formaldehīds	5,2	1,5 / 0	2,8 / 0	0,6 / 0
3.	Metilspirts	5,6	0 / 0	0 / 0	0,3 / 0
4.	Hidroksi-acetaldehīds	7,8	23,4 / 0,1	8,4 / 0	4,0 / 0
5.	Etiķskābe	8,5	3,8 / 7,9	7,5 / 10,7	3,3 / 6,8
6.	Furfurols	16,9	2,6 / 1,7	2,9 / 3,2	4,2 / 2,5
7.	Gvajakols	30,7	3,1 / 2,1	8,7 / 7,7	2,7 / 2,2
8.	Levogliko-zenone	35,5	0 / 0,2	0 / 0	3,3 / 9,2
9.	Metilgvajakols	36,0	4,0 / 3,0	1,9 / 1,7	5,5 / 3,1
10.	1,4:3,6-dianhidrogliko-piranoze	41,8	0 / 0,3	0 / 0	1,1 / 2,4
11.	Etilgvajakols	42,8	0 / 2,1	0 / 3,8	3,4 / 1,5
12.	Oksimetil-furfurols	44,7	3,1 / 3,0	0 / 0	6,2 / 3,7
13.	1,6-anhidro-3-oksigliko-piranoze	46,7	0 / 0	0 / 0	1,9 / 0
14.	Trans-izoevgenols	49,0	3,7 / 0	3,8 / 0	3,2 / 0
15	Vanilīns	50,0	0,3 / 0	0,2 / 0	0,2 / 0
16.	Levoglikozāns	59,8	5,3 / 14,3	0 / 1,6	31,2 / 32,6
17.	1,6- anhidro-glikofuranoze	65,0	3,7 / 0	3,0 / 0	1,7 / 0
	Kopā:		57,4 / 34,7	43,8 / 28,7	76,4 / 64,0

* koksnes analītiskās pirolīzes (inertā atmosfēra) / “ātrās“ pirolīzes (gaisa klātbūtne) aptākļos veidojošies gaistošie produkti.

ISBN 9984 – 779 – 06 – 8

Hidroksiacetaldehīda daudzums samazinās no 23,4% līdz 8,4%, levoglukozāna un oksimetilfurfurola starp pirolīzes produktiem vispār nav. Gvajakola daudzuma palielināšanās un metilgvajakola daudzuma samazināšanās liecina par alkil – aril saišu saraušanas katalīzi lignīna struktūrā. Ugunsaizsargājošā sastāva "FAP" ietekmē koksnes pirolīzes gaistošo produktu sastāvā 1,5 reizes palielinās oglekļa dioksīda un toksiskā formaldehīda daudzumi. Antipirēna „BAHH – 1" darbības mehānisms ir savādāks, par ko liecina atšķirīgs gaistošo koksnes pirolīzes produktu sastāvs. Galvenās atšķirības izpaužas ogļūdeņražu komponentu sastāvā. Līdzīgi kā ar antipirēna „FAP" koksnes apstrādes gadījumā, gaistošo produktu sastāvā samazinās hidroksiacetaldehīda daudzums.

Apstrādātas ar antipirēnu „BAHH –1" koksnes pirolīzes gadījumā tiek izdalīti jauni gaistoši savienojumi – levoglukozenons, 1,4:3,6-dianhidrogluko-piranoze, 1,6-anhidro-3-oksigluko-piranoze, kuri neparādās neapstrādatas un apstrādātas ar antipirēnu "FAP" koksnes gadījumos. Šinī gadījumā gaistošo savienojumu sastāvā 6 reizes palielinās levoglukozāna (galvenais celulozes depolimerizācijas produkts, kura veidošanos katalizē celulozes apstrāde ar skābju reaģentiem) daudzums. Antipirēns „BAHH –1" rada mazāk būtisku ietekmi uz fenolu tipa savienojumu rašanos, kas ir lignīna galvenie destrukcijas produkti. Sevišķi jāpievērš uzmanību tam, ka apstrādātas ar antipirēnu „ BAHH –1" koksnes termodestrukcijas gadījumā gaistošo produktu sastāvā tika identificēts tāds toksisks savienojums ka metilspirts, savukārt formaldehīda veidošanās tiek inhibēta.

Ar pretuguns aizsarglīdzekļiem neapstrādātas un apstrādātas priedes koka "ātrā" pirolīze gaisa plūsmā.

Eksperimenti ar koksni "ātrās" pirolīzes apstākļos gaisa plūsmā tika veikti ar mērķi izpētīt gaistošo produktu sastāvu pēc iespējas tuvāk reāliem ugunsgrēka apstākļiem. Tieši "ātrās" pirolīzes apstākļi patiesi raksturo koksnes termodestrukcijas procesus ugunsgrēka laikā, jo ugunsgrēks ietver sevī dažādus attīstības posmus. Ugunsgrēka laikā novēro gan koksnes ilgstošu kvēlošanas periodu, gan straujās termodestrukcijas periodu - pirolīzi, kā arī beigu periodu – gaistošo produktu degšanu.

"Ātrās" pirolīzes procesā gaisa klātbūtnē netika identificēti jauni termodestrukcijas produkti un toksiski savienojumi (3.2. tabula). Līdzīgi kā analītiskās pirolīzes procesā, galvenie neapstrādātas koksnes ogļūdeņražu termodestrukcijas produkti "ātrājā" pirolīzē ir levoglukozāns, etiķskābe, oksimetilfurfurols, furfurols. Sakarā ar izmaiņām termodestrukcijas reakciju mehānismā, "ātrajā" pirolīzē neapstrādatai priedes koksnei palielinās levoglikozāna daudzums un proporcionāli samazinās hidroksiacetaldehīda iznākums. Tāpat kā analītiskās pirolīzes procesā, apstrādātas ar antipirēnu "FAP" priedes koksnes gadījumā "ātrājā" pirolīzē tika identificēti šādi ogļūdeņražu komponentu termiskās destrukcijas produkti – etiķskābe, furfurols. Lignīna galvenie termodestrukcijas produkti "ātrājā" pirolīzē ir gvajakols, etilgvajakols, metilgvajakols.

Apstrādātas ar antipirēnu "BAHH - 1" priedes koksnes gadījumā "ātrājā" pirolīzē tika identificēti šādi ogļūdeņražu komponentu termiskās destrukcijas produkti: levoglukozāns, levoglukozenone, etiķskābe, furfurols, oksimetilfurfurols.

Summary

The aim of this work was to investigate the composition of the volatile compounds obtained in the thermal degradation process of wood treated with fire-retardants of different mechanism of action so that to compare the efficiency of their action and to identify possible toxic pyrolysis products.

The data of thermal analysis show that the active thermodestruction process for untreated pine wood occurs in the range 235-385^{o}C. The process reaches its maximum rate at the temperature 340^{o}C. The amount of the volatile products formed in the active thermodestruction process is 57% from the total mass of the samples, and its amount increases up to 70.4% at 500^{o}C.

In comparison with the case of untreated wood, the maximum thermodestruction rate for fire-ratardant treated wood is reached in two stages at lower temperatures and with lower mass losses. The carbonized residue, which is formed in the active thermodestruction process, is more

ISBN 9984 – 779 – 06 – 8

thermally stable in fire-retardant treated wood. When the temperature reaches 500^{o}C, the total amount of volatile products decreases, while the yield of the non-flammable carbonized residue increases.

A study of the composition of volatile products, including both easy-to-volatile gaseous compounds, and hydrocarbon and lignin depolymerization monomeric products, by the analytical pyrolysis method makes it possible to investigate the mechanisms of the chemical bonds cleavage in the wood complex.

The results of analytical pyrolysis show that the composition of the volatile compounds released in the wood pyrolysis process includes the monomeric compounds of all three main wood components, namely, cellulose (hydroxyacetaldehyde, 1,6- anhydroglucosaccharides – pyranose and furanose, oxymethylfurfural, etc.), lignin (guaiacol and its derivatives, carbonyl compounds), and hemicellulose (furfural, acetic acid, formaldehyde).

In the pyrolisis process of fire-retardant treated wood, the composition and amount of volatile products changes. The effect of the fire retardant "FAP" in the analytical pyrolysis process manifests itself in a decreased amount of cellulose destruction products. Thus, for example, the diroxyacetaldehyde amount decreases from 23.4% to 8.4%, while levoglucosan and oxymethylfurfural are not observed at all among the pyrolysis products. The increase in the guaiacol amount and decrease in the methylguaiacol amount testify the cleavage of alkyl – aryl bonds in the lignin structure. As a result of the action of the fire-retardant formulation "FAP", the amounts of pyrolysiscarbonic dioxide and toxic formaldehyde in the composition of the volatile products of wood pyrolysis increase 1.5 times. This is typical for "FAP" fire-retardant formulations.

The fire-retardant "BAHH-1" action mechanism is different, which is testified by a different composition of wood pyrolysis products. The major distinctions manifest themselves in the hydrocarbon components composition. Similarly to the case of treatment with the fire-retardant "FAP", the amount of hydroxyacetaldehyde in the volatile products composition decreases.

In the case of the pyrolisis of wood treated with the fire-retardant "BAHH-1", new volatile compounds – levoglucosenone, 1,4:3,6-dianhydrogluco-pyranose, 1,6-anhydro-3-oxygluco-pyranose are identified. These compounds are not observed in the case of untreated wood and that treated with the fire-retardant "FAP". In this case, the amount of levoglucosan (the main product of cellulose depolymerization, whose formation is catalyzed by the treatment of cellulose with acidic reagents) in the composition of volatile compounds increases 6 times. The fire-retardant "BAHH-1" shows a pronounced action on the formation of phenol-type compounds, which are the main lignin destruction products. Special attention should be paid to the fact that, in the case of thermodestruction of the wood treated with the fire-retardant "BAHH-1", a toxic compound such as methanol is identified, while, in its turn, the formaldehyde formation is inhibited.

Fast pyrolysis of wood treated and untreated with fire-retardants in the air flow.

To investigate the composition of volatile products as possible closer to real fire conditions, experiments with wood upon fast pyrolysis in the air flow were conducted. Fast pyrolysis conditions directly characterize the thermodestruction processes in the case of fire, since a fire comprises different development stages, pyrolysis being the first stage.

The results of the study have shown that analytical pyrolysis is a modern, precise method for identifying the toxic compounds of volatile products in processes of both wood pyrolysis and combustion.

The application of analytical pyrolysis enables a prompt determination of the fire protection degree of building wood constructions.

ISBN 9984 – 779 – 06 – 8

Secinājumi

1. Pamatojoties uz termogravimetriskās analīzes rezultātiem, var secināt, ka apstrādājot priedes koksni ar antipirēniem "FAP" un "BANN-1", tiek panākts būtisks koksnes materiāla ugunsaizsargājošs efekts, kas balstās uz pirolīzes procesā izdalījušos degtspējīgo gaistošo savienojumu daudzuma samazināšanos un aktīvā koksnes termodestrukcijas posma novadīšanu zemākā temperatūru apgabalā.
2. Analītiskās pirolīzes rezultāti parāda, ka apstrādājot koksni ar antipirēniem, tiek izmainīts koksnes pirolīzes mehānisms, kā rezultāta palielinās toksisko savienojumu daudzums gaistošos produktos. Apstrādes ar antipirēnu „FAP" gadījumā 1,5 reizes palielinās formaldehīda daudzums, bet "BANN-1" gadījumā formaldehīda daudzums samazinās salīdzinot ar neapstrādatas koksnes, taču nedaudz palielinās metilspirta daudzums.
3. "Ātrās"pirolīzes procesā salīdzinājumā ar analītiskās pirolīzes datiem netika dentificēti jauni toksiski savienojumi.
4. Analītiskā pirolīze var būt kā mūsdienīga, precīza metode gaistošo produktu toksiskosavienojumu noteikšanā kā koksnes pirolīzes, tā degšanas procesos. Izmantojot analītisko pirolīzi var ātri noteikt celtniecības koka konstrukciju ugunsaizsardzības pakāpi.

Pateicības

Izsakām pateicību Latvijas Valsts Koksnes Ķīmijas Institūta Lignīna Ķīmijas laboratorijas pētniecei Vilhelmīnei Jurkjānei.

Literatūra

1. Soburs S.V. Celtniecības materiālu un konstrukciju ugunsaizsardzība. Maskava, Spectehnika, 1999, 106.
2. Dobele G., Rossinskaja G., Telysheva G., Meier D., O. Faix. Cellulose dehydratation and depolymerization reactions during pyrolysis in the presence of phosphoric acid. J. of analitytical and applied pyrolysis. New York, Elsevier Science B.V., 1999, 307-317.
3. Thomas P. Wampler Practical applications of analytical pyrolysis. J. of analitytical and applied pyrolysis. New York, Elsevier Science B.V., 2004, 71, 1-12.
4. Latvijas Standarts. " Koksnes aizsarg-līdzekļi. Testēšanas metodes. LVS 238, 1999, VSIA Latvijas Standarts, 8.
5. Dobele G., Dizhbite T., Rossinskaja G., Telysheva G., Meier D., Radtke S., Faix O. Pre-treatment of biomass with phosphoric acid prior to fast pyrolysis A promising method for obtaining 1,6-anhydrosaccharides in high yields. J. of analitytical and applied pyrolysis. New York, Elsevier Science B.V., 2003, 68-69, 197-211.

ISBN 9984 – 779 – 06 – 8

METHODOLOGICAL BASIS OF CONTROL NETWORK MODERNISATION IN HUGE HYDROTECHNICAL STRUCTURES
LIELU HIDROTEHNISKO OBJEKTU VADĪŠANAS TĪKLU MODERNIZĀCIJAS METODOLOĢISKĀ BĀZE

JANINA ZACZEK-PEPLINSKA

Institute of Applied Geodesy, Warsaw University of Technology,
Plac Politechniki 1, 00-661 Warsaw, Poland, *e-mail*: j.peplinska@gik.pw.edu.pl

Abstract. *Water dams are typical structures which require cyclic and in some cases, permanent control of their conditions. Most of the Polish damming structures are more than fifty years old and funds assigned for their renovation and effective conservation are being continuously reduced. Therefore, it is vital to improve the control of those structures.*

Cyclic geodetic measurements of movements are obligatory elements of control measurement schedule and are important for evaluation of damming structures security. Complex modernisation of geodetic network for movement examination consists of many actions, which goals are:

- *Reactivating devastated network structure,*
- *Modernisation of geodetic process of structures movements determination (concerning steps: measurements and data elaborating),*
- *Enhancing the accuracy of geodetic measurements,*

Increasing a credibility of the movement measurements results.

Keywords: *engineering-industrial geodesy, controls survey of dams, geodetic network, water dam.*

Introduction

Water dams are typical structures which require cyclic and in some cases permanent control of their state. Most of the Polish damming structures are more than fifty years old and funds assigned for their renovation and effective conservation are being continuously reduced. Therefore, it is vital to improve the control of those structures.

In Poland exist 174 water damming structures, which are classified into the 1st and 2nd classes (water damming above 10 m), according to the obligatory classification of importance; their catastrophe would result in considerable material losses and would cause threat to health and life of many people [8].

The age of constructions, as well as the influence of the natural forces, is the crucial factors of water-buildings devastation, which are frequently additionally enhanced by insufficient examination of the geodetic or hydrologic foundations, designers' mistakes, poor quality of building execution, inconsequent realisation of river development programmes and delays in renovation.

Present state of geodetic control

Geodetic control networks for the needs of movements examination.

Cyclic geodetic measurements of movements are obligatory elements of a control measurement schedule and are important to evaluate damming structures security. During the first stage of the movement determination process for a given object a network of control points is established in the course of construction, which is then observed using surveying methods (measurements of angles, distances and elevations) within the entire period of operations performed by the object. Co-ordinates of those points are determined in an external reference system which is independent on conditions of the investigated structure [2], [4].

The term „geodetic network" is very wide and covers: points of the network (their location, construction and equipment), geometric elements of the network (measured angles, directions, distances, differences in elevation), measurement technology and methods of presentation of results.

ISBN 9984 – 779 – 06 – 8

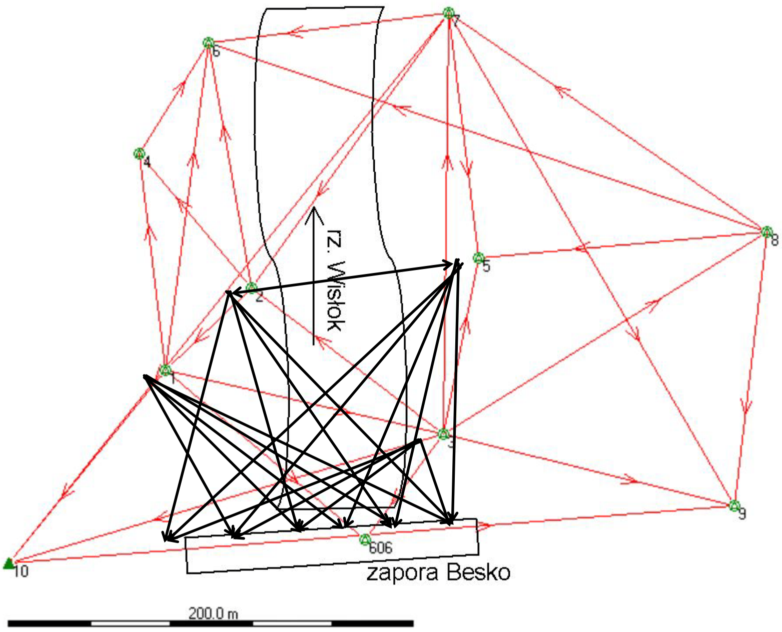


Fig. 1. **A conventional geodetic control network**

a) b)

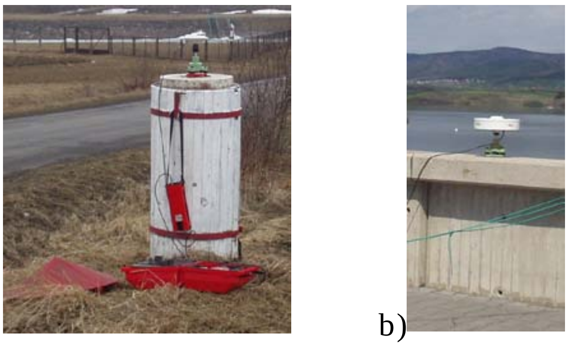


Fig. 2. **Construction of points in a geodetic control network (during GPS survey):**
a – a reference point, b – a point on a copping of the water damming object

Suggestions how to solve a problem

Modernisation of a control network.

The term "modernisation of a geodetic control network" should be understood as re-designing and adaptation of the existing network to current needs and utilisation of that network for an object, which plays its roles related to economy, flood protection, tourism, recreation and sport.

In the process of modernization method of measurements are adapted to requirements of modern technology, which will be applied in the modernised network.

Experiences from the past object monitoring should be considered in the process of modernisation.

Necessity to modernise the control network.

The necessity to modernise the control network may result from:

a) degradation of the network (damaging the network in time),
b) economic factors:
   – connected with costs of the network maintenance,
   – connected with costs and time required by performed measurements,
c) introduction of new technologies of measurements (such as GPS),
d) development of communication possibilities between various measuring instruments and the controlling unit,

ISBN 9984 – 779 – 06 – 8

e) the necessity to increase the accuracy of geodetic measurements.

Objectives of the control network modernisation.

The basic objectives of the network modernisation are:

- reactivating devastated network structure,
- modernisation of geodetic process of structures movements determination (concerning steps: measurements and data elaborating),
- increasing credibility of the movement measurements results.

Advancement of the control network modernisation.

Advancement of geodetic modernisation depends both on needs and financial as well as technical possibilities of the owner and users of the object. The network modernisation may include:

- Modernisation of one of the network elements, e.g. change in network geometry, rising the efficiency standard of measurement process, creating new computational algorithm, considering additional measurement data;
- Updating many, mutually connected elements of the movement analysing process (e.g. measurement technology and computing of movements data);
- Adding new elements to the existing network – e.g. expanding the network by adding new points, measurement gauges, considering additional measurements and/or new methods of control of measurement reliability.
- In the case of general overhaul and reconstruction of an structure, complex modernisation may be performed, which can include all above aspects.

Assumptions for the process of modernisation.

Modernisation does not mean creating the network from the very beginning; therefore it should be based on the following assumptions:

- Introduction of only those changes which are required, considering the lowest possible financial inputs,
- Widening the measuring process with geometric data collection, as, for example, with the use of feeler gauges, inclinometers and other, non-geodetic data, such as hydrological data (indications of piesometers, volumes of filtration etc.), for the control purposes, in order to increase the reliability of measurement results. In the case of the Automated System for Technical Control of Water Dams (Polish abbreviation ASTKZ) new points should be introduced to the network, which will allow to connect geodetic measurements with hydrotechnical and geometrical measurements, which are performed locally (relative measurements, not referred to an external reference system),
- In the future successive network modernisation should be possible, connected with the use of new measurement technologies and new methods of elaboration of measurement results.

Limitations for geodetic network modernisation.

The basic limitations in the process of modernisation:

a) resulting from location and methods of stabilisation of points of geodetic networks and from distribution and types of gauges used for non-geodetic measurements,
b) resulting from the specific features of construction of hydro technical structures,
c) geologic conditions which occur around the structure,
d) connected with real estate property rights (which mainly concern areas surrounding the structure, where new network points are to be located),
e) resulting from the nature conservation regulations, concerning assurance of required visibility between network points,

ISBN 9984 – 779 – 06 – 8

f) in location of new points, resulting from location of living-and-social facilities of an structure, as well as location of housing and industrial areas within surrounding areas (which are often centres for tourism, recreation and water sports),
g) financial, connected with the amount of funds assumed by owners of an structure for modernisation of the network.

Introduction of satellite measurements technology during the geodetic network odernisation.
More than 10 – 20 years have passed from the beginning of construction/ exploitation of the majority of water damming objects. One should also remember about historical objects, which were constructed 100 – 150 years ago or more; which survived after the war and which exist and are currently used, what is economically justified. Cyclic monitoring must also be performed for unused historical structures (for example after the change of the river course), considering their size, in order to ensure security of their constructions.
New measurement technology has become available since the moment of designing and implementation of control networks for those structures; this concerns, in particular, satellite methods (which use signals emitted by satellites of the following systems: GPS -Global Positioning System, GLONASS and GALILEO). Besides their advantages concerning simplicity and speed (GPS RTK – Real Time Kinematic) of measurements, as well as lower constraints concerning point location (no necessity to maintain visibility), the possibility to increase the network scope without the necessity of higher inputs for obtaining comparable accuracy, those methods have also limitations, for example long observation time required for high accuracy (GPS Static), limitations concerning the place of measurements: free horizon, low density of houses and other constructions, location of points far from power supply lines, from axes of radio links, telecommunication masts etc. [1], [6].
Possibilities of performing satellite measurements were not taken into consideration when the existing control networks were designed; points of those networks are often located close to emitters, which cause breaks or disturbances of received signals or they are located at such places where the required horizon is not ensured, for example on steep slopes (this problem occurs mainly in mountainous areas). Sometimes network points are located close to rich vegetation without the possibility to cut it out (this concerns structures located within Landscape or National Parks and within their protection zones).
Another issue concerns location and methods of stabilisation of measuring symbols on a given structure. Besides copping of water dams, where satellite measurements do not cause any troubles, technical elements of sluices, bottom reservoirs, power supply stations are also controlled. In such places there is often no possibility to perform correct satellite measurements as it is impossible to introduce points to a network.
In the process of development and adaptation of the control network to satellite measurements, apart of assuring the geologically stable foundations for points, particular attention should be paid to appropriate construction of points (devices for forced centering), as well as to assurance of the full and uncovered horizon for satellite observations and to lack of radio waves emitting installations located close to the network points (sources of disturbances of satellite signals).

Anticipated issue

Consideration of non-geodetic data in the process of movements examination.
Besides measurements of the geodetic control network, relative measurements are performed for each object, which determine for example changes of inclination to the horizontal plane and deflections of constructional elements from the vertical line, as well as changes of width of expansion joints. Besides those typical geometric values, hydrological data, as well as current information concerning external and internal conditions of an structure, are also registered (temperature and humidity of the air). The majority of sensors are located in control galleries (inside embankments).

ISBN 9984 – 779 – 06 – 8

Fig. 3. **A typical control gallery of a water damming structure**

Possibility of control of geodetic measurements of movements basing on additional data.
Additional data used in the process of control of geodetic measurements may include:

- results of levelling (for the control of measurements of horizontal networks),
- geometric data (acquired from relative measurements performed with the use of such instruments as feeler gauges, inclinometers etc.
- data from gauges and direct registering units, e.g. hydrological data, (indications of piesometers) and from units registering external conditions (i.e. temperature and humidity).

Additional geometric data allow to determine foreseen direct relations, for example: the change in elevation will influence the oblique distance between points, the change of the width of an expansion joint may be disclosed in the value of observed angles and distances in the network, between points located in concrete block of adjacent sections of the construction [7].
Data from geotechnical and hydrological gauges and registering units (changes in indications in the period which directly precedes control measurements and forecasts based on performed interpretation of measurement results for the past multi-year periods), may be used for determination of the so-called areas of uncertainty – geodetic measurements of points located within those areas should be performed with particular attention and it should be repeated, if there is no confirmation of changes in additional data. It should be pointed that such confirmation cannot be the condition of continuation of measurements – the nature of data registered by the discussed gauges differs from the nature of data acquired from geodetic measurements and those data cannot be considered at the same level of reliability. Additional data should be considered as control data only at the level of initial, field elaboration of measurement results.
Consideration of additional data in the process of elaboration of results of geodetic network measurements.
Consideration of additional data should be performed by means of implementation of a calculation module, which uses geometric and non-geodetic data in the process of geodetic data control, besides routine results of measurements of a horizontal geodetic network.
Basing on long-term measurements, external (e.g. atmospheric) conditions, the current structure conditions (e.g. the water level in the reservoir) and current measurement data, the calculation module (which ensures additional data control, besides the currently applied control) would generate conclusions concerning modifications of plans of performed measurements.
Data control should be performed at the time when measurements are performed (if the measuring equipment allowing for the current transfer, storing and analysis of measurement data is available) or directly after completion of measurements, before the working team completes its visit to the structure (the initial field checking), in order to allow repeating or amending performed observations with additional elements (angles, distances) [7].
Increase of reliability of geodetic measurements.
Possibility to detect erroneous observations requires supernumerary observations which ensure information surplus of the system with respect to determined parameters.
The higher the reliability level, the lower the probability that outstanding observations are not detected and that they will be used in the process of determination of unknowns, what would lead to deformations of their values [5].

ISBN 9984 – 779 – 06 – 8

Modernisation of the geodetic control network and amendment of measurement results elaboration by attaching the analysis of additional data will increase the reliability in the so-called, wide context, which includes various "practical" aspects of measurement technology (e.g. qualifications of personnel, periodic control of measuring instruments, introduction of corrections due to disturbing external influences). Improvement of the field checking elements will increase the reliability of geodetic measurements. For the higher number of performed control activities, based on experiences from various engineering fields (geodesy, hydrotechnology, geotechnology in the discussed case), this will result in higher trust of recipients of measurement results.

Checking, which is based on data registered within the period preceding the periodic geodetic measurements, which considers the existing and forecasted trends of changes, may contribute to elimination of gross errors, and thus, to increase the reliability of the geodetic network.

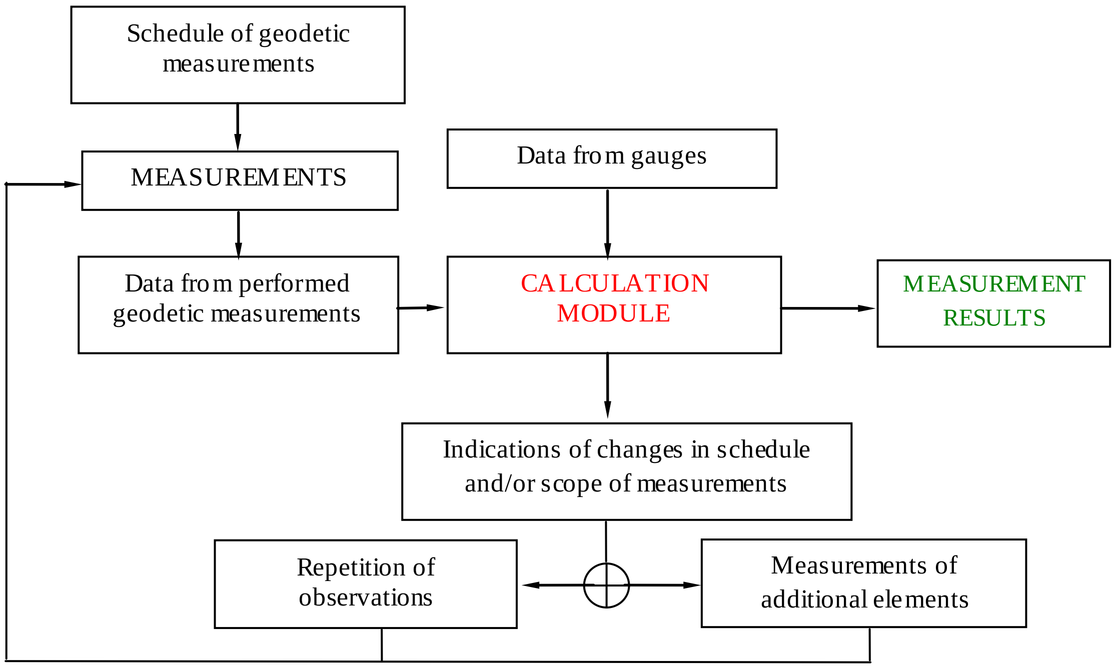


Fig. 4. **A diagram of the initial field checking of geodetic measurements**

Practical use

An example of integration of measuring systems in the process of modernisation of the control network.

An example of the complex approach to modernisation of the geodetic network, used for investigations of movements of a hydro technical structure is the project aiming at modernisation of the control network for the upper water reservoir of the Polish Pumped-Storage Power Station Porąbka-Żar (located in southern Poland, close to Bielsko- Biała, on the Soła River). The project includes:

a) Modernisation of the geodetic network of reference points,
- equipment of all points with installations for forced centering,
- development of the network with long vectors, allowing for reference of satellite measurements to the Euref network,
- transfer of a part of the network from the area of the Landscape Park to the area without any limitations in use,
- if possible, location of points on lands belonging to the Pumped-Storage Power Stations S.A. Company, being the owner of the object, or on the lands belonging to the state.

b) Reconstruction of the geodetic network on the copping of the object:
- possible change of location of existing points and addition of new control points in order to allow for inclusion of non-geodetic gauges, which register geometric changes (shifts and

ISBN 9984 – 779 – 06 – 8

inclination), as well as hydrological gauges located in the control gallery of the reservoir, to the elaboration of results of measurements (based on [3]),

- equipment of points with devices allowing for utilisation of satellite technologies,

c) Automation of geodetic measurements – utilisation of direct, radio communication (controlling and data transmission) between surveying instruments and the computer,

d) Development of specialised calculation modules.

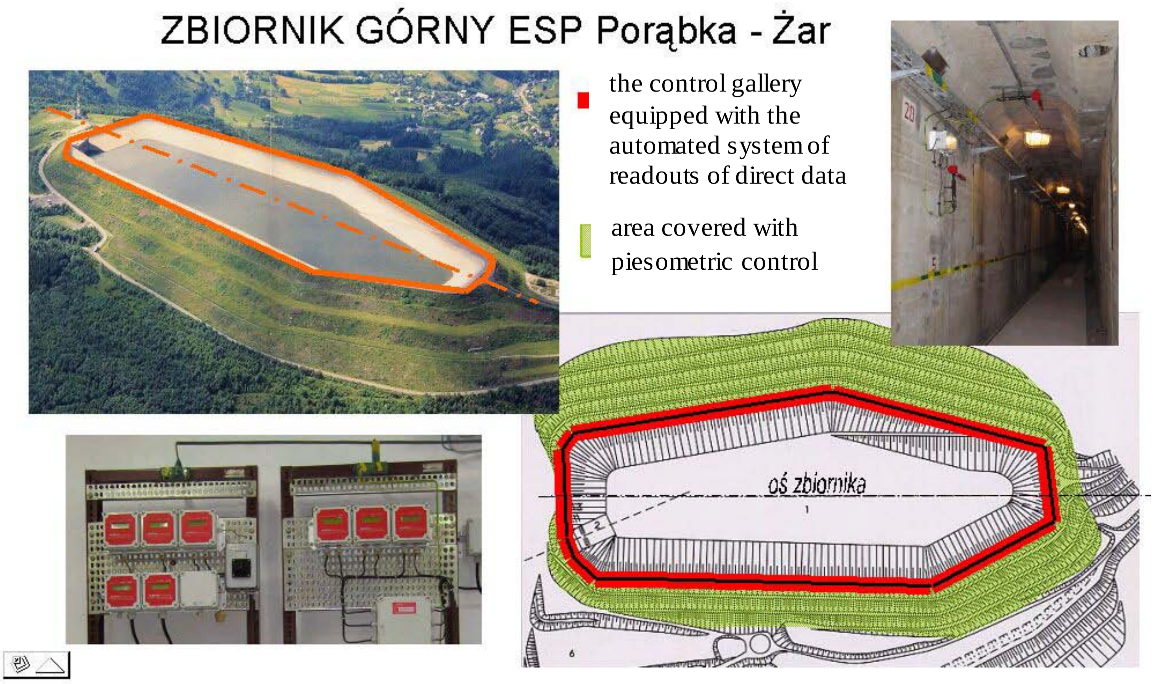


Fig. 5. **The upper reservoir, ESP Porąbka – Żar**

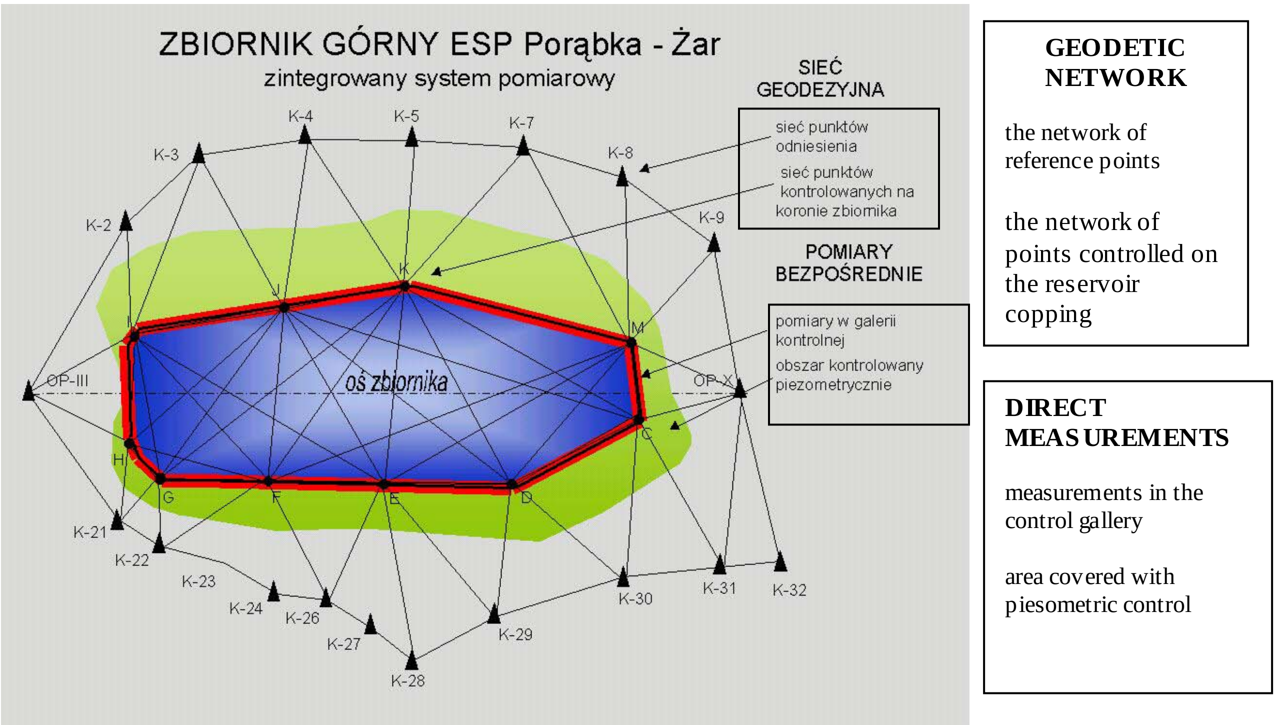


Fig. 6. **The upper reservoir of the ESP Porąbka–Żar – a diagram of the integrated measurement**

ISBN 9984 – 779 – 06 – 8

Conclusions

Modernisation of geodetic control networks used for movements investigations is an important issue for the security of the structure utilisation. Following the development of measurement technology, more possibilities of reliable and more accurate monitoring of changes of engineering objects appear. All new technical achievements may be immediately implemented in the course of development of a design of a new structure; it is not possible for an structure, which has been exploited for many years, without introducing any changes and maintenance of the existing control structures. It should be remembered that during elaboration of such issues, history of an structure cannot be neglected; reference to changes which occurred in the past is very important for interpretation of obtained results and for forecasting the trends of changes.

Attaching additional data in the process of elaboration of periodical measurements results, as well as development of a method allowing for comparison and analysis of various types of data acquired within multi-year periods, may contribute to increase the reliability of results of periodic geodetic measurements. The quality of results is extremely important for evaluation of security of engineering structures.

Development of the schedule of measurements, in the course of measurements, performed basing on control with the use of non-geodetic data, will limit the risk of gross errors and will ensure the higher possibilities to detect such errors.

The possibility of direct checking of an object in real time, using automated systems and radio communication will allow for fast reaction to registered changes.

However, it should be remembered, that the possibility to detect gross errors in the process of initial (current) field checking should not lead to neglecting appropriate instruments preparation and lowering the quality of observations.

References

1. Bałut A.: Zastosowanie GPS w geodezji inżynieryjnej i pomiarach odkształceń. (*Utilisation of GPS in emgineering geodesy and measurements of deformations*) Półrocznik Geodezja. t. 4, z. 1, Wydawnictwo AGH, Kraków 1998;
2. Bryś H., Przewłocki S.: Geodezyjne metody pomiarów przemieszczeń budowli; (*Geodetic methods of measurements of movements of constructions*) Wydawnictwo Naukowe PWN, Warszawa 1998;
3. Fiedler K., Szamowski A., Pietrzykowska H., Tarnowski K.: Interpretacja wyników pomiarów kontrolnych zbiornika górnego i innych obiektów naziemnych elektrowni pompowej Porąbka-Żar za rok 2003; (*Interpretation of results of control measurements of the upper reservoir and other terrestrial objects of the Pumped-Storage Power Station Porábka-ar for 2003*) Warszawa 2004, archiwum Zespołu Elektrowni Wodnych Porąbka-Żar (nie publikowane);
4. Lazzarini T. oraz zespół współautorów: Geodezyjne pomiary przemieszczeń i ich otoczenia; (*Geodetic measurements of dislocations and their surroundings*) PPWK, Warszawa 1977;
5. Prószyński W., Kwaśniak M.: Niezawodność sieci geodezyjnych (*Reliability of geodetic networks*); Oficyna Wydawnicza PW, Warszawa 2002
6. Wasilewski A., Rzepecka Z.: Zastosowanie GPS w geodezji inżynieryjnej (*Utilisation of GPS in engineering geodesy*). Prace Instytutu Geodezji i Kartografii, z.102/2001
7. Zaczek-Peplinska J.: Analiza możliwości wstępnej kontroli geodezyjnych pomiarów przemieszczeń na podstawie danych pomiarowych uzyskanych w galerii budowli piętrzącej, (*Analysis of possibility of the initial control of geodetic measurements of displacements basing on measuring data obtained in the gallery of a water damming* object), XI Międzynarodowe Sympozjum GEOTECHNIKA-GEOTECHNICS 2004, Gliwice-Ustroń 19-22 października 2004;
8. Ośrodek Technicznej Kontroli Zapór – Raport 2002 (*The Centre for Technical Inspection of Water Damming Objects – Report for 2002*); strona internetowa: www.otkz.pol.pl/inf_og/raport_pl.htm

ISBN 9984 – 779 – 06 – 8

WATERSKETCH: TOWARDS SUSTAINABLE RIVER BASIN MANAGEMENT IN THE BALTIC SEA REGION
BALTIJAS JŪRAS REĢIONA UPJU BASEINA ILGTSPĒJĪGAS VADĪBAS NODROŠINĀŠANA

WALTER LEAL FILHO

TuTech Innovation
Harburger Schlossstrassse 6-10, 21079 Hamburg, Germany
Phone: + 49 40 76618059, *fax*: + 49 40 76618078
e-mail: leal@tutech.de

Abstract. *River basin planning in the Baltic Sea Region (BSR) has always been a complex, yet important topic, which has gained a new momentum with the approval of EU Water Framework Directive (WFD) in December 2000. The ultimate goal of WFD is to achieve a good ecological status/potential of all water bodies before 2015. Together with the implementation of WFD also principles of Integrated Coastal Zone Management (ICZM) are to be applied and national expansions of Natura 2000 networks are in progress.*

There are many elements which are important in river basin planning systems. In the Baltic Sea region for example, the pressures posed by economic activities including increasing tourism and port activities have to be considered in land and river basin planning. These matters are dealt with in the context of the Watersketch project, a scheme supported by the Interreg IIIB programme of the European Union. The project aims at producing an extensive planning system and a working scheme that accounts for the various, complex and opposing tasks currently subjected to water usage. The main goal is to produce and describe processes, that aid planning and decision making also in areas with limited resources to meet the diverse requirements concerning water. In addition, the project intends to:

1) *analyse and synthesize the different directives and conventions focused on use of water courses.*
2) *demonstrate the major alternatives of river basin planning with a wide set of case studies ranging from southern tip of Baltic Sea (Poland) to northernmost corner of it (Norway).*
3) *provide a Water Planning Decision Support System for spatial planners, which takes into account all main components needed for economically, socially and ecologically sustainable use of water courses.*

Raise capacity to promote the sustainable development in river basins by means of an information exchange platform, training workshops and the dissemination of the information needed for sustainable use of river basins by means of a handbook.

By a combined approach where planning is complemented by training and information exchange, this project will provide a long-term contribution towards addressing the problem, at the same time that it links itself with other similar projects, achieving synergy and avoiding duplications.

Keywords: *sustainable development – river basin management – network- capacity building.*

Introduction – General Information about the River Elbe

The River Elbe is one of the largest rivers in Central Europe, being in the third place after the river Danube and the river Rhine in terms of length as well as the size of its catchment. Drainage basin area of River Elbe comprises 148,268 km^2 (1,2) and is shared between Germany, Czech Republic, Austria and Poland. However, Austria and Poland count less than 1 % of the catchment area while 2/3 is located in Germany and 1/3 in Czech Republic. The River Elbe arises in the Krkonoše (Riesengebirge), flows through Czech Republic, northern and central part of Germany and discharges in the North Sea near Cuxhaven. The River Elbe covers a distance of 1091 km (727 km in Germany, 364 km in Czech Republic) (2) and along its way, the catchment drains some of the major citys in the area like Prague, Dresden, Berlin and Hamburg (Fig 1.)

ISBN 9984 – 779 – 06 – 8

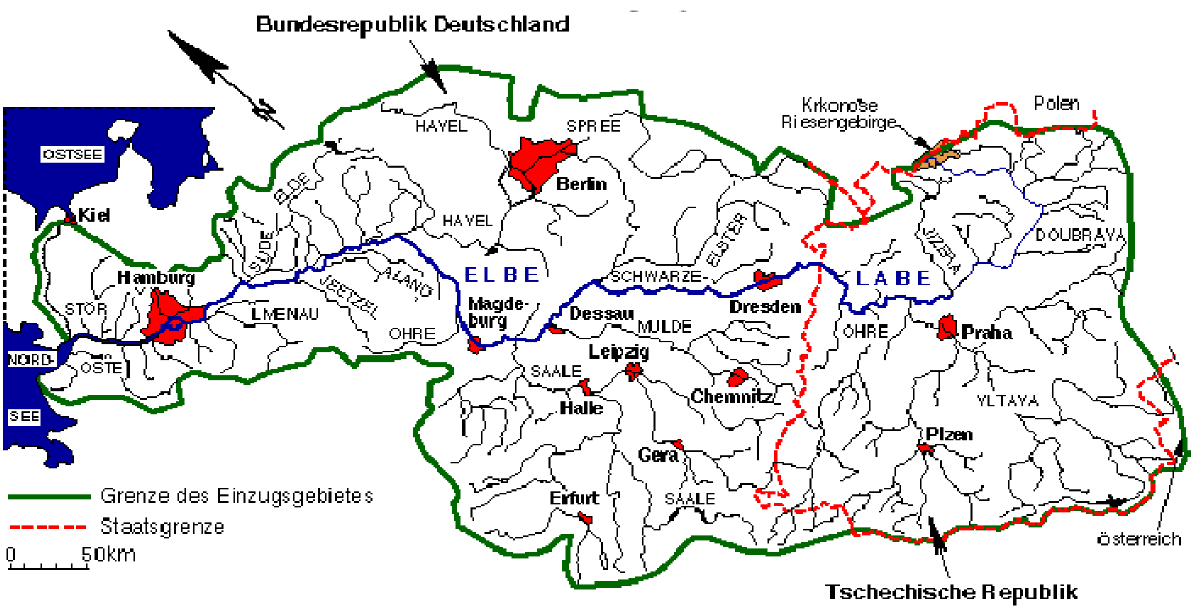


Fig. 1. **Drainage area of the River Elbe (Source: AGRE ELBE, 2001)**

The catchments area covers three main natural regions – the mountain area, the loess region and the Pleistocene lowland. The hydrogeology of the catchments area changes from bedrock aquifers in the southwest mountains to porous sediment aquifers in the lowland. The lower part of the river Elbe is characterised by its estuary and the coastally influenced landscape dominated mainly by the Hanseatic City of Hamburg, especially by its harbour. Tidal fluctuations, which lead to very special forms of wetland habitat and biodiversity, influence also the population and industry located in this region by frequent coastally in-blown storms.

The average annual discharge into the North Sea is about 877 m^3/s (3). The major tributaries are the Moldau/Vltava, Havel and Saale, each comprising a catchment area of roughly 25 000 km^2. The total population living in the drainage basin is around 25 million in total, 18 millon of which in Germany (31% of the total population) and 7 million in the Czech Republic (58% of the total population) (2).

The land area of the catchment area of the Elbe River consists of 29 % forested land, 7% urban areas, 61% agricultural areas and 1,5% water surface (4, 5). The water of the River Elbe is used for several purposes: To a certain extent, it is used to produce drinking water via bank filtration, which makes a comprehensive treatment necessary (6). More than half of the land in the basin is used for agricultural purposes. Main industries include chemical and pharmaceutical industry, paper and pulp industry, metal industry, mining, glass and ceramics and leather and textile industry. A great portion of the basin, around 86% of the German part and 22% of the Czech part, are classified as protected areas of nature reserves (3).

The Free and Hanseatic City of Hamburg

The Free and Hanseatic City of Hamburg is the second largest city in Germany with 1.7 million inhabitants. Like Bremen and Berlin it is a city-state. Hamburg is the cultural and commercial centre of Northern Germany, and its metropolitan region consists of approximately 3 million people. The municipal area is equal to 755,3 km^2 whereas the metropolitan region covers total surface of ca. 19 000 km^2 and embraces 14 districts around the City of Hamburg. With 30 m^2 living space per person, Hamburg enjoys the largest average personal living space of all big cities in the world. In fact, 12% of the city is made up of green and recreation areas whereas ca. 36% of the land use belongs to buildings and open space, 27% to the arable land, 12% to the road area and 8% to the water area (7). Some facts and figures are listed in Table 1.

ISBN 9984 – 779 – 06 – 8

Table 1.

Some facts and figures about Hamburg
(Source: Statistisches Amt für Hamburg and Schleswig-Holstein, 2004)

	Hamburg		Germany		In % of Germany
Inhabitants	1.729.000		82.537.000		2,1
Total Area	75.532	ha	35.703.099	Ha	0,2
Built-up Area and Open Space	26.878	ha	2.308.079	Ha	1,2
Recreation Area	5.702	ha	265.853	Ha	2,1
Road Area	8.860	ha	1.711.764	Ha	0,5
Arable Land	21.000	ha	19.102.791	Ha	0,1
Forested Area	3.432	ha	10.531.415	Ha	0,0
Water Area	6.115	ha	808.462	Ha	0,8
Share of Gross Domestic Product	77.08	Mrd.	2.129.20	Mrd.	3,6
Gross Value Added	70.02	Mrd.	1.963.580	Mrd.	3,6
of which:					
Agriculture, Forestry, Fishing	0,12	Mrd.	21.95	Mrd.	0,5
Manufacturing industry	13.2	Mrd.	475.30	Mrd.	2,8
Trade, Transport,	18.31	Mrd.	365.00	Mrd.	5.0
Financial, renting and business service activities	25.67	Mrd.	589.97	Mrd.	4.4
Construction	1.84	Mrd	87.21	Mrd	2.1
Other service activities	13.11	Mrd	424.15	Mrd	3.1
Unemployment Rate in % (yearly average 2004)	11.0		12.5		
Gross Earnings /Year in Euro	29.319				

The geographic and geologic conditions of Hamburg are closely related to the housing development, population growth and economic structure of the City. Hamburg is thus not only “the city built on the water” - as it is called due to the multiplicity of small rivers and canals besides the Elbe and Alster Lake - but it is also “living from the water” (8). Due to the access to the North Sea and to the Baltic Sea (via the Kiel Canal) and the efficient land and water connections to the hinterland, Hamburg Port plays an important role making Hamburg the most important international trade and logistics centre of Germany and a hub to the whole Baltic Sea Region and Central Europe. The international trade volumes account approximately for one third of the Europe’s export. The port and shipping sectors are employing around 75,000 people in Hamburg. More than 145,000 jobs in a vast range of industrial and service sectors are indirectly dependent on the port. Besides the level of the regional employment the seaport activities of Hamburg exploit also a relevant role on the regional economic growth. In fact, the GDP the seaport related activities generate is proportionally higher than the quote of the GDP related to the other economic sectors of the Hamburg city-region.[1]

Due to its location Hamburg is also very attractive for industries and businesses to settle here. Following Ruhr area and Berlin it is in the third biggest industrial area in Germany. 70% of all industry related businesses in Hamburg concentrate on one of the six branches: Aircraft-, ship- building and automotive industry; electro technology, fine mechanics and optic industry;

[1] Information taken from: [1], [2], [7], [8]

ISBN 9984 – 779 – 06 – 8

mechanical engineering; chemistry; mineral oil processing; or metal production. The importance of Hamburg can be seen also from the fact that not only big industries form their headquarters here but there are also more than 80 000 middle-sized businesses present. [2]

The River Elbe in Hamburg

According to the Water Framework Directive, surface waters are classified on the basis of river basin district. Following that, the sub-river basin of Elbe/Harbour lies on the surface of 156.4 km^2 within the borders of Free and Hanseatic City of Hamburg and incorporates the Entering Hamburg at the river-km of 620 the length of the river Elbe through the city is approximately 77 km long. The landscape of the river basin district can be characterised as a marsh area with its sandy soils mixed with gravel and clay. The deeper subsoil of Hamburg consists of layers shifting from clay to brown coal consisting sands. The flow in the Elbe remains between 1 and 1.5 m/s (the discharge rate varies from 300 m^3/s to 3000 m^3/s) depending on the tides. The river is divided in two branches (*Norderelbe* and *Süderelbe*) near the City of Hamburg forming an estuary with a width of 1.5 km downstream of Hamburg and 18 km near Cuxhaven. However, within Hamburg the river has an average width of 200 m and the depth of 2 to 5.5 m upstream and 15.30 m downstream of *Elbbrücken*. Because of lacking gradient and tidal influence the direction of water drift changes every six hours. For this reason, given water body has to pass the same river section several times needing 4 to 70 days (compared to 1 to 2.5 days upstream of Geesthacht) unless it reaches the open waters of the North Sea resulting in the much greater residence time of polluted water than the upper reaches of Elbe (10).

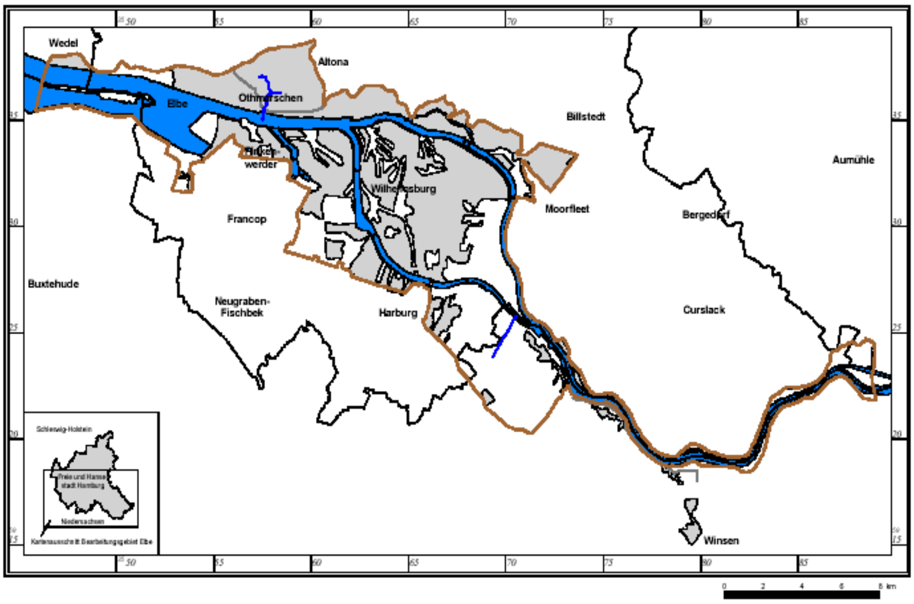


Fig. 2. **Southern and Northern Elbe (9) and the Port of Hamburg**

The water quality, river morphology and other characteristics of Elbe in Hamburg are influenced mainly by the port related and industrial activities, navigation and urbanisation as well as pressures imposed by the activities along the river Elbe upstream of Hamburg. On the other hand the heavy use of Elbe for recreational purposes as well as for attraction of tourists must be stressed.

Current Environmental Problems and related Conflicts of the River Elbe

Table 2.offers a general overview of the various issues surrounding the Elbe in Hamburg, by means of the "Driving force-Pressure-State-Impact-Response" framework. It can be seen in Table 2. that the driving forces resulting in pressures and complemented by the corresponding environmental state, their impacts and responses.

[2] Information taken from: [3], [5], [8], [9]

ISBN 9984 – 779 – 06 – 8

Table 2.

The Driving force-Pressure-State-Impact-Response framework

<table>
<tr><th>Driving force</th><th>Pressure</th><th>State of Environment</th><th>Impact</th><th>Response</th></tr>
<tr><td>Port Activities and Navigation</td><td>Dredging
Utilisation of the port area
Shipping accidents</td><td>Change of river morphology and ecological condition of the river
Pollution (oil, chemicals)</td><td rowspan="3">Disappearance of several species in flora and fauna
Contaminant accumulation in sediments and also in fishes
Treatment and disposal of dredged material made difficult due to the heavy contamination of sediments with heavy metals (especially Cadmium)</td><td rowspan="3">National, European and international policies
National and international cooperation agreements and conventions</td></tr>
<tr><td>Flooding</td><td>Flood protection</td><td>Change of river morphology and ecological condition of the river</td></tr>
<tr><td>Households and Industries</td><td>Point and diffused pollution sources</td><td>Pollution of the river water and sediments with nutrients and hazardous substances</td></tr>
</table>

A major problem among the many seen in Hamburg, is the problem of contaminated sediments. In Hamburg, the dredged sediments must undergo pre-treatment following the disposal within the borders of the City to meet the requirements posed by relatively strict environmental laws. Pre-treatment is done in the large scale METHA plant with the annual throughput capacity of 1 million m^3 sediments and consist of separation into sand, silt and smaller amount s of coarse material (11). Due to the contamination of the silt, it is disposed in two specially constructed silt mounds ensuring environmental safety. Another feasible possibility, bearing however relatively high costs, is the utilisation of the silt as a sealing material in the construction of the dredged material disposal sites, for backfilling former harbour basins and as a raw material in brick fabrication (12). The separated sand is nearly contamination free and therefore can be used as construction material or as a raw material or additive in the industry.

However, the criteria of the dredged material for the Elbe river system were developed in the mid 1990s allowing these sediments to be relocated into the river if meeting the requirements. The concept of sustainable relocation is followed to minimise the effects on the environment.

A further key-issue is still the contamination of sediments in the entire river basin resulting from more than 150 years of mining and industrial activities (11). Although there has been a marked reduction in pollution with heavy metals (reduction of Hg: 84 %, of Cd: 22%), compared to 1989, it is generally still high today (mercury, cadmium, zinc) especially concerning the sediments and suspended matter indicating the continuing inputs into the river from upstream. Pollution with copper is heavy, pollution with lead, chromium and nickel is critical (13). According to the existing LAWA2-Classification, in 1998, suspended sediments were assigned to the class “elevated to high contamination” (Class III-IV) with regard to Hg, Cd and Zn and to “moderate to elevated contamination” (class II-III) with regard to Pb (11).

Among other problematic heavy metals cadmium is one of several contaminants that lead to sediment management problems downstream from the sources namely regarding the dredged

ISBN 9984 – 779 – 06 – 8

material from the port of Hamburg which does not meet the lower Federal German value for disposal into the North Sea (1, 14).

One of the principal problem substances in the Elbe today as well as in the future is hexachlorobenzene (HCB) due to its high persistency and extensive presence in the sediments (8). The reduction in loads is slow also because of ongoing inputs from Czech Republic. Despite a downward trend in pollution loads in the early nineties, DDT and DDD in particular are still found in the Elbe in substantial concentrations, which sometimes reach extreme peak values. The inputs are suspected to come from the Mulde, as DDT concentrations of up to 2 mg/kg have been measured in the sediments of Mulde (14).

Furthermore, oil spills in marine and coastal waters lead to oil slicks. In 2001 aerial surveillance, which under the Bonn Agreement has to be carried out by the North Sea states as an aid to detecting and combating pollution and to prevent violations of anti-pollution regulations, detected 596 oil slicks in the North Sea. In 2003, the Waterways Police authorities of the German coastal states inspected a total of 6,036 ships and found deficiencies in 1,533 cases. In case of minor infringements, they issued cautions to the ships' masters, chief engineers, and engineers and imposed fines of up to 35,00 € in individual cases. 251 cases were referred to the BSH for further handling. The BSH is the German authority imposing fines for administrative offences that have been committed by shipping in violation of international conventions and national regulations for the protection of the marine environment. Under the German ordinance on violations of MARPOL regulations, those responsible on board a vessel commit an administrative offence if they maintain the Oil, Cargo, or Garbage Record Book improperly or do not comply with MARPOL discharge regulations. The existence of illegal overboard pipes from the sludge tank are considered an administrative offence punishable by a fine.

Due to the contamination of Elbe sediments, the Port of Hamburg is still operating a comprehensive dredged material management system. In 2002, 2.8 tons (30%) out of the 9.5 ton of total Cd load in the river Elbe was removed in Schnackeburg using land disposal. Due to the Elbe flood, the load in 2003 was 60% higher than in previous years (11).

The relocation of dredged material poses a volume problem and has an impact as the human pressures on the North Sea. Two effects on the coastal ecosystem have to be considered in relocation or withdrawal from the marine system: on the one hand the withdrawal of slightly contaminated sediments will reduce inputs of contaminants (positive); on the other hand withdrawal of large amounts of sediments will upset the sediment balance in sedimentation areas (negative) (15, 16, 17). In a modern impact analysis both aspects should be put in a context of questions about sustainable river management and sea level rise, with increasing coastal erosion and impacts on mud flats.

As with regard to conflicts, the present environmental issues of concern like leakage of nutrients, especially nitrate, from agriculture and leakage of harmful substances from mining sites remain also in the future. Methods to treat water with increased concentrations of heavy metals from ore mining over and above the existing research on geochemical engineering as well as strategies to avoid or to decrease heavy metal concentrations in the Elbe catchments area are under development but there is still a long way to go. This shows that the present conflict regarding sediment management has no fast solution and will continue probably in the future. However, it depends strongly on the ability of different stakeholders to co-operate and to move towards the common goal – to establish sustainable sediment management for the whole catchments area of the river Elbe, with suitable guidelines and frameworks that fit in the context of Water Framework Directive –a subject looked at in depth in the project WATERSKETCH- and support therefore also reduction of cost to both the society and the environment.

Future conflicts may rise from the several environmental problems which have to be faced and taken into consideration in managing the river Elbe, namely:

Possible decrease and degradation of the habitats due to the climate change resulting from continuing increase of industrialisation and traffic infrastructure as well as further specialisation of agriculture poses a progressing threat to biodiversity;

ISBN 9984 – 779 – 06 – 8

Increases in water temperature and inputs resulting from human activities (e.g. ballast water) may cause sets of problems (e.g. genetic) which may influence populations and the evolution of new species;

Future water quality problems with new hazardous substances like endocrine disruptors may arise. The examples are PCBs and TBT, the production and use of which are being or have been strictly limited or even forbidden;

Due to the development in the shipping sector (e.g. insufficiently trained crews, sub-standard ships, and inadequate salvage capacity) there is a potentially increasing risk of shipping accidents;

Another future threat is a potentially accelerating sea level rise, which may, on the one hand, have an impact on the ecosystem and on the other hand pose an increasing burden on the coastal protection and the safety of the hinterland.

According to the Hamburg´s regional development concept published in the year 2000, the goal is to gain a differentiated regional profile within a trilateral cooperation combining science, labour and surface use politics formed on the basis of guiding projects. Besides harbour operations and settlement of highly specialised industries Elbe has been discovered as a landscape with a high value for urban planning and the improvement of water quality as the ecological basis for life and enhancement of the river's recreational appeal have moved into the centre of debate.

The solution of future conflicts depends on to which extent the barriers to progress in environmental protection and sustainability are to be overcome. This is mainly due to the fact that the nature of problems as well as solutions is complex and international interconnected with different sectors and disciplines. These barriers are underpinned by shortcomings in institutional structures, non-implementation of commitments already made and lack of information on and understanding of possible 'win-win-win' solutions for achieving sustainable outcomes. Protection of natural resources and ecosystems accompanied with social and territorial unity and innovativeness should be considered while finding such solutions.

In the future, harbours are not only important logistics centres and interfaces for the world trade, but they should be used as crystallization points for new industrial "clusters" to minimise the impacts by less use of space, concentration of noise and light pollution and a better control of emissions and pollutants (18, 19). Environmental concerns could lead harbours to an increasing market for green ship wrecking, for vessels such as single-hull tankers, old cargo vessels and naval vessels (9, 11, 14). Some advantages could be provided by recycling expensive raw materials. The EU will issue stringent conditions for ship owners and flags of convenience, which will lead to an increase in the wrecking of older ships.

Conclusions

In order to improve the ecological status of the river, integrated sediment management of the Upper Elbe seems to be an essential measure. This is being considered as case study part of the Interreg IIIB Project Watersketch (http://www.watersketch.net), which looks at the issue of sustainable river basin management in the Baltic Sea region.

By means of sediment management, the unnatural withdrawal of dredged material would be reduced and solid condition of the aquatic system of the Upper Elbe would be supported by the rearrangement of the unladen dredged material. Selective fixed deposition of dredged material as a measure of hydraulic engineering could influence sediment transport in a positive way and at the same time the creation of shallow water zones would be enhanced ecologically.

Contaminated sites in Hamburg as well as in the whole catchment area and the historic contamination emitted from approximately 300 old mining sites in the Elbe catchment area are the main diffused pollution sources causing the contamination of sediment. There has to be analysed to which extent the reduction of dredged material as a contribution to the concept of a

ISBN 9984 – 779 – 06 – 8

sustainable clean port and environment can be achieved. The classification system for substances and areas of concern has to be developed as well as the concept for the handling of historic contaminants. The risk of various contaminant sources should be determined following the site prioritisation considering social and economical parameters for better allocation of resources resulting in the maximum risk reduction and protection of socioeconomic use of the river basin.
For the future, the amount of sediments to be dredged could be reduced by means of hydraulic devices like the current deflecting wall. For example, the Koehlfleet Harbour, one of the largest in the Hamburg Harbour complex, has achieved the major benefits in reducing this siltation by constructing a curved wall at the basin entrance. This structure changes the flow pattern to avoid the trapping effect by the eddies. Due to this construction the annual sedimentation of approximately 290 000 m^3/yr was reduced up to 35 % (10). Reductions of cost were even higher, because all the sediment in the harbour can be dredged by the cheaper water injection (16). As it can be seen, such structural measures are proved to be useful to reduce harbour sedimentation, however might differ on an individual basis. It is expected that an optimized wall will lead to further sediment reduction (16).

In managing the trans-boundary water course like Elbe, the issue of new governments with limited sources inheriting the „legacy of the past" is a serious one, and requires most likely a new thinking about resource sharing across borders and entities. Finally, communication between the stakeholders and raising awareness of the public on the sediment issue is becoming increasingly important in order to improve the future river status. The purpose of communication between different regulatory bodies and policies is to include the sediments into the European environmental policy.
Sustainable river management strategy of the river Elbe has to consider integration and implementation of sectoral strategies with regard to policies/activities in the coastal zone and mainland. In other words, it needs integratives approaches (19). As there is still insufficient or lacking cooperation between local, regional, national and EU authorities in the preparation, implementation, enforcement and coordination of the rules and regulations cooperation between responsible authorities is essential. In order to facilitate sustainable management the rules and regulations should be harmonised and simplified.

References

1. IKSE (1995) Internationale Kommission zum Schutz der Elbe: Die Elbe und ihr Einzugsgebiet. IKSE, Dresden.
2. IKSE (2000) Internationale Kommission zum Schutz der Elbe: Die Elbe von 1990 bis 2000 – 10 Jahre erfolgreiche Zusammenarbeit in der IKSE. IKSE, Dresden.
3. IWAC (2001) 10 Transboundary Rivers in Europe Assessment Practices and Environmental Status. International Water Assessment Centre, Szczecin (http://www.iwac-riza.org).
4. Behrendt H., Hofmann J., The Elbe Catchment and Related Coastal Area: German Bight and Wadden Sea. Part A: Catchment Profile, Institute für Gewässerökologie und Binnenfischerei im Forschungsverbund Berlin e.V, May 2002
5. Leal Filho, W. (ed) (2004) Ecological Agriculture and Rural Development in CEE Countries. Kluwer Academic Publishing, Doordrecht.
6. BALTICOM (2000) Report on port related processes of regional restructuring", Baltic Transport Communication and Regional Development BALTICOM, June 2000.
7. Statistisches Amt für Hamburg und Schleswig – Holstein (2004) Hamburg - ein Stadtporträt in Zahlen". Statistisches Amt für Hamburg und Schleswig – Holstein, August, 2004.
8. Umsetzung der EG-Wasserrahmenrichtlinie (WRRL): Zusammenfassender Bericht über die Hamburger Bearbeitungsgebiete, 2005.
9. Umsetzung der EG-Wasserrahmenrichtlinie (WRRL): Landesinterner Bericht zum Bearbeitungsgebiet Elbe/Hafen Bestandsaufnahme und Erstbewertung (Anhang II / Anhang IV der WRRL), 2005.
10. Christiansen H. (1997) Erfahrungen mit der Strömungsumlenkwand. HANSA, 134. Jahrg., Heft 12, Hamburg, Germany.
11. Arevalo E., Heise S. (2003) Sustainable Solutions to the Sediment Management on the River Basin Scale: The Elbe River Case under specific consideration of risk management and communication aspects, 2nd SedNet-Conference, September 2003.

ISBN 9984 – 779 – 06 – 8

12. Netzband A., Reincke H., Bergemann M. (2002) „The River Elbe – A Case Study for the Ecological and Economical Chain of Sediments“, Journal of Soils & Sediments 2(3), 112 – 116.
13. Salomons, W. (2004) European Catchments: Catchment Changes and Their Impact on the Coast, Institute for Environmental Studies, Vrje Universiteit, Netherlands.
14. Gaus mbH (2004) The Wadden Sea: Maritime Safety and Pollution Prevention of Shipping. Analysis of the existing measures and the implementation of agreements regarding maritime safety and prevention of pollution from ships, Gauss mbH, Bremen.
15. Christiansen H. (1997) Erfahrungen mit der Strömungsumlenkwand. HANSA, 134. Jahrg., Heft 12, Hamburg, Germany.
16. Crowder, R. A.(1995) Study of the Reduction of Siltation by Means of a Current Deflecting Wall, EU-Study LIP II Tidal Flume Measurements, Delft Hydraulics, Netherlands.
17. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit/ Umweltbundesamt (2001) Environmental Policy: Water Resources Management in Germany, Part 2: Quality of Inland Surface Waters. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Umweltbundesamt, Berlin.
18. Hesse M. (2002) „Logistics real estate markets: indicators of structural change, linking land use and freight transport“, paper for the ERSA 2002-Conference „From Industry to advanced Services“, Dortmund, Free University of Berlin, Dept. Of Geography, May 2002.
19. Leal Filho, W., Ubelis, A. (eds) (2004) Integrative approaches towards sustainability in the Baltic Sea Region. Peter Lang Scientific Publishers, Frankfurt.

ISBN 9984 – 779 – 06 – 8

AUTORU SARAKSTS
LIST OF AUTHORS

ADAMOVIČS ALEKSANDRS,	Latvian University of Agriculture, Liela str. 2, Jelgava, LV-3001, Latvia, *ph./fax:* + 371 3005629 *e-mail:* alexadam@cs.llu.lv	LATVIA
BAČELIS KĘSTUTIS	Upyte Research Station of the Lithuanian Institute of Agriculture Linininkų 3, Upytė, Panevėžys district, 38 294, Lithuania, *ph.:* + 370 45555413, *fax:* + 370 45555573, *e-mail:*soja@upyte.lzi.lt	LITHUANIA
BALKEVIČIENE SIMONA	Kaunas University of Technology, Department for Evironmental Engineering, Radvilėnų 19, 50254 Kaunas, Lithuania, *ph.:* + 370 37351008, *fax:* + 370 373000152	LITHUANIA
BEČA MAIJA	Latvian University of Agriculture, Liela str. 2, Jelgava, LV – 3001, Latvia, *e-mail:* aleksandrs.adamovics@llu.lv, jazeps.spruzs@llu.lv	LATVIA
BERGQVIST PER-ANDERS	Umeå University, Department of Environmental Chemistry, SE-901 87 Umeå, Sweden	SWEDEN
BOROVKO LILIJA	Latvian University of Agriculture, Research Institute of Agriculture Agency, Skrīveri – 1, Aizkraukles distr.,LV-5126 Latvia, *ph.:* + 372 5197639, *fax:* + 372 5197512, *e-mail:* borovko@e-apollo.lv	LATVIA
CHRZAN TADEUSZ	University of Zielona Góra Ul. Podgórna 50, Zielona Góra, *ph.:* + 068 3282674 *e-mail:* T.Chrzan@iis.uz.zgora.pl	POLAND
CIEGIS REMIGIJUS	Vilnius University, Kaunas Faculty of Humanities, Muitines 8, Kaunas LT-42280, Lithuania, *ph.:* +370 37 422344, *e-mail:* remigijus.ciegis@vukhf.lt	LITHUANIA
CICĖNAITĖ AURELIJA	Kaunas University of Technology, Chemical Technology Faculty, Department of Environmental Engineering, Radvilenu st. 19, Kaunas LT - 50254, Lithuania, *ph.:* + 370 61067601, *e-mail:* aurelija.cicenaite@gmail.com	LITHUANIA

ISBN 9984 – 779 – 06 – 8

DĒLIŅA AIJA	„Geo Consultant”, K.Ulmana gatve 3, Riga, LV-1004, Latvia *ph.:* + 371 7627504, *fax:* + 371 7623512, *e-mail:* gc@parks.lv	LATVIA
DOBELE GAĻINA	Latvian State Institute of Wood Chemistry, Laboratory of lignin chemistry, Dzērbenes str. 27, LV 1006, Riga, Latvia, *ph.:* + 371 7545142, *fax:* + 371 7550635, *e-mail:* gdobele@ edi.lv	LATVIA
ENDRIUKAITIS ALGIMANTAS	Upytė Research Station of the Lithuanian Institute of Agriculture, Lininink 3, Upytė, Panevėžys district, 38 294, Lithuania, *ph.:* + 370 45555413, *fax:* + 370 45555573, *e-mail:* soja@upyte.lzi.lt	LITHUANIA
GENDELS STAŅISLAVS	University of Latvia, Laboratory for mathematical modelling of environmental and technological processes, Zellu 8, Riga, Latvia, *ph.:* + 371 7033783, *fax:* + 371 7033781 *e-mail:* stasis@modlab.lv,	LATVIA
GIL JÓZEF	University of Zielona Góra, Department of Civil and Environmental Engineering, 65-246 Zielona Góra, Poland, *ph.:* + 4868 3282416, *fax:* + 4868 3247292, *e-mail:* J.Gil@ib.zgora.pl	POLAND
GIRDZIJAUSKAS STASYS	Vilnius University, Kaunas Faculty of Humanities, Department of Informatics, Muitinės g. 8, LT-3000 Kaunas, *ph.:* (8-37) 44280, *e-mail:* stasys.girdzijauskas@vukhf.lt	
GONTASZEWSKA AGNIESZKA	University of Zielona Góra, ul. Z.Szafrana 2, 65-001 Zielona Góra, Poland *ph.:* + 48 683282427, *e-mail:* A.Gontaszewska@ib.uz.zgora.pl	POLAND
GRABUSTS PETERIS	Rezekne Higher Educational Institution, Atbrivoshanas al. 90, Rezekne LV-4600, Latvia *ph.:* + 371 4623798, *e-mail:* peter@ru.lv	LATVIA
GRUZDEVIENĖ ELVYRA	Upytė Research Station of the Lithuanian Institute of Agriculture, Lininink 3, Upytė, Panevėžys district, 38 294, Lithuania, *ph.:* + 370 45555413, *fax:* + 370 45555573, *e-mail:* soja@upyte.lzi.lt	LITHUANIA

ISBN 9984 – 779 – 06 – 8

GULBIS VILNIS	Latvian University of Agriculture, Motor Vehicle Institute, 5 J.Cakstes boulv., Jelgava, LV-3001, Latvia, *ph.:* + 371 9151295, *ph.:* + 371 6872244, *fax:* + 371 3020762 *e-mail:* Vilnis.Gulbis@llu.lv	LATVIA
JANKAUSKIENĖ ZOFIJA	Upytė Research Station of the Lithuanian Institute of Agriculture, Linininkų 3, Upytė, Panevėžys district, 38 294, Lithuania, *ph.:* + 370 45555413, *fax:* + 370 45555573, *e-mail:* soja@upyte.lzi.lt	LITHUANIA
JANKAUSKAITĖ MARGARITA	Institute of Geology and Geografy, T. Ševčenkos str. 13, Vilnius, LT-2600, *ph.:* + 370 52104692, *e-mail:* rita@geologin.lt	LITHUANIA
JANKŪNAITE DALIA	Kaunas University of Technology, Department of Environmental Engineering Radvilėnų pl. 19, Kaunas, LT-50270, Lithuania, *ph.:* +(370)37300182, *fax:* +(3702)37300152, *e-mail:* daina.kliaugaite@stud.ktu.lt	LITHUANIA
JAKOVIČS ANDRIS	University of Latvia, Laboratory for mathematical modelling of environmental and technological processes, Zeļļu 8, Riga, Latvia, *ph.:* + 371 7033779, *e-mail:* ajakov@latnet.lv	LATVIA
JEGOROVA ILONA	Kaunas University of Technology, Chemical Technology Faculty, Department of Environmental Engineering, Radvilenu st. 19, Kaunas LT - 50254, Lithuania, *ph.:* +370 610 67601, *e-mail:* aurelija.cicenaite@gmail.com	LITHUANIA
JUKĀMA KRISTĪNE	University of Latvia, Faculty of Biology, Kronvalda bulvaris 4, Riga, LV-1586, *ph.:* +371 7034864, + 371 9364133, *e-mail:* mara.vikmane@lu.lv	LATVIA
KAĶĪTIS AIVARS	Latvian University of Agriculture, Institute of Mechanics, J. Čakstes bulv. 5, Jelgava, *ph.:* + 371 3080674, *fax:* + 371 3005685, *e-mail:* aka@cs.llu.lv	LATVIA
KALIS HARIJS	Institute of Mathematics Latvian Academy of Sciences and University of Latvia Akadēmijas square-1, LV – 1524, Riga, Latvia, *e-mail*: kalis@lanet.lv	LATVIA

ISBN 9984 – 779 – 06 – 8

KANGRO ILMĀRS	Rezekne Higher Education Institution, Atbrivoshanas al. 76, Rezekne, LV-4600, Latvia, *e-mail:* kangro@ru.lv	LATVIA
KATKEVIČIŪTE JOLITA	Kaunas University of Technology, Chemical Technology Faculty, Department of Environmental Engineering, Radvilenu st. 19, Kaunas LT - 50254, Lithuania, *ph.:* +370 61067601, *e-mail:* aurelija.cicenaite@gmail.com	LITHUANIA
KAUNELIENE VIOLETA	Kaunas University of Technology, Chemical Technology Faculty, Department of Environmental Engineering, Radvilenu st. 19, Kaunas LT - 50254, Lithuania, *ph.:* +370 61067601, *e-mail:* aurelija.cicenaite@gmail.com	LITHUANIA
KLIAUGAITE DAINA	Kaunas University of Technology, Department of Environmental Engineering Radvilėnų pl. 19, Kaunas, LT-50270, Lithuania. *ph.:* + 370 37300182, *fax:* + 370 237300152, *e-mail:* daina.kliaugaite@stud.ktu.lt	LITHUANIA
KLIUČININKAS LINAS	Kaunas University of Technology, Department for Evironmental Engineering, Radvilėnų 19, 50254 Kaunas, Lithuania, *ph.:* + 370 37351008, *fax:* + 370 373000152, *e-mail:* linas.kliucininkas@ktu.lt; jozaik@ktu.lt	LITHUANIA
KONDRATOVIČS ULDIS	University of Latvia, Faculty of Biology, Kronvlada bulvāris 4, Rīga, LV-1586, *ph.:* +371 7034864, + 371 9364133, *e-mail:* mara.vikmane@lu.lv	LATVIA
KOWALSKI RYSZARD	Warsaw University of Technology, Institute of Applied Geodesy, Plac Politechniki 1, 00-661 Warsaw, Poland, *e-mail:* j.peplinska@gik.pw.edu.pl	POLAND
KRAIŃSKI ANDRZEJ	University of Zielona Góra, ul. Z.Szafrana 2, 65-001 Zielona Góra, Poland *ph.:* +48 683282427, *e-mail:* A.Gontaszewska@ib.uz.zgora.pl	POLAND
KRONBERGS ĒRIKS	Latvian University of Agriculture, Institute of Mechanics, J. Cakstes boulv. 5, Jelgava, Latvia, LV3001, *ph.:* + 371 3080674, *fax:* + 371 30 27238, *e-mail:* eriks@cs.llu.lv	LATVIA

ISBN 9984 – 779 – 06 – 8

LEAL FILHO WALTER	TuTech Innovation, Harburger Schlossstrassse 6-10, 21079 Hamburg, Germany, *ph.:* + 49 4076618059, *fax:* + 49 4076618078 *e-mail:* leal@tutech.de	GERMANY
MATISOVS IVARS	Rezekne Higher Education Institution, Atbrivoshanas al. 76, Rezekne, LV-4600, Latvia, *ph.:* + 371 4625145, *e-mail:* ivars@dau.lv	LATVIA
MEKŠS PĒTERIS	University of Latvia, Faculty of chemistry Latvia, Riga, Kr. Valdemara str. 48, LV 1013 *ph.:* + 371 7377436, *fax:* + 371 7378731, *e-mail:* p.mekss@lu.lv	LATVIA
MOCKUVIENE JOLITA	Kaunas University of Technology, Department for Evironmental Engineering, Radvilėnų 19, 50254 Kaunas, Lithuania, *ph.:* + 370 37351008, *fax:* + 370 373000152, *e-mail:* linas.kliucininkas@ktu.lt; jozaik@ktu.lt	LITHUANIA
MOSKALIOVA VERA	Vilnius University, Kaunas Faculty of Humanities, Department of Informatics, Muitinės g. 8, LT-3000 Kaunas, *ph.:* + 370 837)44280 *e-mail:* vera.moskaliova@vukhf.lt	LITHUANIA
MROWCZYNSKA MARIA	University of Zielona Góra, Institute of Building Engineering, 65-516 Zielona Góra, ul. Z. Szafrana 2, Poland, *ph.:* + 48 683282636, *e-mail:* m.mrowczynska@ib.uz.zgora.pl	POLAND
NENORTAITE JOVITA	Vilnius University, Kaunas Faculty of Humanities, Muitines 8, 44280 Kaunas, Lithuania *ph.:* + 370 37422566, *e-mail:* jovita.nenortaite@vukhf.lt	LITHUANIA
NULLE IMANTS	Latvian University of Agriculture, Institute of Mechanics,J. Cakstes boulv. 5, Jelgava, *ph.:* + 371 3080674, *fax:* + 371 3005685, *e-mail:* aka@cs.llu.lv	LATVIA
NIKITIN OLEG	AS Eesti Põlevkivi, Development Department Jaama str. 10, Jõhvi, 41533, Estonia *ph.:* + 372 3364123, *fax*: + 372 3364803, *e-mail:* oleg.nikitin@ep.ee	ESTONIA

ISBN 9984 – 779 – 06 – 8

OZOLA AGRITA	Museum of Tukums City, Harmonijas str. 7, Tukums, LV 3101, *ph.:* + 371 3182390, *fax:* 371 31 22237, *e-mail:* tukmuz@apollo.lv	LATVIA
PAREIGIS RIMANTAS	Vilnius University, Kaunas Faculty of Humanities, Muitines 8, Kaunas LT-42280, Lithuania, *ph.:* + 370 37422344, *e-mail:* rimantas.pareigis@vukhf.lt	LITHUANIA
PASTARUS JÜRI-RIVALDO	Tallinn University of Technology, Department of Mining, 5 Ehitajate tee St, Tallinn, 19086, Estonia, *ph.:* + 372 6203850, *fax:* + 372 6203696, *e-mail:* pastarus@cc.ttu.ee	ESTONIA
PLŪME IMANTS	Latvian University of Agriculture, Faculty of Technics, Cakstes boulv. 5, Jelgava, Latvia, LV-3001. *ph.:* + 371 3080674, *fax:* + 371 3027238, *e-mail:* imants@cs.llu.lv	LATVIA
PLŪME BENITA	“Sandio”, Liela str 3-24, Jelgava, LV-3001 *ph.:* + 371 9114406 *e-mail:* benitap@inbox.lv	LATVIA
PROLS JĀNIS	„Geo Consultants”, K.Ulmaņa gatve 3, Riga, LV-1004, Latvia *ph.:* + 371 7627504, *fax:* + 371 7623512, *e-mail:* gc@parks.lv	LATVIA
RANCĀNE SARMĪTE	Latvian University of Agriculture, Research Institute of Agriculture Agency, Skriveri-1, Aizkraukles raj., LV-5126, Latvia, *ph.:* + 371 5197524, *fax:* + 371 5197512, *e-mail:* maruta_sp@navigator.lv	LATVIA
RAČYS VIKTORAS	Kaunas University of Technology, Department of Environmental Engineering Radvilėnų pl. 19, Kaunas, LT-50270, Lithuania, *ph.:* + 370 37300182, *fax:* + 3702 37300152, *e-mail:* daina.kliaugaite@stud.ktu.lt	LITHUANIA
RADZEVIČIUS ALFREDAS	Institute of Geology and Geography T.Ševčenkos str., 13, Vilnius, LT-2600, *ph.:* + 370 52104708, *e-mail:* aradzev@geologin.lt	LITHUANIA
ROMĀNOVA DINA	University of Latvia, Kronvalda boulv- 4, Riga, LV-1586	LATVIA
STRAUPE INGA	Latvian University of Agriculture, Liela str. 2, Jelgava, LV-3001, *e-mail:* inga.straupe@llu.lv	LATVIA

ISBN 9984 – 779 – 06 – 8

SMITS MAREKS	Institute of Mechanics, Faculty of Engineering, Latvia University of Agriculture, J. Cakstes boulv. 5, LV-3001, Jelgava, Latvia, *ph.:* +371 3080674; *fax:* +371 3027238; *e-mail:* eriks@inka.cs.llu.lv	LATVIA
SIMUTIS RIMVYDAS	Vilnius University Kaunas Faculty of Humanities Muitines 8, 44280 Kaunas, Lithuania, *ph.:* + 370 37422566 , *e-mail:* rimvydas.simutis@vukhf.lt	LITHUANIA
SABANOVS SERGEI	Tallinn Technical University, Department of Mining Ehitajate tee 5, VII-202, Tallinn, 19086, Estonia *ph.:* + 372 6203850, *fax:* + 372 6203696, *e-mail:* sergei.sabanov@mail.ee	ESTONIA
SARKIUNAITE INGRIDA	Kaunas Faculty of Humanities, Vilnius University Muitines 8, Kaunas LT-42280, Lithuania, *ph.:* +370 37422344, + 371 422566, *e-mail:* ingrida.sarkiunaite@vukhf.lt	LITHUANIA
SERŽĀNE RASMA	Riga Technical University, Faculty of material science and applied chemistry, Azenes 14/24, Rīga, LV-1048, Latvia, *ph.:* + 371 7089220, *fax:* + 371 7615765, *e-mail:* mara@ktf.rtu.lv	LATVIA
SOKOLOVS ALEKSANDRS	Baltic Scientific Instruments (A Bruker AXS Company), Ganibu dambis 26, a.k.33, Riga, Latvia, *ph.:* + 371 7383947, + 371 7383919, *fax:* +(371)7382620, *e-mail:* bsi@bsi.lv	LATVIA
SPRUŽS JĀZEPS	Latvian University of Agriculture, Liela str. 2, Jelgava, LV – 3001, Latvia, *e-mail*: aleksandrs.adamovics@llu.lv, jazeps.spruzs@llu.lv	LATVIA
STRĒLE MAIJA	Riga Technical University, Faculty of material science and applied chemistry, Azenes 14/24, Riga, LV-1048, Latvia, *ph.:* + 371 7089220, *fax:* + 371 7615765, *e-mail:* mara@ktf.rtu.lv	LATVIA
SPĀRNIŅA MARUTA	Latvian University of Agriculture, Research Institute of Agriculture Agency, Skriveri-1, Aizkraukles raj., LV-5126, Latvia, *ph.:* + 371 5197524, *fax:* + 371 5197512, *e-mail:* maruta_sp@navigator.lv	LATVIA
STALAŽS ARTŪRS	Faculty of Biology, University of Latvia Kronvalda bulvaris 4, Riga, LV-1586, *ph.:* + 371 7034864	LATVIA

ISBN 9984 – 779 – 06 – 8

STRAMKALE VENERANDA	Scientific centre of agriculture of Latgale, Jaunvilani, Rezeknes raj., Latvia, *ph.:* +3 71 4628140, + 371 9465004, *e-mail:* aldisstr@apollo.lv	LATVIA
STRŪVE ZIGMĀRS	Baltic Scientific Instruments (A.Bruker AXS Company), Ganibu dambis 26, a.k.33, Riga, Latvia *ph.:* + 371 7383947, + 371 7383919, *fax:* + 371 7382620, *e-mail:* bsi@bsi.lv	LATVIA
ŠVARTA AGRITA	Latvian University of Agriculture, Research Institute of Agriculture Agency, Latvia, *ph.:* + 371 8353634 *e-mail:* svarta@inbox.lv	LATVIA
ŠMIGINS RUSLANS	Latvia University of Agriculture, Motor Vehicle Institute, 5 J.Cakstes boulv., Jelgava, LV-3001, Latvia, *ph.:* + 371 9151295, + 371 6872244, *fax:* + 371 3020762 *e-mail:* Ruslans.Smigins@llu.lv	LATVIA
TARAŠKEVIČIUS RIČARDAS	Institute of Geology and Geography, T. Ševčenkos 13, LT 2600,Vilnius, *ph.:* + 370 2104708, *fax:* + 370 2104695, *e-mail:* Taraskevicius@geo.lt,	LITHUANIA
TEIRUMNIEKS EDMUNDS	Riga Technical University, Faculty of material science and applied chemistry, Azenes 14/24, LV – 1048, Riga, Latvia Rezekne Higher Education Institution, faculty of Engineering Atbrivoshanas aleja 76, LV – 4601, Latvia, *ph.:* + 371 4625145, *fax:* + 371 4625167, *e-mail:* edmunds@ru.lv	LATVIA
URBANOVIČS IGORS	Latvian Stat Institute of Wood Chemistry, Laboratory of lignin chemistry Latvia, Riga, Dzerbenes iela 27, LV 1006, *ph.:* + 371 7545142, *fax:* + 371 7550635, *e-mail:* gdobele@ edi.lv	LATVIA
URNIEŽAITE INGA	Kaunas University of Technology, Department of Environmental Engineering, Radvilėnų pl. 19, Kaunas, LT-50270, Lithuania, *ph.:* + 370 37300182, *fax:* + 3702 37300152	LITHUANIA
UŽGA- REBROVS OLEGS	Rezekne Higher Education Institution, Atbrivoshanas al. 90, Rezekne, LV-4600, Latvia, *ph.:* + 371 4622904, + 371 9472205	LATVIA

ISBN 9984 – 779 – 06 – 8

VALŪNAS IRMANTAS	Kaunas University of Technology, Department of Environmental Engineering Radvilėnų pl. 19, Kaunas, LT-50254, Lithuania, *ph.:* + 370 37300182, *fax:* + 370 37300152, *e-mail:* Irmantas.Valunas@stud.ktu.lt	LITHUANIA
VALBAHS EDUARDS	Baltic Scientific Instruments (A Bruker AXS Company), Ganibu dambis 26, a.k.33, Riga, Latvia, *ph.:* + 371 7383947, + 371 7383919, *fax:* + 371 7382620, *e-mail:* bsi@bsi.lv	LATVIA
VETEIKIS DARIJUS	Vilnius University, Faculty of Natural Sciences, M. K. Čiurlionio 21, LT-03101, Vilnius, Lithuania, *ph.:* + 370 2104709, *e-mail:* jankauskaitė@geo.lt	LITHUANIA
VIGOVSKIS JĀNIS	Latvian University of Agriculture, Research Institute of Agriculture Agency, *ph.:* + 371 8353634 *e-mail:* svarta@inbox.lv	LATVIA
VIKMANE MĀRA	University of Latvia, Faculty of Biology, Kronvalda boulv. 4, Riga, LV-1586, *ph.:* +371 7034864, + 371 9364133, *e-mail:* mara.vikmane@lu.lv	LATVIA
ZACZEK-PEPLINSKA JANINA	Warsaw University of Technology, Institute of Applied Geodesy, *e-mail:* j.peplinska@gik.pw.edu.pl	POLAND
ZINKUTĖ RIMANTĖ	Institute of Geology and Geography T.Ševčenkos str., 13, Vilnius, LT-2600, *ph.:* + 370 52104708, e-mail: zinkute@geologin.lt	LITHUANIA
ZIHMANE KRISTĪNE	Riga Technical University, Faculty of material science and applied chemistry, Azenes 14/24, Riga, LV-1048, Latvia, *ph.:* + 371 7089220, *fax:* + 371 7615765, *e-mail:* mara@ktf.rtu.lv	LATVIA

ISBN 9984 – 779 – 06 – 8