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18.11. - 20.11.2015

organizované pod záštitou:

doc. Ing. Klaudia Halászová, PhD. - dean of theHorticulture and Landscape Engineering Faculty

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Obsah

PROPOSAL TO CALCULATE THE RIPARIAN BUFFER STRIP WIDTH OF SURFACE WATER BODIES

Jaroslav ANTAL, Elena KONDRLOVÁ

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ABSTRACT

Considering that the localization of riparian buffer strips is already determined by location of the stream, it is necessary to design their width, eventually propose vegetative species selection. Currently, the width of riparian buffer strips is usually determined by the more or less accurately defined characteristics of watercourses and the adjacent areas. The fixed recommended values of riparian buffer strip width ranges from 2 m to 30 m (> 30 m) depending on the adjoining slope steepness, erosion intensity on the adjoining slope and the functions which the strip should fulfil . The paper presents a modified equation of riparian buffer strips width calculation that takes into account the length of adjoining slope and its landuse, the amount of designed rainfall, soil properties as well as the required retention effectivity of riparian buffer strips. Thus, proposed formula includes the individual natural properties of the study area and provides more precise site-specific calculation of riparian buffer strip width at the catchment scale.

KEY WORDS

riparian buffer strip, slope length, surface runoff, potential retention, runoff curve number

INTRODUCTION

Riparian buffer zones are often advocated as environmental management tools for reducing impacts of land use activities on aquatic resources. The buffer zone, area, or strip is generally regarded as the strip of land that separates an upland or hillslope area from streams, lakes or wetlands. Land use activity is modified in this zone to prevent adverse effects on the water quality, biota and habitat within the watercourse. Parkyn (2004) summarizes various forms of riparian management:

- Grass Filter Strips: Fenced strip of rank paddock grasses to filter nutrients and sediment.
- Headwater or riparian wetlands: Fenced wetlands as hotspots for nutrient removal
- Rotational Grazing: Filter strips with varied stock grazing practices, such as occasional light grazing by sheep.
- Forested or planted native trees: a buffer of native trees to return ecological function to the stream and provide water quality benefits.
- Production trees or plants: a buffer of forestry trees left unharvested along stream banks, or production trees that are planted in riparian zones for selective harvesting with minimal disturbance
- Multi-tier system: a combination of buffers where native forest trees may be used beside the stream to enhance ecological function and biodiversity, a buffer of production trees may occur outside of that and at the outer edge beside agricultural land a grass filter strip may be used.

In general, riparian zones perform a wide range of environmental as well as social and economic valuable functions such as (Wenger, 1999; Jurík et al., 2012) trapping/removing sediment, contaminants and nutrients from runoff; stabilizing streambanks and reducing channel erosion; storing flood waters; maintaining habitat for aquatic organisms by water temperature control; providing woody debris and habitat for terrestrial organisms, improving esthetical, recreational and educational opportunities. Water quality of stream can be improved by fencing stock out of streams and retiring riparian margins from agricultural land use. The reduction of contaminants and sediments from overland flow is due to increasing the infiltration into soil, intercepting particulates, and removing soluble nutrients by plant uptake and denitrification (Parkyn, 2004).

Factors influencing the effectiveness of riparian buffers include soil type, type of vegetation, its density and structure, role of buffers in the ecosystem integrity, edge effects, surface roughness properties of adjacent land, intensity of land use and an urbanisation degree of the surrounding area (Macura, Halaj, 2013). Hawes and Smith (2005) highlighted as factors especially slope, rainfall, soil type and its infiltration rate, amount of impervious surfaces and vegetation structure characteristics. Table 1 presents the estimates in nutrient load reduction resulting from application of different buffer types. It is obvious, that the efficiency of removal/reduction of the specific nutrient is dependent on vegetation structure of the buffer. Moreover, the vegetation structure influences also the effectiveness to perform the other functions (Jurík et al., 2012).

Table 1 Estimated reduction of nutrient loads from implementation of riparian buffers (Hawes, Smith, 2005)

Buffer Type	Nitrogen	Phosphorus	Sediment
Forested	48-74%	36-70%	70-90%
Vegetated Filter Strips	4-70%	24-85%	53-97%
Forested and Vegetated Filter Strips	75-95%	73-79%	92-96%

Riparian buffer strip and vegetated filter strip (VFS) are often used to refer to strips of grass or other plants installed between or below agricultural fields to reduce erosion and trap contaminants (Wenger, 1999) and can be viewed as a last line of defence for attenuating contaminants and sediments before entering the water body (watercourse, reservoir, pond, etc.) (Parkyn, 2004). Therefore, the proper design of buffer dimensions is crucial to fully implement their functions.

Currently, the width of riparian buffer strips is usually determined by the more or less accurately defined characteristics of watercourses and the adjacent areas, e.g (Schulz et al., 1997):

- the minimum width of 3 m if the runoff is not the main problem;
- the minimum width of 6 m if the vegetation strip is also supposed to reduce (capture) the transport of eroded soil particles into water bodies;
- the minimum width of 20 m if the vegetation strip is supposed to reduce the penetration of agricultural chemicals into water bodies;

- the minimum width dependent on the category of the watercourse, namely 4 m for the water course narrower than 10 m, 6 m for watercourses from 10 to 50 m wide, and 10 m for watercourses of which the width between bank lines is greater than 50 m;
- the recommended width ranges between 2 m up to 26 m, depending on the slope of the riparian buffer strip and on the water erosion intensity on the adjacent areas (Muchová et al., 2009).

The width of a buffer strip is measured perpendicular to the stream. The chosen width should reflect the intensity of source, the topography, and whether the buffer is to protect streams from groundwater or surface water sources (Prosser et al., 1999). According to Hawes and Smith (2005) scientific studies have shown that efficient buffer widths range from 3 m for bank stabilization and stream shading, to over 90 m for wildlife habitat. Furthermore, the necessary width for an individual site may be less or more than the average recommendations, depending on soil type, slope, land use and other factors. In order to prevent most erosion, vegetated buffers of 9 m to 30 m have been shown to be effective. Regarding the water quality, the same authors, refer to buffers that range from 5 to 50 m and from 15 to 100 m for nutrients (nitrogen and phosphorous) and pesticides, respectively. Prosser and Karssies (2001) present recommended grass filter strip widths estimated for typical values of annual soil loss and filter strip slope under conditions of dispersed overland flow. According to these estimates the filter strip width ranges from 9 to 20 m for slopes from 1 to 10 %, respectively at the soil loss rate of 30 t ha^{-1} y^{-1}.
A fixed buffer width is the easiest to administer. Studies unanimously support the conclusion that buffer efficiency at filtering out pollutants increases with width. However, this does not increase infinitely, and the goal is to find the most efficient width (Hawes, Smith, 2005). The other buffer type is known as the three zone system, the buffer is divided into three parts with different width and vegetation types to help maximizing the efficiency of the whole buffer. To slow surface runoff, trap sediment and pesticides, the filter strip of grasses and herbaceous plants of minimum width of 9 m should be established as the outer zone. There are also approaches and models that have been created to consider individual site factors in determining the buffer width. Hawes and Smith (2005) introduced the formula developed at Cook College Department of Environmental Resources:

$$\text{Buffer width} = 2.5\ (\text{time of travel of overland flow}) * (\text{slope})^{0.5} \qquad (1)$$

Considering the drawing in Figure 1, there is a high probability that the size of contributing area per unit length of contributing area is not equivalent under natural conditions, while for the local slope length – L_P between the catchment boundary and the water course usually applies that:

$$L_{P,1} \neq L_{P,2} \neq L_{P,3} \neq \cdots \neq L_{P,n} \qquad (2)$$

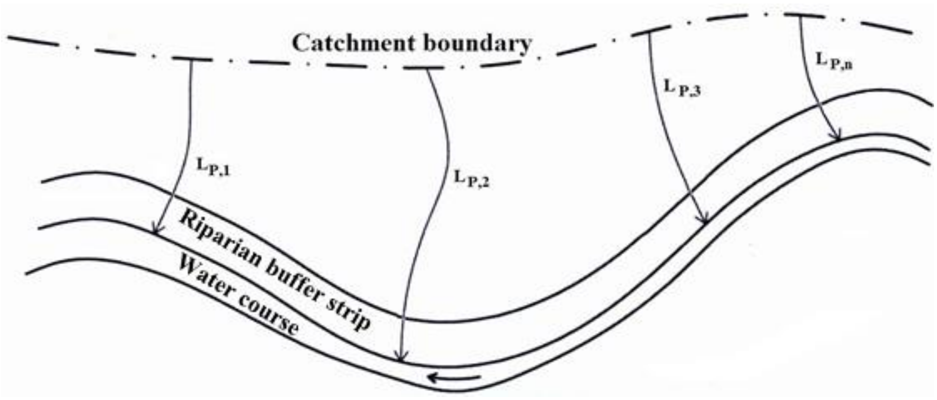

Figure 1 The length of local slopes between the catchment boundary and the water course (Source: Muchová, Antal, 2013, modified by authors)

Most of the methods of buffer strip width determination described above do not take into account this fact, neither the possibility of varying landuse and surface roughness on the adjacent slope. It is obvious, that according to the equation (1), the width of the buffer strip cannot be constant. The aim of this paper is to propose a method of estimation the riparian buffer strips width that takes into account the length of adjoining slope and its landuse, the amount of designed rainfall, soil properties as well as the required retention effectivity of riparian buffer strips.

MATERIAL AND METHODS

The primary task of riparian filter strip is to disconnect the surface runoff from the adjacent slope and transform the inflow onto subsurface water. These strips should be preferentially located along the contours and the distance from the catchment boundary along the steepest slope should be equal or less then the L_P – the maximum length of slope that can be applied without risk of water erosion.

Initially the minimum width of filter strip used to be determined according to equation that considered the infiltration capability of designed filter strip as well as adjacent slope (protected strip) (Cablík, Jůva, 1963 in Antal, 1985):

$$D \geq L_p \cdot \frac{i_{D,N} - v_{i,L}}{v_{i,D} - i_{D,N}} \quad (3)$$

where: D - width of the filter strip (m)

L_p – the width of adjacent slope/protected strip (m)

$i_{D,N}$ - intensity of the designed rainfall ($m.s^{-1}$)

$v_{i,L}$ – infiltration intensity on the protected strip ($m.s^{-1}$)

$v_{i,D}$ - infiltration intensity on the filter strip ($m.s^{-1}$)

Since it is difficult to estimate the soil infiltration rate for different landuse at variable quality of land cover, the credible data are missing. Therefore, we recommend to combine the formula (3) with the worldwide known runoff curve numbers designated as CN that are used e.g. in catchment scale calculations of sediment delivery ratio (Kondrlová et al., 2013) and the amount of direct surface runoff (Šinka, Kaletová, 2013; Kaletová, Šinka, 2012). This approach estimates the potential (maximum) retention and the height of direct runoff according to formula (4) (Chow, 1964 in Antal, 1985) and thus takes into account specific properties of soil, landuse and vegetation cover:

$$H_D = \frac{(H_{D,N} - 0{,}2\,.\,A)^2}{H_{D,N} + 0{,}8\,.\,A} \tag{4}$$

where: H_D - the height of direct surface runoff (mm)

$H_{D,N}$ – the height of designed rainfall (mm)

A – potential retention of the contributing area (mm)

RESULTS AND DISCUSSION

The proposed modification of the equation (3) is based on the condition that the designed width of VFS should be sufficient to trap the entire volume of rain fallen on the filter strip increased by the amount of surface runoff to VFS. The proposed equation (5) takes into account the length and the landuse of the adjacent slope, the amount and duration of designed rainfall, the soil hydrological properties as well as the hydrological characteristics of the vegetation cover of VFS.

$$D \geq L_P\,.\,\frac{H_{O,L}}{0{,}2\,.\,A_D - H_{D,N}} \tag{5}$$

where D – width of the vegetation filter strip (VFS) (m)

L_P – the length of the adjacent slope (m)

$H_{O,L}$ – amount of surface runoff from adjacent area (mm)

A_D – potential retention of the filter strip (mm)

$H_{D,N}$ – the amount of designed rainfall (mm)

If equation (5) is added the following parameter $e \leq 1$ that expresses the required proportion of the amount of surface runoff transformation from adjacent areas to subsurface water by VFS and the parameter x_n, which expresses the ratio between the required width of the riparian buffer strip - D_n pertaining to the related local slope $L_{P,n}$ and the length of this local slope - $L_{P,n}$, then the equation (2) can be modified to the form:

$$D_n \geq L_{P,n}\,.\,e\,.\,\frac{H_{O,L}}{0{,}2\,.\,A_D - H_{D,N}} \tag{6a}$$

resp.

$$x_n = \frac{D_n}{L_{P,n}} \geq e.\frac{H_{O,L}}{0{,}2\,.\,A_D - H_{D,N}} \tag{6b}$$

Figure 2 shows the dependence of x_n to $H_{D,N}$ in case that the adjacent slope is used as fallow, soil belongs to the hydrologic group A and that $e = 1$, thus we want the VFS to transform the entire surface runoff from the contributing area to subsurface water.

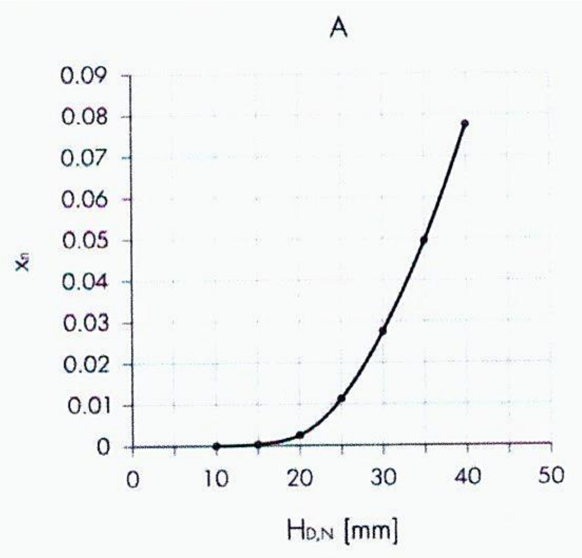

Figure 2 The dependence of x_n=f($H_{D,N}$) (Source: Muchová, Antal, 2013)

Prosser and Karssies (2001) proposed equation (7) in their work to determine the width of FVS:

$$w = Y + \frac{1}{\rho_g H_g} \cdot \left[\left(\frac{Aa}{l_s}\right) - \left(\frac{\rho_b {H_b}^2}{2tan\theta}\right)\right] \quad (7)$$

where: w – whole width of VFS (m)

Y – additional width for trapping of fine suspended sediment beyond the sediment wedge. Recommended values are Y=2 m for low and moderately erodible soils, resp. Y=5 m for highly erodible soils.

ρ_g – average bulk density of sediment deposits on VFS (t.m^{-3})

H_g – sediment depth in vegetation of VFS (m)

A – annual soil loss from plot above VFS (t.ha^{-1}.y^{-1})

a – total plot area (m^2)

l_s – length of sediment deposit along VFS (m)

ρ_b – average bulk density of sediment deposits at the front of VFS (t.m^{-3})

H_b – sediment depth at the front of VFS (m)

θ – slope gradient at the VFS edge (°)

Their design of a filter strip considers three factors:

a) the amount of sediment that gets stored in the backwater before the grass strip

b) the width of grass strip required to store the remaining sediment

c) an additional width of un-impacted grass to trap as much if fine suspended sediment as possible.

Prosser and Karssies (2001) used average annual soil loss as an indicator of the intensity of a typical large erosion event as soil loss in any season is focused in a few events at most. Such filters will be effective sediment traps over most conditions, but will not be effective for extreme events such as 1 in 100 year recurrence interval events. To determine the bulk density of sediments and annual soil loss requires field measurements and monitoring, therefore this kind of data might not be available for many areas. On the other hand, input information on management practices and quality of vegetation cover as well as landuse required for equation (5) can be evaluated easier using various sources (crop rotations, aerial/satellite images, visiting the field), although the criteria selection might be at specific cases subjective. In case that the long term rainfall observations are available, the calculation of VFS can take into account any desired rainfall recurrence interval.

Our approach is in agreement with the conclusions of Parkyn (2004) that because of the link between streams and their catchments, improved land management together with riparian management are required to achieve improvements in water quality and stream habitat. Research for the future will be most effective if it addresses catchment scale issues such as these. Riparian management options will need to be designed with the hydrological pathways, soil drainage, and topography of the catchment in mind and targeted to areas where the most benefit can be achieved. Therefore, to fulfil these goals, VFS design should result in variable width considering individual site factors.

CONCLUSION

There are various approaches of calculation the width of vegetated filter strip. Although the fixed buffer width is easier to administer, the effectiveness of the buffer at the specific site is uncertain. To meet the objectives of riparian management and gain the highest benefit from VFS, the catchment scale approach considering the local area characteristics such as landuse as well as its hydrological and topographical characteristics or annual soil loss is recommended for VFS width calculation. Since filter strips have a limited sediment storage capacity beyond which they are no longer effective, the precise design of strip vegetation structure is also crucial.

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THE INFLUENCE OF CLIMBERS GROWING ON NOISE BARRIERS FOR THE DISPERSAL OF SOUND

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SUMMARY

The aim of this work was to examine the influence of climbing plants covering acoustic screens for the dispersal of sound.

Noise measurements were made at main arteries of communication in the city, behind screens covered with climbers as well as in places with no acoustic barriers. The results were analyzed with statistical methods which showed the influence of climbers on the dispersal of sound waves. The analysis showed a correlation between the organization of traffic and placement of plants on noise barriers. The presence of both factors at the same time significantly reduces noise pollution.

KEYWORDS

climbing plants, noise pollution, noise barrier, acoustic screens, sound waves.

INTRODUCTION

Noise is one of the major pollutants affecting human health. The fast development of transport industry causes excessive noise emission and road traffic is the main source of noise pollution in big cities. Over the two thirds of the population of Europe is currently exposed to noise exceeding the 55 dB norm, due to the fact that most of the people live in big cities (Klaeboe 2012). Designers of land traffic networks in the majority of Polish cities could not predict such a rapid growth in the use of road transportation. As a result, street congestion is the source of greater noise pollution intensified by agitated drivers honking their horns which contributes to noise exceeding permissible levels. Therefore, in places where urban structure allows, acoustic screens are used as noise barriers. However, such a solution causes space fragmentation as well as limitation of sight. This type of facility frequently destroys the composition of space and architecture in the place where it is situated. The application of climbers softens the sharp shape of acoustic screens and adds character to the monotony of vertical surfaces. Big screens covered with climbing plants may constitute an attractive background, changing colours with the seasons (Borowski and Marczyński 2005). Planting climbers on acoustic screens is also the simplest way of reducing air pollution due to their ability of phytoremediation (remediation of contaminated air and soil). It turns out that plant barriers also act in an indirect way.

Independent groups of researchers have shown that vegetation can directly reduce the noise. The way we perceive sound arduousness vary - when we cannot see its source, it seems to be less annoying (Dzhambov i Dimitrova 2004). Research on attenuation of sound waves, relates mainly to trees and shrubs. A model of noise reduction with tree belts was examined by Cook and Haverbeke (1974). They concluded that the width of vegetation belts is a significant noise reduction factor. Greater width, composed of more trees, increases absorption. Other studies have also concluded that tree belt width of at least 30m provides greater noise reduction and diffusion (Reethof 1963). When the tree belt was longer, the

noise reduction effects were greater (Reethof and Heisler 1976). One of the first in Central Europe, was the research done by Supuka (1984). He measured the noise insulation capacity of four model of verdure. Although relatively simple devices were used for the study, the results were quite interesting. The meadow space, of an open agricultural landscape, mixed stand of *Quercus robur* L., *Q. ceris* L., and *Carpinus betulus* L. in leafless stage, and with leafs (in summer), one row of *Thuja oreirntalis* L. 1,5 m wide, and *Pinus nigra* Arnold., 10 m wide and a compact stripe of *Forsythia* (Thumb.) 3 m wide were compared. In comparison with air damping effect in an open field, the model of *Pinus nigra* and *Forsythia*, showed the highest efficiency in attenuation of sound. Supuka (1991) conducted further studies, and shown, that the effect of attenuation is stronger especially to higher frequency of sound from 1-16 kHz, which is harmful to man. The most effective are belts of greenery width 12 -15 m.
Fang and Ling (2003) selected 35 large plantations of single species with a uniform density and height, and an ambient noise for acoustic measurement. An ambient noise maintained at 48 ± 2 dBA. City traffic noise was recorded as the noise source in this experiment. The sound pressure level range was 73–77 dBA at a distance of 5m from the source. Control test runs were set up on open ground near tree belts being tested to compare the differences in sound pressure levels. In the 35 tree belts studied, the group that consisted of dense shrubs had the best reduction effect. Fang and Ling (2003) concluded, that to provide the best reduction effect, shrubs should be planted under trees.

The unit of sound intensity, which is most commonly used in the study is Bel and Decybel - dB. Decibels describe the ratio of sound pressure to the reference pressure. In the case of the acoustics the most common reference level is the threshold of audibility. The level of 0dB does not mean absolute silence only that examined sound is below the threshold of audibility (Alton 2004).

AIM OF WORK

The objective of the work was to examine the influence of climbing plants covering acoustic screens on the dispersal of sound waves.

MATERIALS AND METHODS

Measurements of noise density have been made at sites meeting the following criteria:
roads with intense traffic, suitable length of the screens partly covered with climbers and the same screens without climbers. Another important condition was the lack of alternative sources of noise that could distort the results of measurements. The routes fulfilling the demands were as follows: Al. Prymasa 1000-lecia, Al. Armii Krajowej, Al. Wilanowska, ul. Generała Maczka (fig.1). The measurements were also made at the Route E67 (S8), in villages: Trojany, Niegów, Gaj and Mostówka (fig.2). The volume of traffic was examined in 2005 by Biuro Planowania Rozwoju Warszawy (Tab.1). The volume of traffic at Route E67 was examined by Generalna Dyrekcja Dróg Krajowych i Autostrad in 2010. It was assessed that the average use of the route is 23 207 vehicles daily.

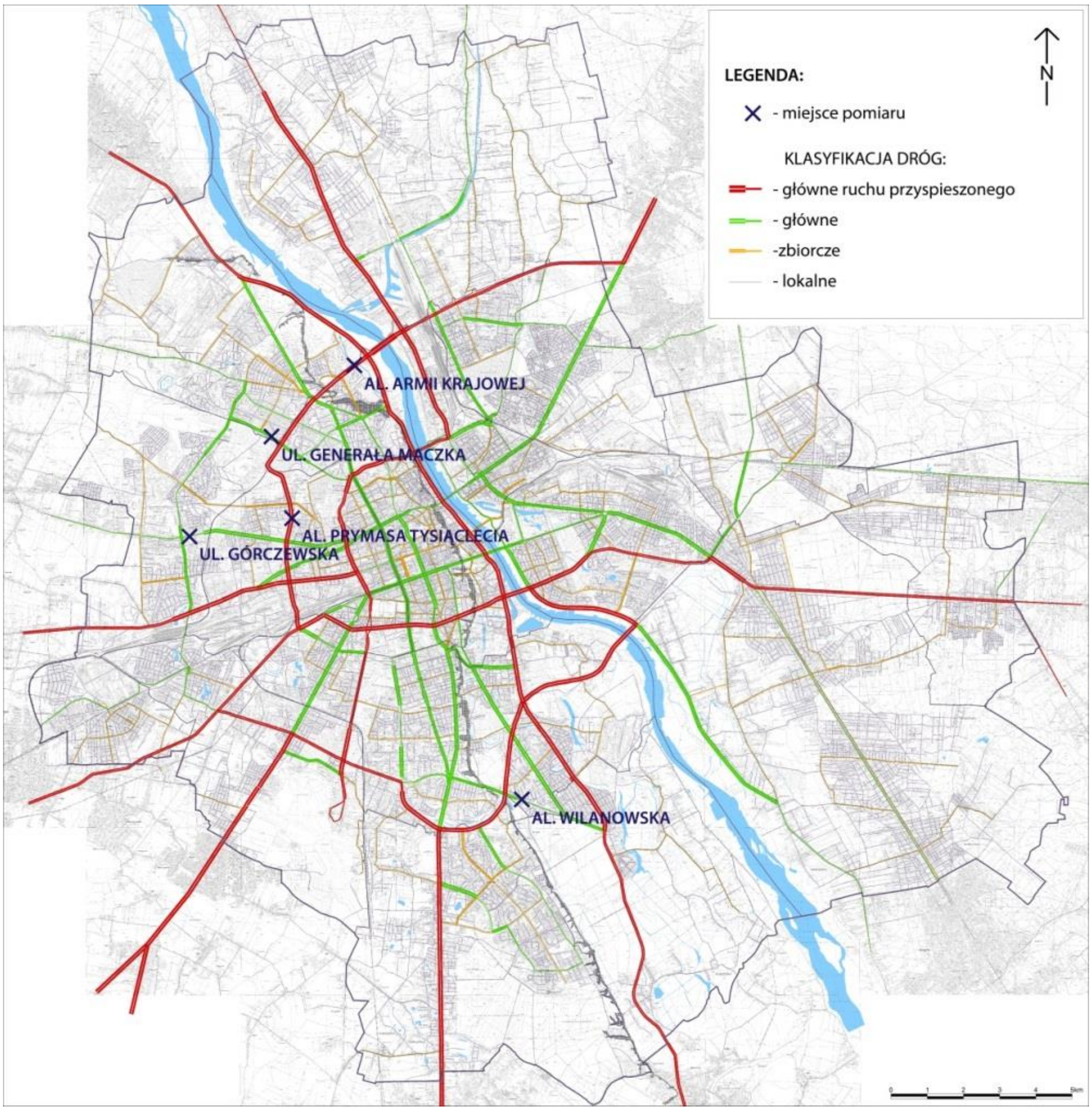

Figure1 The points of measurements at the main arterial roads in Warsaw

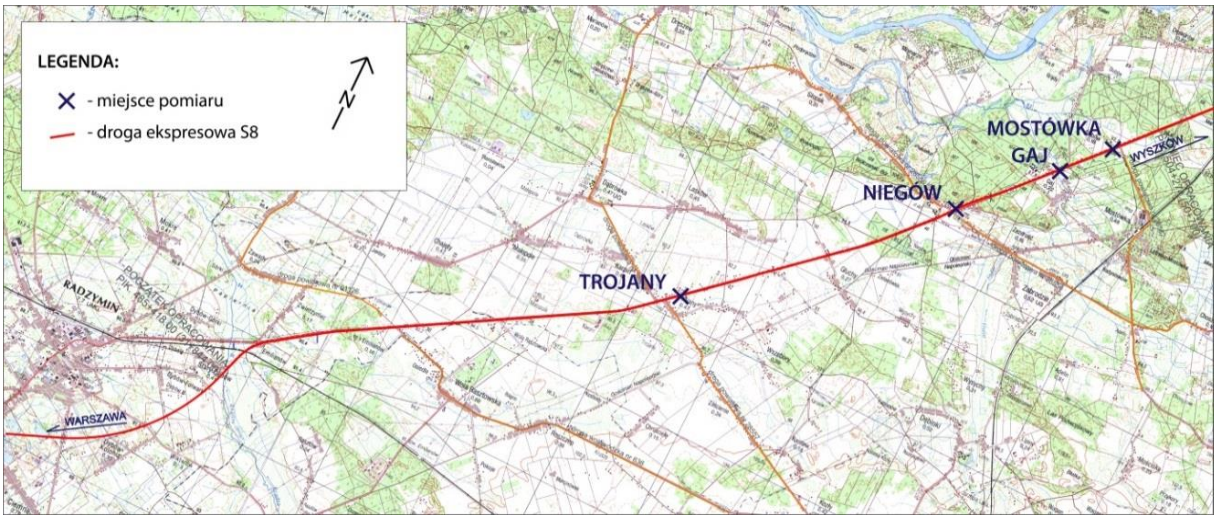

Figure 2 The points of measurement at the Route S8, Warszawa – Białystok

Table 1 The number of vehicles at selected routes during peak traffic (Biuro Planowania Rozwoju Warszawy S. A. 2005)

The route	Morning peak hours traffic	Afternoon peak hours traffic
Al. Prymasa 1000-lecia	7909	7143
Al. Armii Krajowej	5691	6343
Al. Wilanowska	2948	1114
Ul. Generała Maczka	2789	2893
Ul. Górczewska	2002	2348

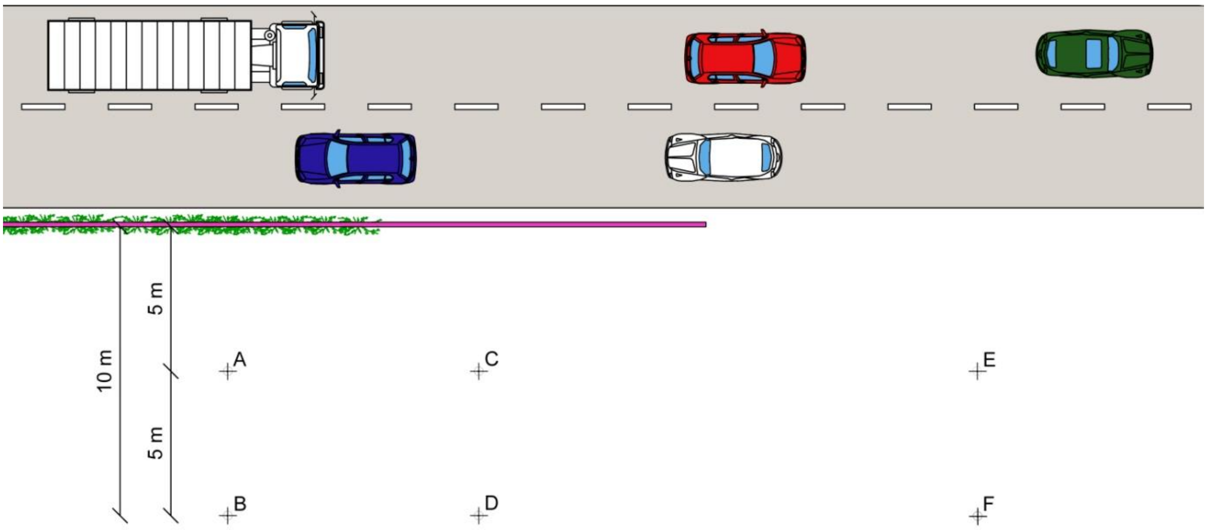

Figure 3 Location of measurement points in relation to acoustic screens

Noise measurements were made with sonometer DT-8852 CEM, the device complies with the standard IEC61672-1 Class 2.

Specification of the sound level meter (sonometer): the measurement range 30-130 dB, weighting filters A and C, indication of exceeding upper / lower measuring range, accuracy ± 1.4 dB, measurement resolution of 0.1 dB.

During the measurement, the sound level meter was placed on a tripod at the height of 1.2 meters above the ground. The speaker was directed toward the acoustic screen. The distance from the screen was measured with the measuring tape (photo 1). A single measurement lasted two minutes. Measurements were repeated if there was an event disturbing the measurement, such as the occurrence of a noise source located on the same side of the screen as the sound level meter.

Photo1 The measurement of noise intensity in 10 meters distance from the acoustic screen at Aleja Prymasa 1000-lecia (Draps 2014)

RESULTS

- The presence of climbers on acoustic screens and noise intensity

The data received from measurements have been analyzed by adopting the statistical analysis method. The influences of the distance and traffic management on noise density have been analyzed as well. The software used for the data analysis was STATISTICA.
It can be seen that the level of noise intensity depends on the presence of climbers and the adoption or not of acoustic screens. The results show that there are three homogenous groups and statistically diverse mean values (fig.4).
In the first analysis the data was not categorized relative to the distance from the screens. Next, corresponding analysis was carried out by dividing the data into the results of measurements made from the 5 meters and 10 meters.
The analysis of the data of measurements made at 5 meters showed similarity to the general results – there were significant differences between the mean values of noise density (fig 5).
In the case of the 10 meter measurements, there were no significant differences between the noise density behind the screens with climbers and those without climbers (fig 6).

- Noise density and the efficacy of climbers on acoustic screens

The histograms that follow represent the comparison of different values categorized so as to show the distribution of noise density depending on the presence of climbers on screens.
The chart illustrates noise density distribution behind the screens with climbers at 5 meters from the point of measurement.
The majority of observations fall into the range of 65 -70 dB (30,17%) as well as 70-75 dB (34,46%) and are 2/3 of all observations. The values above 75 dB make up 15,08% of the results (fig.7).
The histogram (fig. 8) presents similar distribution to the diagram (fig.7). The range 65 -70 dB make up 69,09 % of all observations, while noise exceeding the 75 dB make up 19,46 % of the observations which is 1/3 more than that which occurred on the screens with climbers.

Such noise level distribution implies that plants efficacy in noise absorption grows in proportion to higher noise intensity.

Traffic organization impacts on the degree of noise pollution. Noise is significantly intensified by continuous traffic rather than by intermittent (pulsate) traffic.

The charts indicate mutual influence of traffic organization and climbers.

The diagram illustrates the distribution of the values of noise density behind the screens without climbers from measurements made at a distance of 5 meters by roads with intermittent traffic. The values beyond 75 dB make up 11, 71 % of all measurements (fig.9).

The diagram (fig.10) illustrates the distribution of the values of noise density behind the screens with climbers from measurements at a distance of 5 meters, by roads with intermittent traffic. The values beyond 75 dB make only 7, 39% of all measurements, which is 4,79% less in comparisons to screens without climbers (fig.9, 10).

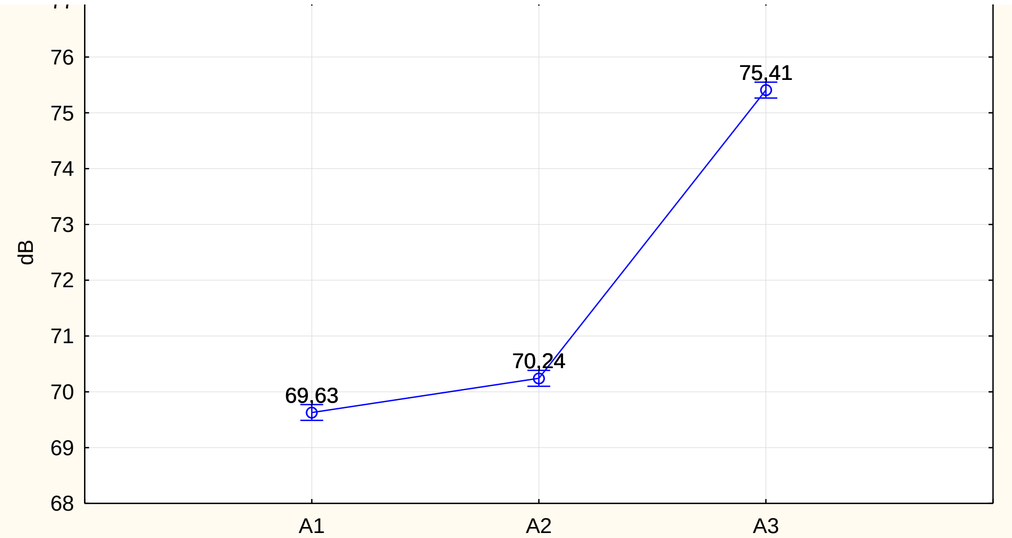

Figure 4 Average noise intensity: A1 –screen with climbers, A2 – screen without climbers, A3 – no screen, and 95% confidence intervals

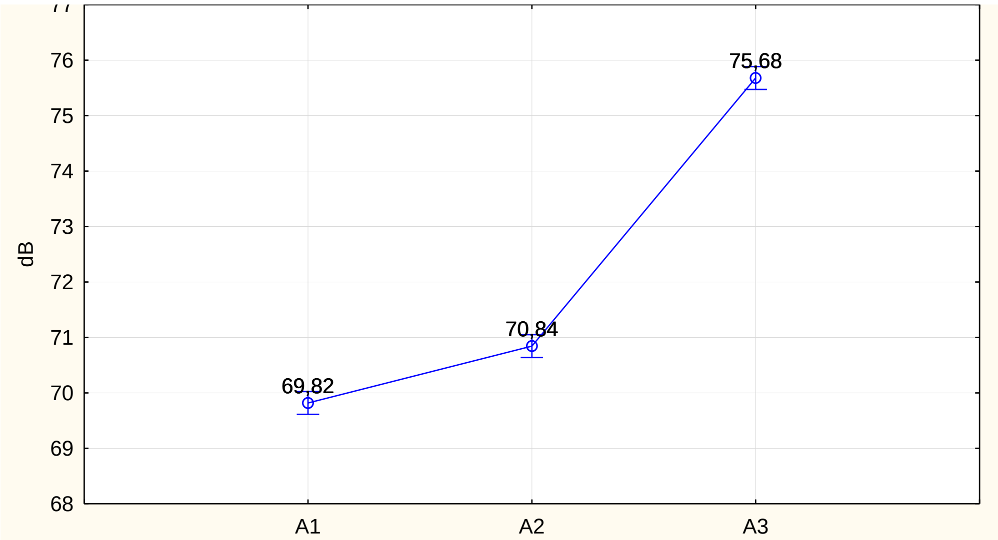

Figure 5 Average noise intensity: A1 – screen with climbers, A2 – screen without climbers, A3 – no screen, at a distance of 5 meters and 95% confidence intervals

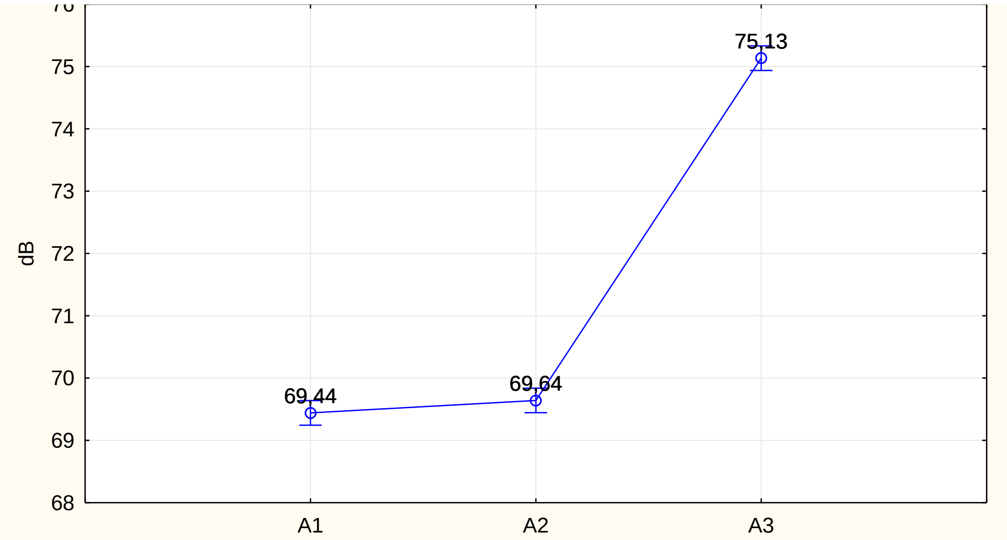

Figure 6 Average noise intensity: A1 – screen with climbers, A2 – screen without climbers, A3 – no screen, at a distance of 10 meters and 95% confidence intervals

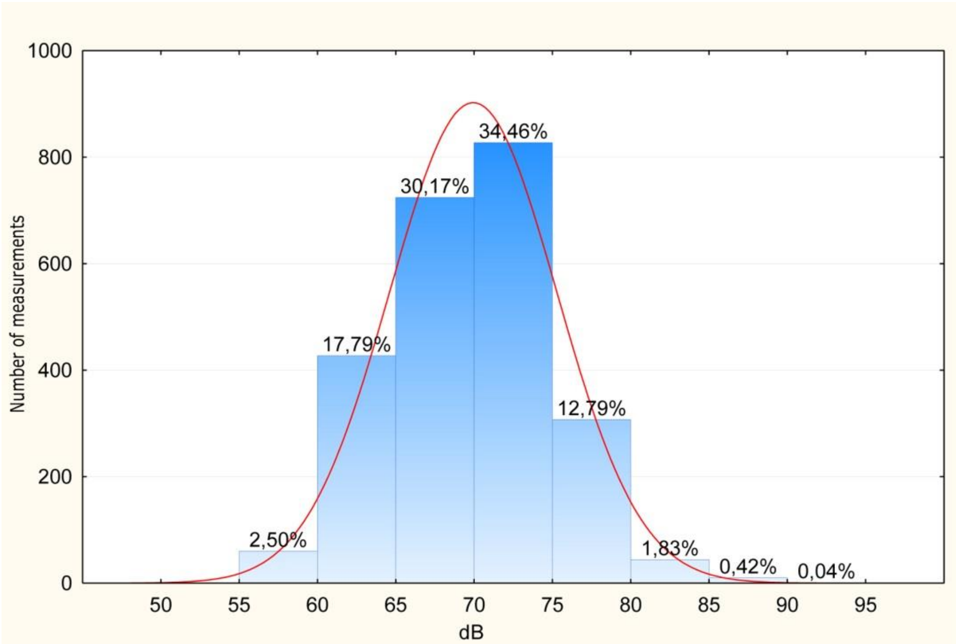

Figure 7 The histogram of measurement values of noise intensity behind screens with climbers, measurements made at distance of 5 meters

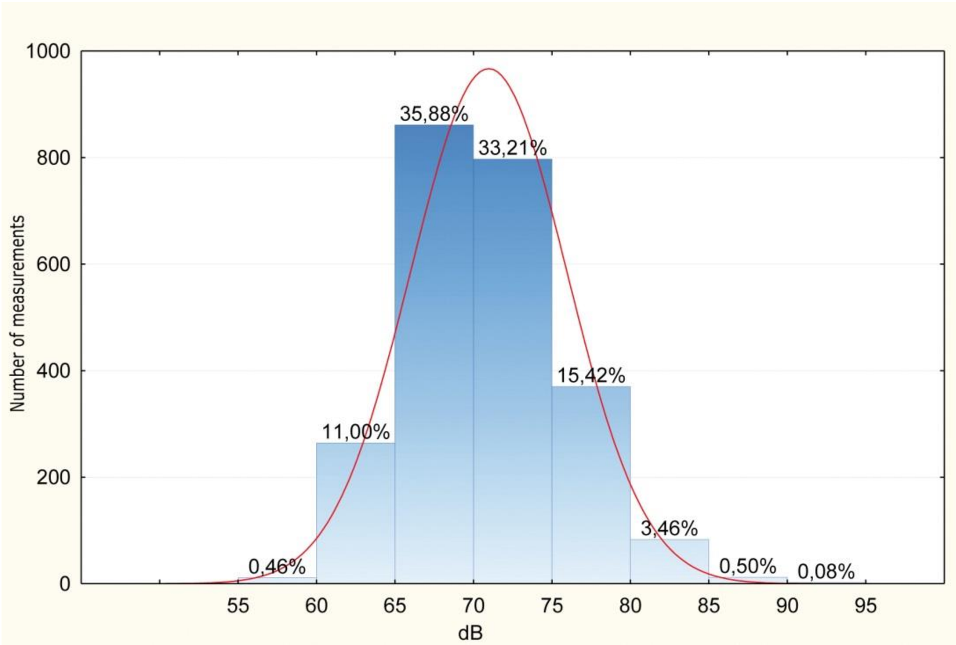

Figure 8 The histogram of measurement values of noise intensity behind screens with no climbers, measurements made at a distance of 5 meters

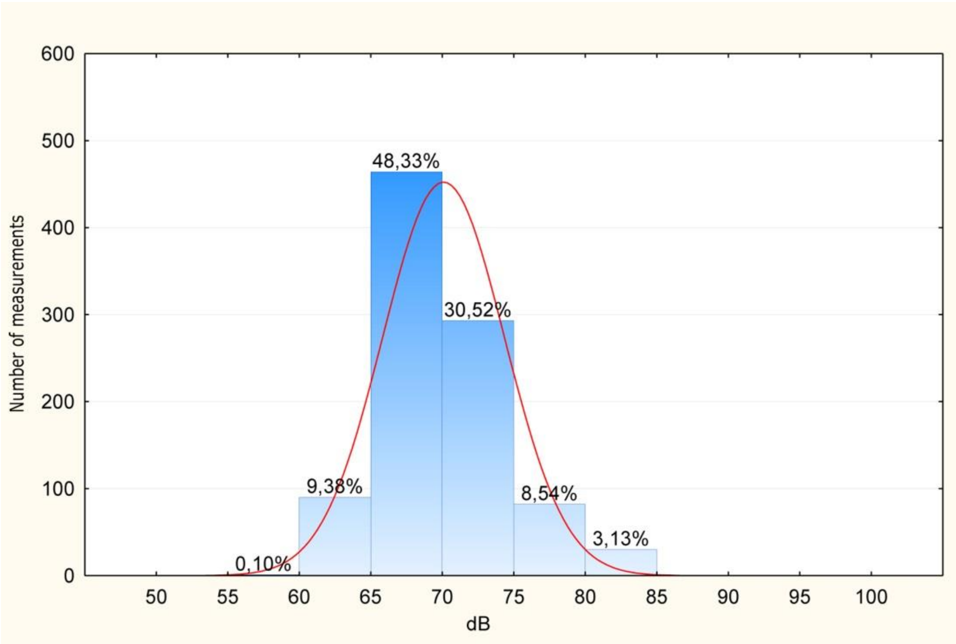

Figure 9 The measurement values of noise intensity behind screens without climbers on a road with intermittent traffic, measurements made at a distance of 5 meters

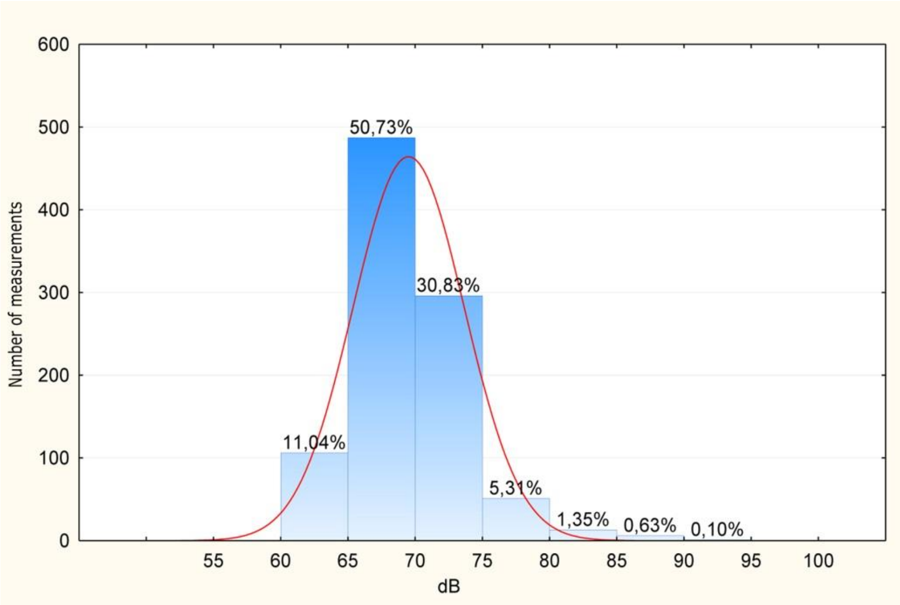

Figure 10 Measurement values of noise intensity behind screens with climbers on roads with intermittent traffic, measurements made at a distance of 5 meters

DISCUSSION

The research proves that there is a significant impact thanks to the presence of climbers on acoustic screens and the reduction of noise density. Climbers planted by acoustic screens have an ability to limit noise levels. It is the result of absorption and dispersal of sound waves. This effect seemed most apparent when the measurements were made at a distance of 5 from screens.

The measurements made by screens at a distance of 10 meters from the road showed no significant impact of climbers on noise distribution. The absence of relevant change in noise density is probably due to the decrease of acoustic shadow. As the distance grows the diffraction effect occurs (sound wave diffraction at the edge of a sound barrier). As a result of this, the efficacy of acoustic screens decreases as the distance grows.

The difference observed – in noise intensity behind the screens with and without climbers - is not big and falls in the range of the sonometer precision. It can be assumed that at test level the error of measurement was standard. The data base used for the analysis consists of 14 400 records. With this multitude of measurements the error was averaged and it could not have any impact on the results. The plants ability of noise absorption has been confirmed by Timur and Karaca (2013) who in their work "Vertical gardens" describe the advantages of vertical gardens mentioning acoustic isolation of buildings. In their opinion creating a vertical garden on an elevation of a building is capable of reducing noise down 5 dB.

Due to the fact that this type of a garden is made of PCW board, felt, soil substrate and plants it does not prove the capability of plants to reduce noise, because noise decrease may be influenced by all ingredients of the vertical garden system. There has not been any examination made so far showing to what degree a vertical garden system without plants would reduce noise.

Although it was not the aim of the research, it has also proved that efficient organization of traffic helps to reduce noise intensity. This effect was observed also by Chambers (2005) as well as by Chambers and Jensen (2005).

The analysis showed that effective noise wave's absorption by plants can be assessed mainly in places with high noise density.

CONCLUSIONS

1. Climbers on acoustic screens are prove, to have the capability of reducing noise intensity.
2. The difference in noise absorption is significant when measurements are taken at 5 meter from screens.
3. Climbers covering acoustic screens are capable of reducing mainly the noise of values higher than 75 dB.

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BENCHMARKING AND TYPOLOGY METHODS IN SERVICE OF SPATIAL PLANNING. COMPREHENSIVE ASSESSMENT OF DEVELOPMENT POTENTIAL

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ABSTRACT

One of the issues of modern economy is how to measure development level of individual geographical areas. Study of region competitiveness and regional disproportions is a challenge in and of itself.

This paper tackles the issue of assessing level of development and development potential of communes (gmina, third-tier administrative units) in the Kraków district (powiat, second-tier administrative unit) that border on the city of Kraków. A detailed analysis of the communes' situation performed for the paper was based on selected social, economic, and environmental indices. Measurement of development processes, as one of the tasks of modern economy, was carried out using the benchmarking and typology method. An attempt was made to define causes of the current situation and possible disparity in the level of development of the communes. Any spatial differences in terms of the dominant direction of development of a commune were looked into. The analysis facilitated assignment of the communes to separate developmental groups (predefined with appropriate assumptions). Data used in the analysis comes from Local Data Bank (LDB).

KEY WORDS

Local Data Bank (LDB), benchmarking method, typology, development potential

INTRODUCTION

Commune development is man's responsibility. Humans contribute to successes and failures by taking various actions. Therefore, any decisions made by local authorities should follow from studies and strategies based on facts (Borodako, 2004). This would facilitate defining a feasible direction of development. According to Brol (2008), territorial development is influenced both by exogenous and endogenous factors that are, to some extent, the “key to success”. It is possible by outlining not only strengths but also problems of administrative units and solutions to resolve difficulties or reduce their degrading impact. One of the methods for stimulating development and, according to Czyż-Gwiazda (2006), helping to increase competitiveness, is benchmarking. Typology facilitates classification and description of objects. It makes systematisation and description of their relations possible, which in turns helps to make strategic decisions.

MATERIALS AND METHODS

Study area includes territory of 10 communes (both rural and rural-urban) in the Małopolskie Voivodeship, Kraków district that border on the city of Kraków (Fig. 1).

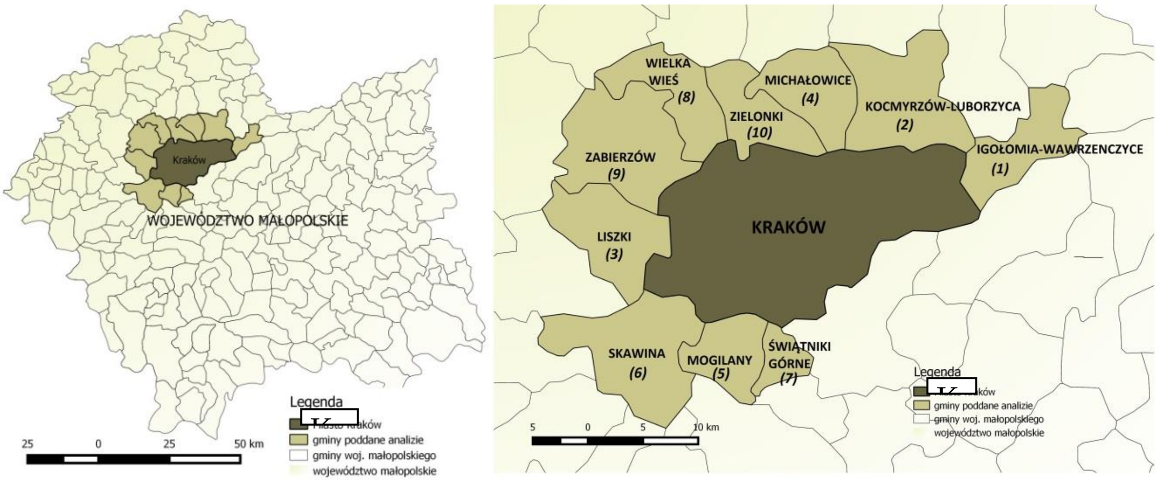

Figure 1 Study area
(Source: Own work)

The indices were selected in such a way as to make analysis for the study area as effective as possible. They facilitated comprehensive assessment of development potential of the communes and outlining possible directions of development. This stage is of vital importance as incorrect selection of indices could result in distorted picture of the situation and suggest infeasible solutions. As shown in Table 1, the indices were divided into 4 research sectors: society, economy, spatial development, and environment. Development potential of a region is made up of various factors. It is a result of resources each commune has, both human (sector I: society) and economic (sector II: economy), and local conditions (sector IV: environment). Furthermore, possibilities and abilities to use these resources are very important or even vital (sector III: spatial development). The potential is in a way a sum of these interdependent factors. This method of data selection facilitated a broad and multidimensional description of studied places. Each sector has information on various features that impact commune's development potential.

Table 1 Summary of indices

SECTOR I: SOCIETY	
X1	Population density, number of residents per 1 km^2 [people/km^2]
X2	Change in population per 1000 residents [people]
X3	Demographic burden: number of people under or over working age per 100 people of working age [people]
X4	Total population growth [%]
X5	Share of unemployed persons registered as work seekers in the number of people of working age [%]
SECTOR II: ECONOMY	
X1	Share of public road expenditures in total expenditures (communes excluding towns with district rights) [%]
X2	Expenditures per capita [PLN]
X3	Revenue per capita [PLN]
X4	Registered business entities per 1000 people [-]
X5	Entities removed from the register of businesses per 10,000 people [-]
SECTOR III: SPATIAL DEVELOPMENT	
X1	Length of active water supply system to total area [km/km^2]
X2	Length of active sewage system to total area [km/km^2]
X3	People using water supply system in % of total population [%]
X4	People using sewage system in % of total population [%]

X5	Share of area included in a valid local spatial development plans in total area [%]
SECTOR IV: ENVIRONMENT	
x1	Commune forests to total commune area [%]
x2	Area protected by law to total commune area [%]
x3	Greenery to total area [%]
x4	Water consumption for needs of the national economy and population during the year per capita [m^3/person]
x5	Industrial and municipal wastewater requiring treatment discharged into waters or into the ground during the year per capita [m^3/person]

(Source: Own work)

Statistical data used in the analysis is for year 2014 and was extracted from Local Data Bank (LDB). A set of tabulated lists and visualisations (cartograms and thematic maps) was made from sorted data and analysed in depth. Intensity of individual phenomena was taken into consideration and an attempt made to define their causes and consequences.

Development potential was assessed using two methods: benchmarking and typology. Benchmarking, a type of comparative analysis, can be used on multiple levels to fit various needs. In the case of local government units, it can be used to determine their competitive position, create local development policy, and find solutions that could resolve problems or mitigate their repercussions by utilising knowledge about units that employed the right solution for a particular problem (Podręcznik dobrych praktyk regionalnych, 2007). According to the Słownik Rozwoju Regionalnego [Dictionary of Regional Development] cited at www.regioportal.pl, this method facilitates positive results by basing on experience and knowledge of those who achieved satisfactory (better) results in a given sector. This method or process involves periodic measurement of values and juxtaposing of results to improve unit's effectiveness (Borodako, 2004). Świerk (2004) notes that the clue of this method is that solutions that turned out to be ineffective or harmful for the development process are set aside. Imperfection and negative aspects of the method that make it rather unpopular have to be mentioned. First of all, it is an arduous and costly process. Lack of predefined analytical rules may be considered both an advantage and a flaw of the method. On the one hand, it may introduce chaos and faulty results but on the other hand, it allows researchers to adjust the method to the purpose of the analysis and manner of using the results it yields. This is further confirmed by Kuczewska (2007). According to her, no assessment method is perfect as content of a work should be adjusted to its specific characteristics.

In this work, the original benchmarking method involved assignment of points to indices (0 to 3, where 3 is the best) according to intensity of a given phenomenon. Features classified to individual sectors were given weights to reflect assumed significance of a feature for the whole sector (values from 1 to 5, where 1 is the least significant factor). Calculated weighed means (product of assigned points and weight of a feature) were used to assign aggregated points to communes to each of the four sectors. Due to differences in significance of individual sectors in commune development, “reduction weights for sectors” were employed (1 to 4). Society was deemed to be the most important sector as it is the primary task of a commune to cater society's needs. Therefore, a weight of 4 was assigned to it. The “spatial development” sector was assigned reduction weight 3 due to indices for technical infrastructure network included in it as it is the infrastructure that, in a way, determines location of investments in a given area and impacts its development. Economy was assigned weight 2 as the driving force behind progress. Environment was assigned weight 1 as it does not impact development directly and is an accessory value. Calculation of weighed mean facilitated classification of individual communes to one of three types: large, medium, and small development potential commune.

Next stage was to prepare a typological analysis. Typology, study of types, facilitates classification and arrangement of objects or phenomena. Similarities between elements of a certain set emerge when they are assigned to specific standard subgroups (Kamińska-Szmaj, 2001). Wysocki (2010) notes the foundation of each typological procedure, which is to create input data matrix made up of features characteristic of the selected objects. It is vital that these features are coherent, logical, and factually related to the studied phenomenon. Numerous papers have indicated the challenge and importance of appropriate selection of diagnostic features. This choice often determines results of the typology (Sompolska-Rzechuła, 2013). What is important, typology can be applied to various fields just as benchmarking. It may have terminological, classificational, or heuristic functions (Domański, 1964). Systematisation and provision of clear definitions of concepts and sets as well as describing them in such a way as to compare them with predefined types reveal new, unknown facts and patterns. As regards spatial units, there are numerous studies that employ the discussed procedure: from typology of "space" as a signifying notion (Lisowski, 2014) to typologies of agriculture or residential space (Groeger L., 2012). The most common and primary study subjects are administrative units (communes, districts, or voivodeships) or cities, census districts, or statistical localities (Frankowski, 1991). It is strictly related to availability of statistical data, which is the basic source of information about space.

For this paper, the purpose of the typological analysis was to determine development potential of the selected communes of the Kraków district as well. Information derived from indices of the four sectors discussed above was utilised in the study. In order to include the widest possible scope of information in the analysis, one diagnostic feature from each sector was selected. It was the feature that was the most related to other ones in its group (most representative of a given sector) and the least related to other features chosen for the study (each piece of information included at most once). Selected features had to exhibit the greatest variance possible. Multiple units of measure were used as the study concerned various phenomena. For any comparisons to be possible, a normalisation procedure was necessary. In this case, factual characterisation of features was applied followed by the zero unitarisation method. The characterisation involved determining whether a feature can be deemed to be a stimulant (has a positive impact on development of a region) or an inhibitor (has a negative impact on development). After standardisation of the selected diagnostic features, a synthetic index was calculated. Based on the index, administrative units were assigned to individual typological groups. As was the case with the benchmarking method, each commune was categorised as one of three types.

RESULTS AND DISCUSSION

In light of the benchmarking analysis and typology, study results involved composing a final (aggregated) juxtaposition based on the synthetic results. This facilitated a comprehensive assessment of situation of the studied communes and determination of their development potential. It also suggested alternative directions of development.

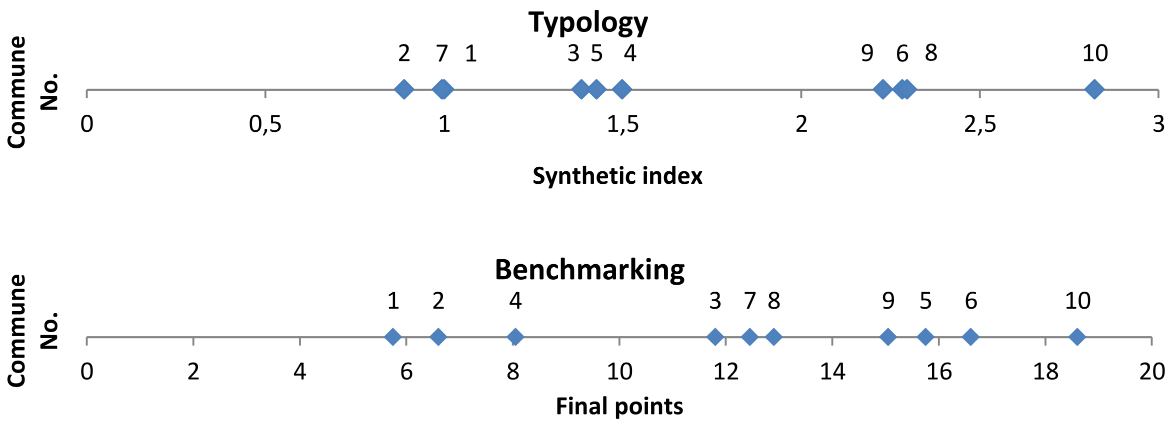

Chart 1 Aggregated juxtaposition. Benchmarking and typology results
(Source: Own work)

Based on the benchmarking analysis [Chart 1], it was found that the following communes have the greatest development potential: Zielonki (18,6 final points), Skawina (16,6), Zabierzów (15,1), and Mogilany (15,8). The best results in the three most important sectors (economy, environment, and spatial development) were calculated for the commune of Zielonki, which was the undisputed leader among the studied areas. Typology also indicates this commune to be the best in development (synthetic index – 2,82). According to "Rzeczpospolita" daily, Zielonki is the best commune among the 1566 rural communes in Poland as concluded in a national poll: 11th "Rzeczpospolita's" ranking of local governments. By taking innovative actions to stimulate development, the community attracts investors and entrepreneurs (www.zielonki.pl, access: 2.10.2015). Igołomia-Wawrzeńczyce (5,8 final points), Kocmyrzów-Luborzyca (6,6), and Michałowice (8,1) were counted among the communes with the poorest development as per the benchmarking analysis. The first of them received the lowest amounts of points for two sectors (spatial development and environment). The same applies to the second one (in its case the sectors were society and economy). The lowest number of points for society was awarded to the commune of Michałowice. This was confirmed by typological analysis assigning the above-mentioned units and Świątniki Górne (0,99 synthetic index) and Liszki (1,38) to the group of the lowest development potential. These communes demonstrated the lowest values of the synthetic index.

Table 1 The value of final points and synthetic index for individual units

Unit	Benchmarking (final points)	Typology (synthetic index)
Igołomia-Wawrzeńczyce	5,75	1,00
Kocmyrzów-Luborzyca	6,60	0,89
Liszki	11,80	1,38
Michałowice	8,05	1,50
Mogilany	15,75	1,43
Skawina	16,60	2,28
Świątniki Górne	12,45	0,99

Wielka Wieś	12,90	2,30
Zabierzów	15,05	2,23
Zielonki	18,60	2,82

(Source: Own work)

Results of both methods are very similar. Both in benchmarking and typology, the same communes were classified as the best or the worst in terms of development potential. This indicates not only correct application of both methods but, with all probability, confirms results of the study. The classification may be used as a basis for local authorities of the examined governmental units to take actions to improve unfavourable situation, especially for communes in the last group. These actions should focus primarily on increasing indices in the worst sectors. Igołomia-Wawrzeńczyce should aim its efforts to improve environmental conditions and spatial development. Their projects should be channelled to expand their utility network, protection of existing habitat, and increasing share of forests and greenery in commune's area. Authorities of Kocmyrzów-Luborzyca should focus on society and economy. Better conditions for business and pro-family policy tools would certainly improve commune's ranking in terms of development potential. Detailed analysis for each commune could determine precise tasks necessary in terms of the indices chosen for the study. The example of the commune of Zielonki, which was deemed to be exhibiting the best development in both methods, can be helpful while making specific decisions. It should also be noted that the analyses exhibited no relation between type of commune (rural or urban-rural) and its level of development. At this stage, right actions of local authorities are the key. By taking well-thought out decisions based on research, they may contribute to rapid development.

SUMMARY

Legal regulations and competition for development funds considerably impact monitoring of commune situation and rational and informed management of own resources. Study of these resources and applicable economic parameters is part of benchmarking analysis (Batko et al., 2010). Typology method is a useful tool for making good decisions as well. It facilitates systematisation of knowledge about communes in terms of various indices and assigning these units to predefined evaluation groups. Commune authorities' competencies include unit's direction of development. They are responsible for this aspect because they are, to some extent, free to make decisions in this regard. These decisions should be prudent and impact public good (Kochmańska, 2007). Constant innovation (use of benchmarking and typology by local authorities certainly is innovation), reaction and adaptation to volatile environment, and making well-thought out decisions based on factual data definitely help achieve success and assumed goals. Suburban communes have a chance to attract investors due to high prices of land in large urban agglomerations and unavailability of large development areas. This greatly improves development and competitive advantage of administrative units.

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Zielonki municipality www.zielonki.pl

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LONG-TERM INFLUENCE OF BIOCHAR ON SANDY LOAM SOIL PHYSICAL PROPERTIES

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ABSTRACT

A 1.5-year field experiment with randomized block design was conducted to study of the effects of biochar amendment on water holding capacity and porosity of soil. We hypothesized that addition of biochar will increase the water-holding capacity of a sandy loam soil, and that the

depth of biochar incorporation will influence the rate of biochar surface oxidation in the amended soils. The field study was conducted at the experimental site in Nitra region Slovakia (lat. 48°19´00´´, lon. 18°09´00´´). Biochar was applied in to the soil in III. 2014 in rates 10 and 20 tha^{-1} and also enriched biochar in rates 10 and 20 tha^{-1}. After 1.5 year of application there were taken samples for determination of hydrophysical properties. The porosity of the soil was increased by every variant of experiment except enriched biochar in rate 10 tha^{-1}. The same situation was with soil water holding capacity. Application of biochar in rates 20 tha^{-1} increased water holding capacity by 0.9% vol., what in real represented increasing by 10 %.

KEY WORDS

Biochar, water holding capacity, soil moisture, porosity

INTRODUCTION

The use of biochar as a means to ameliorate soil physical properties and, particularly, the soil water holding capacity, has emerged after identifying its general high porosity (Liang et al.,2010, Horák and Šiška, 2009) and large inner surface area (Kishimoto and Sugiura, 1985; Van Zwieten et al., 2010).The effects of biochar on soil physical properties depend on several factors, such as biomass or feedstock type, pyrolytic condition, application rate, and environmental condition (Balashov et al., 2010; Felber et al.). The porosity of biochar depends on (i) the temperature of pyrolysis – increasing with increasing temperature up to ~750 °C (Schimmelpfennig and Glaser, 2011) – and (ii) the type of feedstock used (Calvelo Pereira et al., 2011; Hina et al., 2010).

Karmakar et al. (2009) studied the effect of application of fly ash, rice husk ash, and paper factory sludge on the growth and yield of rice in theacid lateritic soil of India. They showed that the application of these industrial wastes improved soil properties by decreasing soil bulk density and increasing soil pH, organic carbon, available nutrients, and rice yield. Lately, looking the recalcitrant of C-organic in a black carbon material which is also known as biochar, many scientistsinterested in using this black carbon material as a soil amendment (Glasser et al., 2002; Woolf, 2008). A lot of experimental results have indicated that biochar applications can improve soil properties (Lehman et al., 2003; Liang et al., 2006; Chan et al.,2007) and increase crop yield (Yamato et al., 2006; Chan et al., 2008).

Chan et al. (2007) showed that biochar application had improved some physical soil properties, such as increased soil aggregation, water holding capacity, and decreased soil strength. Novak et al. (2009a) found that addition of switch grass biochar (made at 500 °C) to a sandy Ultasol increased soil water retention by 15.9% relative to no-biochar controls. Chan et al. (2007) applied biochar made from green waste at 450 °C by slow pyrolysis to an Alfisol. They detected significantly more water retained by soils at field capacity in the biochar-amended soils relative to control soils for biochar application rates of 50 and 100 Mg ha^{-1}.

The effects of biochar on other soil physical properties, such as penetration resistance, hydraulic conductivity, bulk density, and soil structure, have not been fully evaluated in field conditions (Agusalim et al., 2010; Asai et al., 2009; Busscher et al., 2010; Chan et al., 2007; Glaser et al., 2002; Laird et al., 2010). Under this context, we hypothesised that soil application of biochar could improve the hydrophysical properties such as water holding capacity and porosity of soil.

MATERIALS AND METHODS

Biochar characterization

Biochar used for the field experiment was produced from paper fibersludge and grain husks (1:1 w/w) (company Sonnenerde, Austria) by pyrolysis at 550°C for 30 minutes in a Pyreg reactor (Pyreg GmbH, Dörth, Germany).

Table 1 Characteristics of biochar

	C %	C g kg^{-1}	N %	N g kg^{-1}	H %	H g kg^{-1}	O %	O g kg^{-1}
Biochar	53.1	531	1.4	14	1.84	18,4	5.3	53

Enriched biochar

Enriched biochar was created by adding compost (C%: 17,8; N%: 1,36), which contained 45%vol. of green waste, 45%. Of milk sump and the remaining 10%vol. the rock dust. The ratio of biochar and compost was 30 wt% to 70% by weight (Horák, 2015).

Experimental area

This field trial was conducted at the experimental site of SUA-Nitra (Nitra-Malanta) in Nitra region of Slovakia (lat. 48°19´00´´; lon. 18°09´00´´) from March 2014 to October 2015. The soil was classified as OrthicLuvisol (FAO, 1998). The average annual air temperature was 10.3°C and annual precipitation was 640mm (Horák, Igaz, 2015).

The field experiment consisted of treatments: Control (without adding biochar), B10 (soil+biochar in rate 10 t/ha) and B20 (soil+biochar in rate 20 t/ha), EB10 (soil+ enriched biochar in rate 10 t/ha) and EB20 (soil+ enriched biochar in rate 20 t/ha) . Every plot was in 3 replications. There were 15 plots (4m x 6m), separated by a protection row 0.5 m. Biochar and enriched biochar was applying into the soil in March 2014 and 1.5 year after application there were taken the samples of soil for measuring of hydrophysical properties.

After 569 days of incubation, indisturbed ring samples were taken for the determination of water holding capacity of soil and porosity.

Determination of water holding capacity of soils

To test the effect bio-char on the soils' water holding capacity – WHC (also known as field capacity), WHC of the soils and soils treated with bio-char were determined. WHC is the maximum amount of water the freely drained soil can hold, which is estimated after a saturated soil has been allowed to drain without allowing its moisture stores to be depleted by evaporation. To do this, 20 grammes of the air- dried soil sample, in triplicate, were put in a plastic container (with a wire mesh at the bottom) and placed in a dish of water. This was allowed to become saturated, for approximately six hours. The container was removed from the water and covered with cling-film to prevent loss of water by evaporation. It was then hanged on a retort stand overnight to allow drainage. All samples were allowed to drain for the same amount of time. Next, soil was carefully removed from the container, put in a pre-weighed container and the total weight of moist soil and moisture container was taken. The samples were then dried in an oven at 105^{o}C until no further water loss occurred, and reweighed to record the oven-dried sample (Šimanský et. al., 2015).

RESULTS AND DISCUSION

Efects of biochar on soil porosity

It has been demonstrated, that application of biochar and enriched biochar had impact on porosity of soil. The porosity of soil was increased by every variant of experiment except enriched biochar in rate 10 tha^{-1}. There were decreasing by 0.9 % vol. 10 tha^{-1} increased the porosity of soil from 39.9 to 40.1 % vol. For the rate 20 tha^{-1} of biochar, it was higher vaue. There was increasing to 41.1 % vol. EB20 tha^{-1} increase porosity by 0.4% vol.

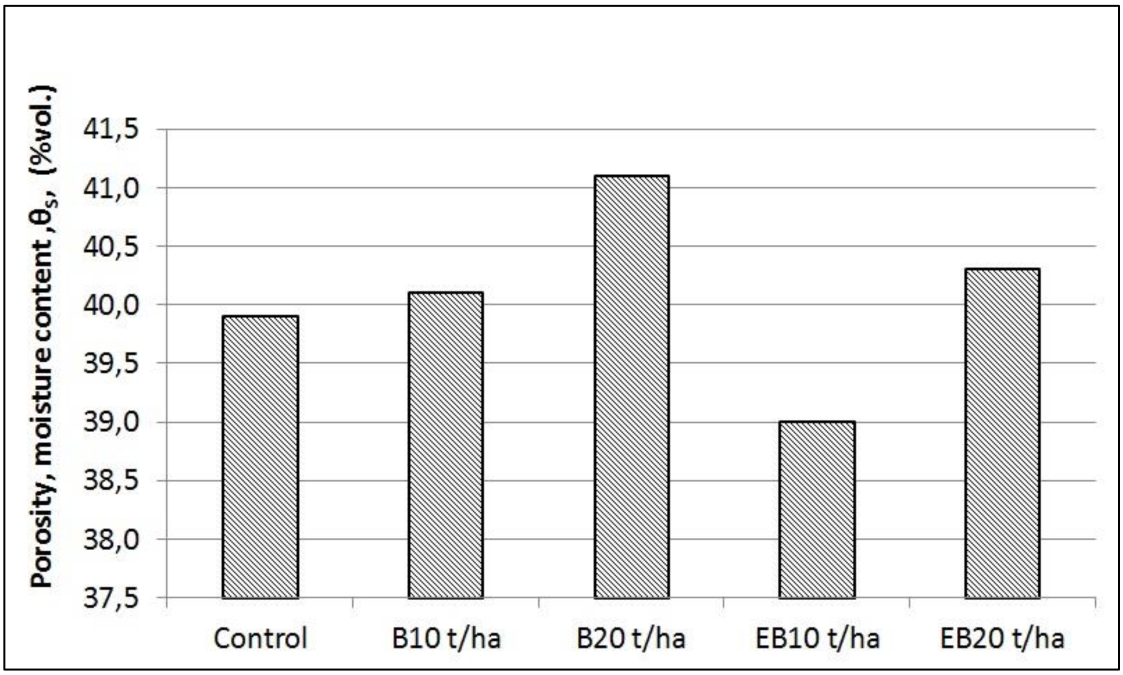

Figure 1 Soil porosity 1.5 year after application of biochar and enriched biochar into the soil in depth 5-10cm

Effect of biochar on water holding capacity of soil

Figures 1shows the effects of applying biochars (B10 and B20) and eriched biochar (EB10 and EB20) at 10 and 20 tha^{-1} to the soil. The biochar in rates 10 and 20 tha^{-1} increased the water holding capacity of soil in Malanta. For the soil with 10 tha^{-1} of biochar, it was from 34.1 to 34.2 % vol. The change in rate 20 tha^{-1} was bigger. It was by 0.9 % vol., what in real presented increasing by 10 %. Enriched biochar influenced the water holding capacity of soil in two ways. Enriched biochar 10 tha^{-1} decreased the water holding capacity by 1 % vol. And 20 tha^{-1} of EB increased water holding capacity on value 35.1 % vol., which was the biggest increasing from the all of the treatments. Confirming observations by Tryon (1948) that moisture retention increased particularly when charcoal (biochar) was applied to sandy soil. Furthermore, this is also proof of Downie et al.'s (2009) proposition that because small pores in biochar retain moisture, and because small pores (with a relatively large water holding capacity, as this scales with the pore radius) are largely absent in coarser-textured soils, biochar should have the greatest effect on water retention.

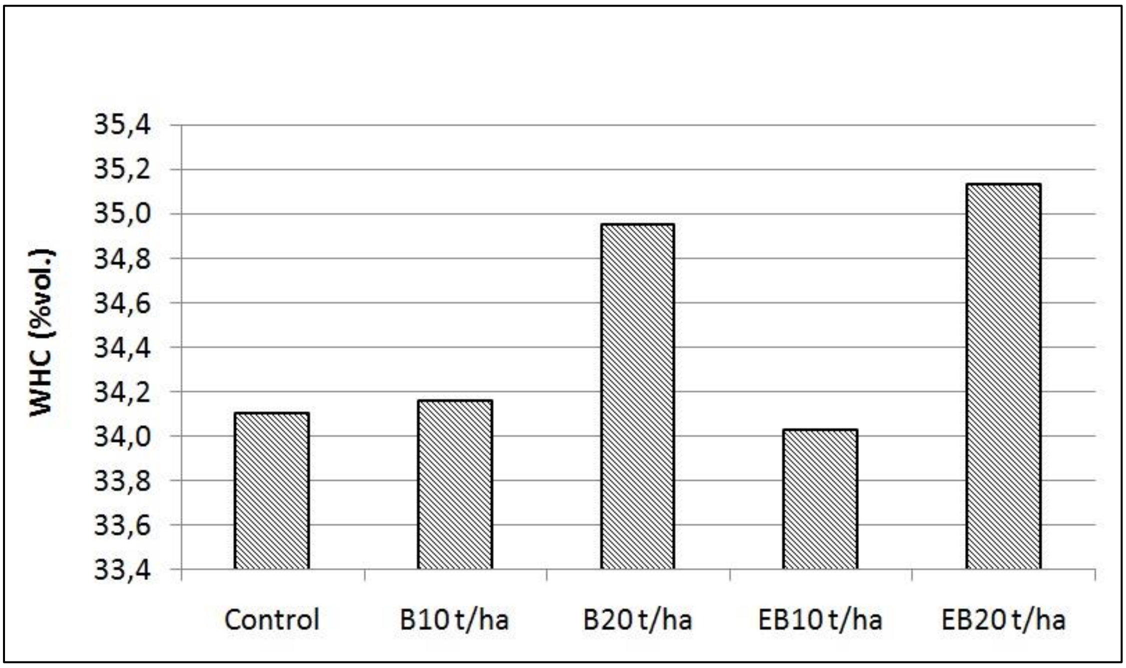

Figure 2 Water holding capacity of soil 1.5 year after application of biochar and enriched biochar into the soil in depth 5-10cm

CONCLUSION

We used in the experiment 2 rates of biochar 10 and 20 tha^{-1} and also enriched biochar 10 and 20 tha^{-1}, which were applicated into the soil. We measured hydrophysical properties 1.5 year after application using samples taken from experimental area Malanta. Water holding capacity was increased by biochar in rates 10 and 20 tha^{-1} and enriched biochar in rate 20 tha^{-1}. Enriched biochar in rate 10 tha^{-1} decreased water holding capacity of soil. Porosity of soil was higher after application of 10 and 20 tha^{-1} of biochar and 20 tha^{-1} of enriched biochar.

ACKNOWLEDGEMENT

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SPATIAL ANALYSIS OF AREAS WITHOUT ACCESS TO A PUBLIC ROAD IN THE VILLAGES OF THE COMMUNE SŁAWNO USING GIS TOOLS

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SUMMARY

The agricultural transport roads play an important role not only in terms of individual farms, but also in the whole issue of furnishing rural areas. They are part of the technical infrastructure necessary for communications and transport, they participate in shaping the rural landscape and their conduct affects the form and size of agricultural or forest areas falling within the network of the roads. The proper shaping an acreage of the crop rotation fields on the farm is closely connected with the convenience of access to these areas. The access to the plots can be improved by properly designed system of roads, as well as by the appropriate spatial location of the fields relative to an existing layout of roads.

The aim of the paper is to present the possibilities of using GIS methods in the analysis of the areas without access to a public road. The study was conducted in 34 villages of the commune Sławno located in the district of Opoczno, the Łódzkie province.

KEYWORDS

agricultural land surveying, land consolidation, agricultural transport roads, spatial structure of rural areas, GIS.

INTRODUCTION

The process of land integration plays a vital role in rural space management, since it stimulates the development of functions those areas perform including, but not limited to, economic, social and environmental spheres. Through changes in the structures of land ownership and use, it offers possibilities of isolating functional and spatial areas, thus removing potential spatial, environmental and social conflicts. It favourably influences the development of agriculture, including in particular ecological production as well as other non-agricultural functions. Carrying out the process of land integration facilitates conducting of agricultural production through reducing costs incurred by farms, and clears the way for introducing modern technologies. It also helps to rationally utilize arable land resources through adjusting land layout and existing infrastructure to farms' needs [Bielska & Leń, 2015]. Impediments in access to land plots under cultivation are a common problem in many regions of Poland. Predominantly, that problem concerns the Małopolskie province [Janus, 2011; Taszkowski & Janus, 2013; Janus et al., 2014], the Podkarpackie province [Błaż & Noga 2011], as well as the Łódzkie province [Leń & Wójcik, 2015]. The goal of the paper is the spatial analysis of areas without access to public roads in villages of the Sławno commune. The analysis has been carried out with the use of GIS (Geographic Information System) techniques, which provide appropriate tools and functions that support examination of spatial relations of objects included in databases under consideration.

Description of the research object

The commune of Sławno is located in the east part of the Łódzkie province, on Wzgórza Opoczyńskie Hills, which form the northern area of Wyżyna Kielecka Upland, 80 km from the city of Łódź, 20 km from, the town of Tomaszów Mazowiecki, and 10 km from the town of Opoczno. It has the surface area of 128 km2, which rates it in the group of medium-sized communes, as far as their surface areas are concerned. On the north it borders on the communes of Tomaszów Mazowiecki and Inowłódz, on the east with the commune of Opoczno, on the south with the communes of Białaczów and Paradyż, and on the west with the commune of Mniszków. The commune area is inhabited by 7,872 residents living in 33 villages. National road no 12 that links the towns of Piotrków Trybunalski and Radom, and regional road no. 173 from the town of Opoczno to the city of Łódź run through the commune area [www.ugslawno.pl].

DATA AND METHODOLOGY

Register data used for studying areas deprived of access to roads were obtained from the District Centre for Geodesic and Cartographic Documentation in Opoczno. The data were obtained in a vector form as ESRI Shapefiles. In view of the specific nature of the issue, spatial analysis were based mainly on two layers: that of record plots and that of arable land. For the examination of spatial structure of the commune of Sławno, an analysis of geometry recorded in the form of vector files with the use of GIS tools was applied. To that effect Geomedia and QGIS softwares were used, which provide a wide selection of proper analytic procedures based on geometry and descriptive data. Based on an attribute query, all objects of the "road" types were picked out. As a result of the query, there were 321 such objects obtained, which provided basis for further analyses of spatial relationships existing with "record parcel" type objects (in total 27,733 parcels were examined). At the same time it should be noted that data obtained from the said District Centre included minor topological errors which, due to the nature of the analyses, might have given an incorrect result. In order to eliminate the impact of topological errors, there were buffer areas created for "road" type objects, covering the areas within a distance of 1 m and 2 m. Next, spatial analysis was performed to check the overlapping of "record parcel" type objects and the so-created buffer areas. In that way there was obtained a layer of objects directly neighbouring on the road network. The supplementation of the obtained layer was provided by parcels that do not have direct links with roads. The results were shown in the form of a map (Fig. 2) and specified in the table (Table 1) in the form of the number of parcels (with and without access), with their respective surface areas. That made it possible to trace, graphically and analytically, spatial relationships existing in the area of the commune of Sławno.

ANALYSIS OF RESULTS

The analysis of spatial relationships existing between road-type objects and record parcel-type objects demonstrated (Table 1, Fig. 2) that 20% of land plots in the commune of Sławno do not have access to the road network, and those land plots constitute 15% of the overall commune's surface area. It should be stressed that the said result was obtained when analysing all forms of land ownership, without splitting into particular ownership record groups. The biggest number of such land plots without access to the road network, as many as 471 of them, were identified within the Kunice Section (Table 1). The specified figure constitutes 1/3 of the total number of land plots in that section, whereas their overall surface area amounts to ca. 20% of the overall area of the section (133 out of 683 ha). A high number of land plots without an access on a relatively small area is related mainly to the fragmented ownership structure of land in the Kunice Section – 70% of land plots below 0.6 ha of surface area [Głowienka & Leń, 2015] (Fig. 2, Fig. 3). Those land plots are situated along drainage ditches in the south part of the Section.

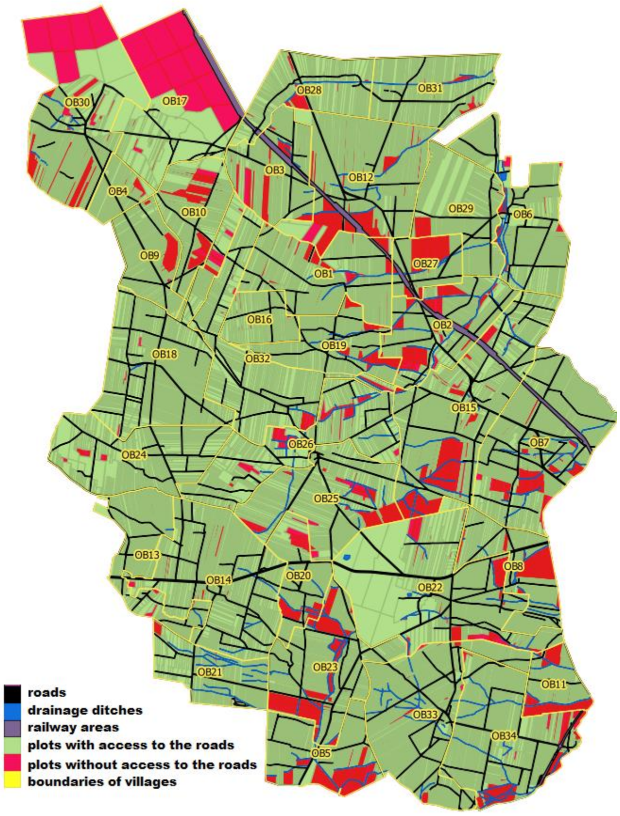

Figure 2 Spatial distribution of land plots without access (red) and with access (green) to public road network in the area of the commune of Sławno.

Table 1 Specification of the number and surface areas of land plots with and without access to public road network in the area of the commune of Sławno.

No.	Section	Overall area [ha]	Number of land plots in the Section	Land plots							
				Bez dojazdu				Z dojazdem			
				Number	%	Surface area [ha]	%	Number	%	Surface area [ha]	%
1	Antoninów	408,7	881	181	21	43,0	10,5	700	79,5	365,7	89,5
2	Antoniówka	346,2	920	278	30	74,2	21,4	642	69,8	272,0	78,6
3	Bratków	288,3	605	137	23	50,1	17,4	468	77,4	238,2	82,6
4	Celestynów	95	187	28	15	10,0	10,5	159	85,0	85,0	89,5
5	Dąbrowa	280	789	227	29	75,8	27,1	562	71,2	204,2	72,9
6	Dąbrówka	370,3	830	206	25	25,4	6,9	624	75,2	344,9	93,1
7	Gawrony	607,6	1768	254	14	76,4	12,6	1514	85,6	531,2	87,4
8	Grążowice	264,7	1239	276	22	48,4	18,3	963	77,7	216,3	81,7

9	Grudzień Kolonia	209,3	619	80	13	22,3	10,7	539	87,1	187,0	89,3
10	Grudzień Las	247,5	1227	455	37	59,5	24,0	772	62,9	188,0	76,0
11	Józefów	136,4	454	236	52	50,6	37,1	218	48,0	85,8	62,9
12	Kamień	550,8	1024	283	28	107,9	19,6	741	72,4	442,9	80,4
13	Kamilówka	259,2	570	24	4	7,7	3,0	546	95,8	251,5	97,0
14	Kozenin	584,2	928	81	9	22,4	3,8	847	91,3	561,8	96,2
15	Kunice	683,8	1523	471	31	133,5	19,5	1052	69,1	550,3	80,5
16	Ludwinów	135,1	251	31	12	6,2	4,6	220	87,6	128,9	95,4
17	Olszewice	559,2	126	22	17	269,3	48,2	104	82,5	289,9	51,8
18	Olszowiec	588,1	947	39	4	21,6	3,7	908	95,9	566,5	96,3
19	Ostrożyna	252,1	1029	294	29	38,9	15,4	735	71,4	213,2	84,6
20	Owadów	195,5	850	308	36	48,2	24,7	542	63,8	147,3	75,3
21	Popławy	232	279	26	9	10,4	4,5	253	90,7	221,6	95,5
22	Prymusowa Wola	755,3	1419	216	15	63,2	8,4	1203	84,8	692,1	91,6
23	Janków Psary	425,4	1260	376	30	105,1	24,7	884	70,2	320,3	75,3
24	Sepno Radonia	410,2	431	17	4	7,7	1,9	414	96,1	402,5	98,1
25	Sławno	439,3	933	193	21	64,8	14,7	740	79,3	374,5	85,3
26	Sławno Kolonia	442,7	577	87	15	47,2	10,7	490	84,9	395,5	89,3
27	Szadkowice	149,1	471	117	25	55,1	37,0	354	75,2	94,0	63,0
28	Tomaszówek	275,4	327	43	13	17,9	6,5	284	86,9	257,5	93,5
29	Trojanów	313,9	557	59	11	20,2	6,4	498	89,4	293,7	93,6
30	Unewal	638,5	849	202	24	237,2	37,2	647	76,2	401,3	62,8
31	Wincentów	303,1	552	96	17	15,0	5,0	456	82,6	288,1	95,0
32	Wygnanów	454,6	609	49	8	16,7	3,7	560	92,0	437,9	96,3
33	Zachorzów	535,3	1387	86	6	19,6	3,7	1301	93,8	515,7	96,3
34	Zachorzów Kolonia	512	1315	357	27	73,8	14,4	958	72,9	438,2	85,6
Total:		12948,8	27733	5835		1945,4		21898		11003,4	

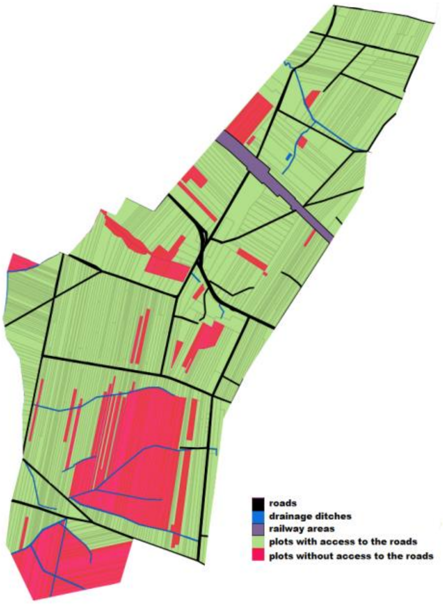

Figure 3 Spatial distribution of land plots without access (red) and with access (green) to public road network within the Section of Kunice in the commune of Sławno.

For comparison, Figure 4 presents visualization of the results of analysis of spatial distribution of land plots with and without access to public roads on the example of two Sections of Józefów and Ludwinów, respectively, where the overall surface area of the Section is almost the same (Table 1), while due to a high level of fragmentation, the number of land plots differs almost twice and amounts to 454 (village of Józefów) and 251 (village of Ludwinów). Following a completed spatial analysis, it turned out that surfaces areas of land plots without an access to the road network differed considerably one from the other (Table 1, Fig. 4).

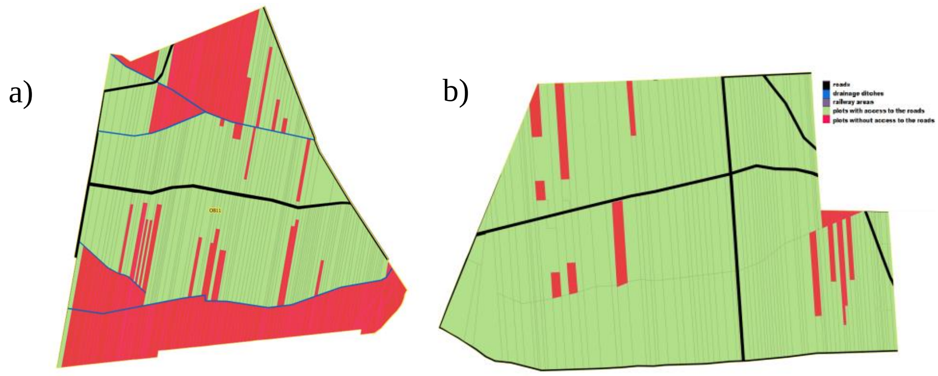

Figure 4 Spatial distribution of land plots without access (red) and with access (green) to public road network within the Sections of (a) Józefów; b) Ludwinów.

In the case of the Józefów Section (Fig. 4a) a share of over 50% of land plots without a direct access to the road network has been noted (236 out of 454) (Table 1). Similarly to the Kunice Section, those land plots are located in the neighbourhood of drainage ditches and occupy the surface area of 50 ha, or 37% of the overall surface area of the Section. On the other hand, in the Ludwinów Section, as few as 31 land plots (out of 351) do not have access to roads located within the Section area, and constitute only 4.6% of its overall surface area. Also notable is the result of analysis obtained for the Olszewice Section, where the surface area of land plots without access to roads was almost 50% of the overall surface area of the Section. Such a big surface area share of examined land plots is related to their individual surfaces areas, ownership forms, and types of use. No wonder: as much as 75% of surface areas of land plots in the Olszewice Section are forest land plots owned by State Forests (Głowienka i Leń, 2015), so that is why these are mainly forest tracks that serve the purposes of transport and communications. For Szadkowice and Unewal Section similar percentage share results were obtained, both in terms of actual numbers and surface areas of land plots without access to the road network. They were 25% and 24%, respectively, of the total number of land plots within the Section, and 37% of the overall surface area of the Section. It should be noted that the village of Unewal is 4 times bigger than the village of Szadkowice in terms of their respective surface areas, while the number of land plots is 2 times higher. Based on results obtained (Table 1, Fig. 2, Fig. 4a), there were Sections identified, in which the problems of the lack of access to land plots is, practically, non-existing. These are the following Sections: Sepno Radonia, Kamilówka, Olszewiec, Wygnanów, Zachorzów, Kozenin, Popławy, and Ludwinów. For the aforementioned villages, surface areas of land plots without access to the road networks was up to 4.6% at the most of the overall surface area of the given Section, whereas their numbers fell within the range of 4% to 12% of the total number of land plots in the Section. Analysing the spatial arrangement of objects (Fig. 2) for the specified Sections, one can notice that the road network in that area is very well developed. It is characteristic that such situation occurs mainly in Sections in the west part of the commune of Sławno (i.e. Olszewiec, Sepno Radonia, Kamilówka) that neighbour on the commune of Mniszków. Also worth emphasizing is a very good results obtained for the Sections of Zachorzów and Popławy. In that case, over 90% of land plots have access to the road network (94% and 91% of the respective total numbers of land plots in both Sections), which amounts to ca. 96% of the overall surface area of those Sections (Table1). At the same time, it should be noted that those Sections have a very well developed systems of land reclamation drainage ditches, which, in the case of e.g. Kunice Section of Józefów Section resulted in a substantial reducing of accessibility to roads. Slightly worse results were obtained for other Sections, namely: Antoniów, Bratków, Celestynów, Gawrony, Grudzień Kolonia, Ostrożyna, Sławno, Sławno Kolonia, and Zachorzów Kolonia. The majority of them are located in the central part of the commune of Sławno. In that group of villages, surface areas of land plots with direct access to roads ranges from 85% to 95% of the overall surface area of particular Sections, while the number of land plots oscillates in the range of 13% to 27% of the total number of land plots in particular villages. With respect to part of Sections under consideration, i.e. Antoniówka, Dąbrowa, Grudzień Las, Owadów, and Janków Psary there were results obtained, which show a moderate accessibility of land plots to the road network. Surface areas of land plots with access to roads in those Section maintains on the level of 76% to 79%, which corresponds to 63% to 70% of the total number of land plots in particular villages.

SUMMARY

Based on the analysis of spatial relations that exist between land plots and roads in 34 villages of Sławno commune, were identified villages that indicate a high need to improve accessibility to the road network. These were the three villages (Józefów, Szadkowice, Unwal), in which the land plots without access to roads have a total area of approximately 420ha (21% of surface area for this type of land plots in the commune). The main causes abnormalities of communication are: a dense network of drainage ditches, large plots of land fragmentation, poorly developed road network and geographical location. In 17 villages of the commune the area of the land plots affected by lack of access to roads was ranged from 10-30% of the area of each village. But for 13 villages, which were analyzed, there were no occurrence of the problem of the availability of parcels to routes.

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AKTUÁLNE MOŽNOSTI DPZ V KULTÚRNEJ KRAJINE
ACTUAL OPTIONS OF THE REMOTE SENSING IN THE CULTURAL LANDSCAPE

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ABSTRAKT.

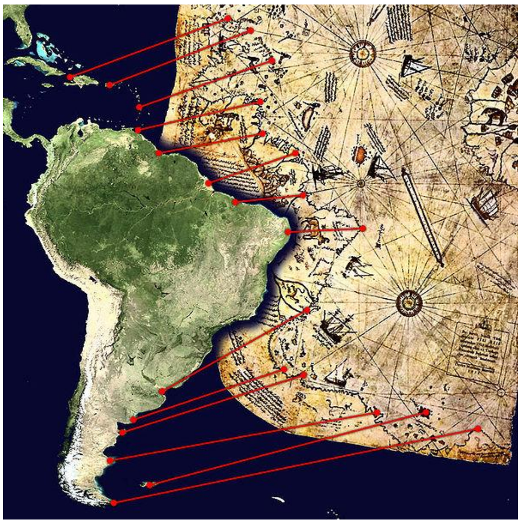
Družicový diaľkový prieskum zeme sa využíva už viac ako polstoročie a za tú dobu sa jeho potenciál neustále zvyšoval. Výrazný pokrok zaznamenalo vyvinutie snímačov zaznamenávajúcich rôzne spektrálne pásma. DPZ v kultúrnej krajine umožňuje sledovať významné zmeny spôsobené prírodnými faktormi, ale aj antropogénnou činnosťou. Zvlášť dôležitými dôsledkami je výskyt extrémnych klimatických javov spôsobujúcich na jednej strane sucho ale najmä vysoké zrážky spôsobujúce záplavy. Pokiaľ je kultúrna krajina usporiadaná v súlade s princípmi manažmentu povodia, nepriaznivé vplyvy záplav sa nemusia prejaviť devastujúco. Pre identifikáciu záplavových oblastí je najvýhodnejšie využitie IR spektrálneho pásma, ktoré pri interakcii s vodou, dopadajúce žiarenie z veľkej časti pohlcuje a teda na snímkach je zaplavené územie zobrazované tmavou farbou.

KLÚČOVÉ SLOVÁ

Krajina, spektrálne pásmo, reflexia. povodňové mapy, priepustnosť pôdy

ÚVOD

Už v priebehu storočí, ľudia pre orientáciu využívali mapy, ktoré postupom času nadobúdali stále väčšiu a väčšiu presnosť. Z histórie je známa mapa Piri Reisa zobrazujúca pobrežie Južnej Ameriky a Antarktídy (Obr. 1).



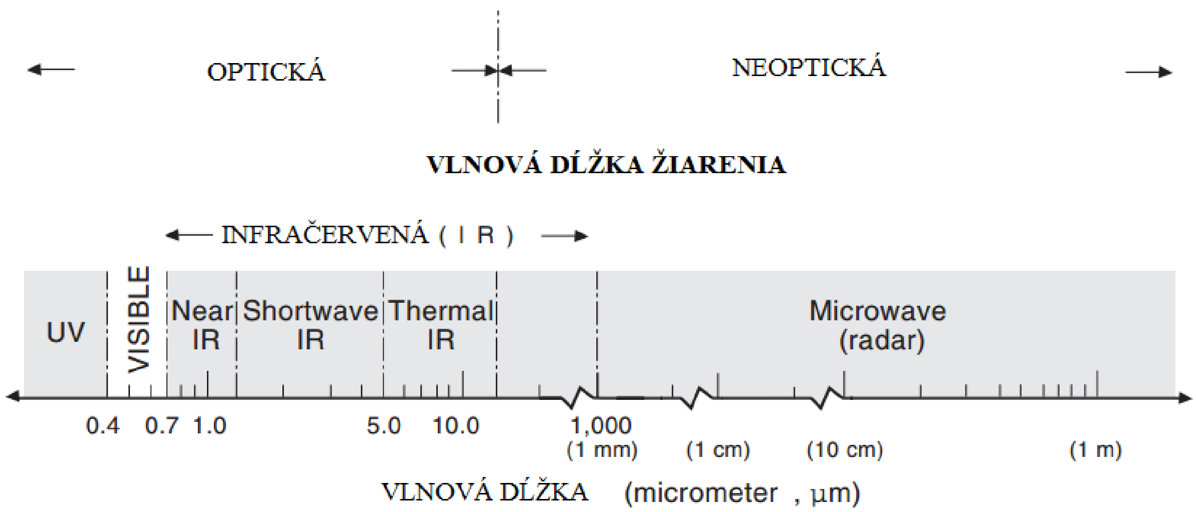
Obrázok 1 Interpretácia mapy Piriho Reisa (Zdroj: wikipédia)

Jej pôvod nie je doteraz objasnený. Uvedený záznam mapy zodpovedá snímke z družice v polohe na Káhirou. Časť nášho územia je zobrazená na mape Tabula Hungariae ad quqtour latera per Lazarum z roku 1513. Postupne vznikali ďalšie mapy zobrazujúce jednotlivé kontinenty. Súčasnosť vďačí za mimoriadne presné mapy, ktoré boli vyhotovené vďaka fotogrametrii. Tak máme v súčasnosti k dispozícii ortofotosnímky, ortofotomapy a tiež digitálne modely reliéfu. Toto všetko dalo základ pre vytvorenie povodňového ohrozenia. Na mape povodňového ohrozenia je zobrazený rozsah záplav, ktoré by spôsobili povodne s určitou dobou opakovania. Takéto mapy vznikli pomocou kombinácie družicového prieskumu a vytvorenia digitálnych máp terénu. Prebiehajúca klimatická zmena je charakterizovaná veľkými rozdielmi v distribúcii zrážok v priebehu roka a výskytom extrémnych javov akými je dlhotrvajúce sucho a intenzívne dažde či už krátkodobé miestne, alebo dlhotrvajúce zrážky zasahujúce rozsiahle regióny. V takýchto prípadoch vznikajú povodne, ktorých vplyv môže byť krátkodobý, ale môže mať aj dlhodobejšie účinky. Pre sledovanie týchto javov je vhodné používať družicové snímky (Schowengerdt,2006). Samotné snímky tvorené digitálnym záznamom je potrebné vhodným spôsobom spracovať. Digitálny záznam pri diaľkovom prieskume Zeme je založený na dvoch hlavných faktoroch. Je to elektromagnetické žiarenie vo zvolených spektrálnych dĺžkach a veľkosť plochy (PIXEL) z ktorej sa meria odraz žiarenia (Glass, 2013). Reflexia povrchových objektov v rôznych spektrálnych pásmach je rôzna a na základe tejto odlišnosti je možné určovať charakter a vlastnosti povrchových objektov (obr. 2).

Rozlíšenie snímok má niekoľko charakteristických úrovní ako sú priestorové, spektrálne, rádiometrické a časové. (Vojtko R. a Reuichwalder P.2009**)**
Vhodným nástrojom pre vymedzenie zaplavených oblastí z dát SAR môže byť detekcia zmien v zázname. Porovnáva sa reflexia každého pixla v priebehu určitého časového obdobia. V prípade zaplavenia, získame odraz diametrálne odlišný od pôvodnej reflexie.

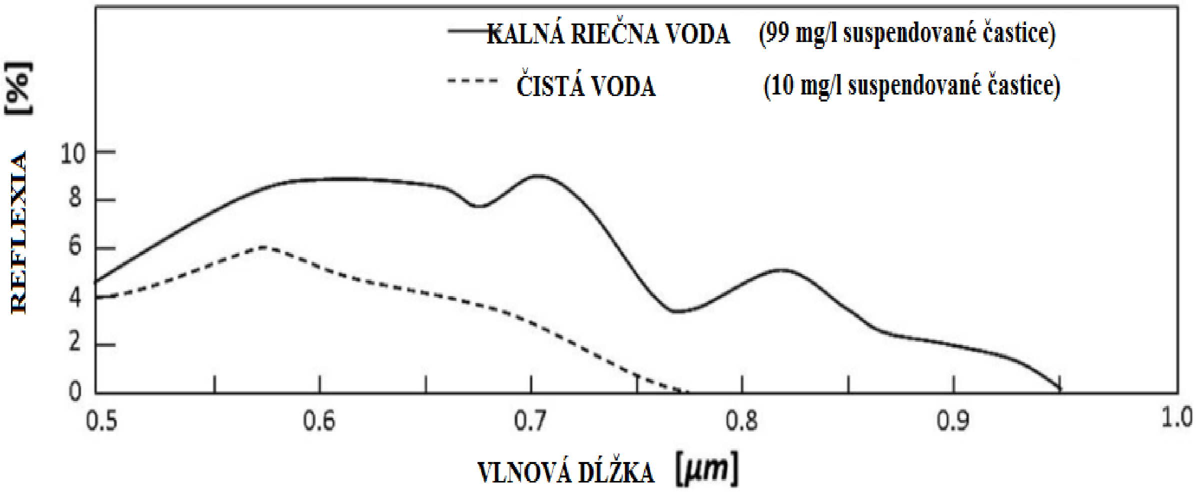
MATERIAL AND METHODS

Družicové analógové a digitálne snímky umožňujú pri interpretácii identifikovať jednotlivé objekty na obidvoch druhoch snímok, či už čiernobielych, alebo farebných, priamou rekognoskáciou vodných plôch na základe skúseností a vizuálneho posúdenia. Ďaleko väčšiu možnosť však poskytujú digitálne snímky vo vybraných spektrálnych pásmach.

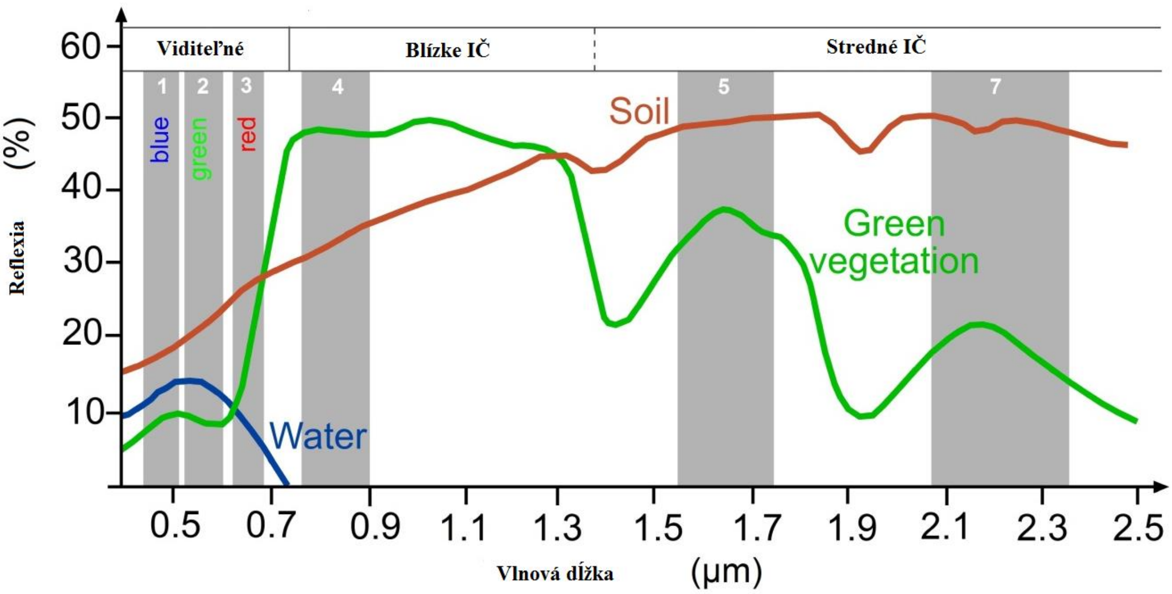


Obrázok 2 Elektromagnetické spektrum optické a mikrovlnné zobrazovania (Carver et al. 1987)

Pri mikrovlnnom prieskume sa využíva radarový systém, pri ktorom sa sleduje energia vracajúceho sa „lúča“ po odraze od povrchu. V tomto prípade je rozhodujúca drsnosť, textúra a topografia povrchu (Obr.3). V prípade „zrkadlových“ hladkých povrchov, dochádza k odrazu žiarenia a spätná energia je nulová. V prípade zatopenia poľnohospodárskeho pôdneho fondu pokrytého vegetáciou, spätný odraz radarového žiarenia závisí od výšky hladiny vody a hustoty zaplaveného porastu (Obr. 4).



Obrázok 3 Spektrálna reflexia čistej a zakalenej vody vo viditeľnom a blízko infračervenom pásme (0.5–1.0 μm) (Adapted from Davis et al. [31].)



Obrázok 4 Reflexia vegetácie, pôdy a vody vo viditeľnom spektre a infračervenom pásme. (Carver et al. 1987)

Pri intenzívnych zrážkach, dopadajúca voda nestačí infiltrovať do pôdneho profilu a len časť ktorá sa zachytí formou intercepcie znižuje celkové množstvo vody dopadajúcej na povrch terénu, ktorá sa veľmi rýchlo mení na povrchový odtok (VUPOP, 2013). Pokiaľ územie nie je schopné dočasne akumulovať zrážkovú vodu, po dosiahnutí času koncentrácie odtoku v povodí, dosiahneme maximálny odtok z územia, ktorý môže prekročiť transportnú kapacitu riečneho koryta a následne voda vybreží a zaplaví okolité územie. V závislosti od jeho výškového usporiadania, v prípade zatopených rovín, odtok z územia a jeho trvanie bude závisieť od sklonu územia smerom k vodnému toku. Obyčajne rovinaté územie nebýva sklonené k toku a teda prúdenie vody je závislé len na rozdiele výšky hladiny v smere gradientu potenciálneho odtoku. V tomto prípade je však tiež dôležitá infiltračná schopnosť pôdy, ktorá umožní tzv. tlakovú infiltráciu vody do pôdneho profilu. Toto sa však uskutoční len v prípade, že v pôde existujú voľné póry na umožnenie vsaku vody do pôdy. Pre zabezpečenie tohto procesu je potrebné odvádzať prebytočnú vodu z pôdu pomocou systematickej pod povrchovej drenáže prepojenej sieťou odvodňovacích kanálov do recipientov.

VÝSLEDKY A DISKUSIA.

Pokiaľ máme záujem využiť produkty DPZ pre posudzovanie zaplavených území v dôsledku povodní a nedostatočného odvodu vody z povrchu zaplaveného PPF máme niekoľko možností.

- Využitie družicových alebo leteckých snímok čiernobielych alebo farebných vo viditeľnom spektre (Obr.5),
- Využitie multispektrálnych snímok záujmového územia s využitím kombinácie rôznych spektrálnych pásiem,
- Využitie radarových snímok.

Pričom môžeme využiť v prípade dostatočného kontrastu obrazu skúsenosti s identifikáciou a interpretáciou snímok DPZ, alebo využiť systém automatickej detekcie zmien v zázname.

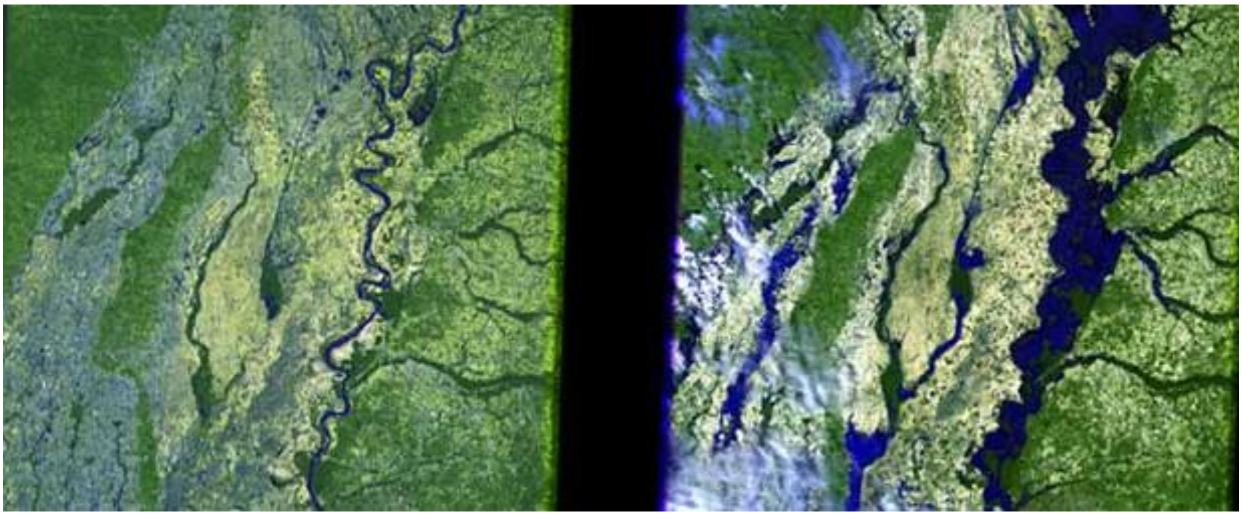
A B

Obrázok 5 Porovnanie snímky s vodnou plochou vo viditeľnom spektre (A) a multispektrálnom móde, (B, 2. 5. A 7. pásmo) (Landsat Image Interpretation James S. Aber)

Pri digitálnom snímku, identického územia pred zaplavením a po zaplavení, máme dve snímky, na ktorých časť zobrazovacích jednotiek (pixlov) zmení svoju charakteristiku.

Na digitálnej obrázku 6 je stav pred zaplavením a po zaplavení a čiastočnom odtečení vody. Ak odpočítame digitálne hodnoty obidvoch snímok v štvorcoch v ktorých nenastala zmena

ostane tá istá hodnota reflexie a teda ak odčítame hodnoty každého štvorca, v mieste bez zmien získame hodnotu „nula“. V miestach zmenených čísiel reflexie nastala zmena.
Odtok vody zostávajúcej na zaplavených územiach prebieha na niekoľkých úrovniach. Najprv je to vsakovanie do pôdy, potom povrchový odtok s následne pod povrchový odtok drenážnymi systémami. Vertikálna infiltrácia je funkciou koeficientu filtrácie kf, pričom rýchlosť infiltrácie môže dosiahnuť hodnotu koeficientu filtrácie, nakoľko hydraulický sklon je rovný „1“ (Kaletová,2010).



Obrázok 6 Rieka Missisipy pri Menfise 12.05.2006 a 10.05.2011 pri povodni Landsat 5 Zdroj: USGS/NASA.

Toto však platí len pokiaľ infiltrujúca voda nedosiahne hladinu podzemnej vody, ktorá následne začne stúpať až dosiahne povrch terénu. V tom momente sa ukončí infiltrácia. Odtok vody v pôdnom profile následne prebieha formou nasýteného prúdenia vody v pórovitom prostredí, pričom je potrebné brať do úvahy minimálny gradient sklonu vyplývajúci z malých výškových rozdielov hladín vody v pôde meraných na pomerene veľké vzdialenosti. Pri rozdiele hladiny 0,1 m na vzdialenosť 300 metrov gradient zodpovedá hodnote $3{,}3.\ 10^{-4}$, čo pri vysokom koeficiente filtrácie rovnom $1.0\ m.d^{-1}$ zodpovedá hodnote rýchlosti horizontálneho prúdenia $0{,}00033\ m.d^{-1}$ - teda $0{,}33\ mm.d^{-1}$, v podstate nulová rýchlosť.
Trochu lepšia je situácia povrchového prúdenia keď následne môže odtok prebiehať po povrchu terénu, pričom gradient vychádza z rozdielu hladín vody v smere k recipientu, keď za rovnakých odtokových podmienok pričom môžeme vychádzať z Chézyho rovnice (Kaletová, 2013):

$$v = c\ (R.I)^{0,5}$$

c – rýchlostný súčiniteľ ($0{,}5\ m.s^{-1}$)

$$C = 1/n \times R^{0,16}$$

n – drsnosť povrchu (inundačné územia n = 0,035)
R – hydraulický polomer (v prípade plošného odtoku = h – hrúbka vrstvy odtekajúcej vody 5cm)

$$C = 1/0{,}035 \times 0{,}05^{0,16} = 17{,}69$$

I – pozdĺžny sklon územia ($3{,}3.\ 10^{-4}$ podľa predchádzajúceho príkladu)

Rýchlosť prúdenia vody zodpovedá

$$V = 17{,}69 \times (0{,}1 \times 3{,}3.\ 10\text{-}4)^{0{,}5} = 17{,}69 \times 0{,}00547 = 0{,}10\ m.s^{-1}.$$

Toto by však platilo len v prípade, že územie má sklon.

Vo väčšine prípadov však ide o rovinaté územia a tak jediný spôsob úniku vody z povrchu je evaporácia – teda výpar z hladiny. Priemerná hodnota výparu z vodnej hladiny v najteplejšom mesiaci (júli) je 122 mm, z čoho vyplýva priemerný denný úhrn 4 mm. (Novák 2001) z čoho vyplýva, že územie zaplavené 40 cm vrstvou vody, má potenciál odparenia až 100 dní.

ZÁVER

Letecké, a satelitné snímky vytvárajú možnosti pre presnú identifikáciu lokalít ohrozených dlhotrvajúcimi záplavami a podmáčaním pôdy a poľnohospodárskych kultúr. V sústave kultúrnej krajiny boli vymedzené územia v rámci poľnohospodárskeho pôdneho fondu aj s príslušnými opatreniami, ktoré ohrozovali optimálne využitie územia pre poľnohospodársku produkciu.

Najúrodnejšie pôdy boli v oblastiach, kde hrozilo podmáčanie pôd v jarnom období z hľadiska potreby urýchliť vstup na pôdu pre začatie poľnohospodárskych prác na jar, zabezpečené potrebnou odvodňovacou sústavou, ktorá mala za cieľ zabezpečiť odvedenie prebytočnej vody z pôdy tak, aby v priebehu dvoch až troch týždňov po skončení zimného obdobia bolo možné vstúpiť na pôdu. Tento systém zabezpečoval zníženie hladiny pod povrchovej vody na optimálnu úroveň stanovenú normou odvodnenia, závislou od druhu pôdy a spôsobu využívania pozemkov.

Funkčný stav odvodňovacích systémov je v súčasnosti veľmi problematický, nakoľko už viac ako 25 rokov sa nezabezpečuje pravidelná kontrola, opravy a rekonštrukcie odvodňovacích systémov na Slovensku (Húska, 2013). V ,mnohých prípadoch ostávajú značné plochy PPF zaplavené vodou, ktorá spôsobí totálne zničenie úrody. Analýza potenciálu pretrvávania záplavy územia je uvedená v predchádzajúcej časti.

Príčinou sú jednak už spomenuté nefunkčné odvodňovacie systémy v dôsledku nezabezpečenia ich údržby, ale aj v mnohých prípadoch nové investičné celky, ktoré boli vybudované bez ohľadu na existujúce odvodňovacie sústavy, pričom došlo k prerušeniu zvodných drénov a odvodňovacích potrubí.

Bolo by potrebné obnoviť systém údržby a starostlivosti o odvodňovacie sústavy aj za pomocou verejnoprospešných prác, ktoré by sa mohli organizovať na úrovni samospráv. Patrili by sme opravy a údržba kanálov, drenážnych výustí, kontrolných a spádových drenážnych šachiet a kontrola funkčnosti sústav.

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APPLICATION OF EXTENDED HABITAT SUITABILITY CURVES FOR DEPTH IN NITRICA RIVER

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ABSTRACT

The paper is based on objectification and parameters modification of habitat suitability curve for depth. The habitat suitability curve is one of the many basic parts of Instream Flow Incremental Methodology (IFIM). IFIM is the methodology where the quality of aquatic habitat is interpreted according to a bioindication. The bioindication is provided by ichtyofauna;. as a bioindicator for this paper the minnow (*Phoxinus phoxinus*) was chosen. The main reason for selecting this spieces as a bioindicator, was its sufficient frequency during the ichthyologic survey in the chosen river. The basic result from the field measurement is the habitat suitability curve for depth. However, this suitability curve is not adequate to describe the aquatic habitat therefore the scientific research was oriented on modification of habitat suitability curve for a wider flow range. For the evaluation System of Environmental Flow Analysis (SEFA) was used. SEFA is a new software that implements the substance of the IFIM. The modification of the habitat suitability curve is applied on the Nitrica River.

KEYWORDS

Instream Flow Incremental Methodology (IFIM), Area weighted suitability (AWS), System for Environmental Flow Analysis (SEFA), habitat suitability curve (HSC)

INTRODUCTION

Stream quality of habitat is significantly affected by ecosystem. Developed methods of the quality habitat assessment do not have adequate utilization rate (they are applied very rarely or minimum in most of the countries, including Slovakia). Their usage should be analogous to assess other aspects of the ecological status of the stream, such as water quality, minimal stream flow or biota integrity. Different species are related to a different range of habitat, thus there is a need of comprehensive approach. The basic aim of our research was to objectify the fish habitat preference in the range of specific discharges before the fish are washed out from their position. Fish are considered as the best bioindicator, mainly because of their long life cycle. Another reason is that fish are very sensitive to changes in channel morphology and their ability to migrate. This underscores the importance of fish as a bioindicator (Macura et al. 2011, [7]; Lasne et al., 2007, [6]; Belcakova, 2005, [1]). In this study, fish species minnow (*Phoxinus phoxinus*) was chosen as a bioindicator. According to Kottelat and Freyhof (2007) [5], minnow prefers a wide range of cold and well oxygenated habitats from small, fast-flowing streams to large nordic lowland rivers and from small upland lakes to large oligotrophic lakes. This species is usually associated with salmonid fish. Spawning takes place over clean gravel areas in flowing water or on wave-washed shores of lakes. The minnow is able to survive during a winter time in coarse substrate or in deep pools with low current.

Ecological status of stream is influenced by many factors (Halaj et al., 2013) [2], from which the most important is the fauna and flora biotope of the stream aquatic zone that characterizes the habitat. Stream habitat structure has a substantial impact on the organization and structure of biological communities (Maddock, 1999, [8]). The aim of the habitat quality modelling is mainly to provide a basis for assessment or prognosis of biological changes that should represent a potential impact on ecological changes. These changes are important in the decision-making process of stream quality management. For ecological water quality modelling are used models based on the IFIM methodology, in this case model SEFA, was used.

Data from ichtyologic survey are basic input in model SEFA. It is represented by the abundance of bird and fish species, with the occurrence parameters. Abiotic habitat characteristics together with the ichthyofauna characteristics are the basis for the suitability curves development. Suitability curves show the habitat parameter preference of a particular species bioindicator. Suitability curves are based on the assumption, that a specific type of fish prefers certain combinations of abiotic parameters. These parameters may be different, but the highest impact has the water depth, velocity in verticals and bottom substrate in the stream. Measured suitability curves characterized by frequency polygon reflect behavior of the bioindicator in relation to the stream discharge. Based on the measured data, Skrinar (2011) [9] described mathematical expression for the suitability curves. Many studies have confirmed that even in different streams, specific fish species prefer similar habitat characteristics. There were done many works focused on implementation of the one stream habitat characteristics on a different stream (Thomas & Bovee, 1993 [10]). A limit for measured suitability curves usage is their applicability to a specific discharge, for which measurements were realized. Using a wider range of discharges is not appropriate, according to the several studies, which have proved differences in the usage of suitability curves at different discharge rates (Holm et al., 2001. [3]; Ibbotson, & Dunbar, 2002 [4]). The aforementioned studies confirm that the usage of suitability curve determined at a particular discharge should not be applied to other discharges.

Transformation of the suitability curves is documented for an example of the Nitrica River.

MATERIAL AND METHODS

Materials

- ✓ Network of characteristic points for creation of the stream channel morphology in 1D hydraulic model. The field measurements were performed on 14th October 2010.
- ✓ Ichthyofauna characterization according to the measurements performed on 20th July 2010.
- ✓ The measurements by the current meter were done on 20. July 2010 and 14. October 2010.

Methods

- ✓ Calculation of hydraulic parameters using 1D hydraulic model.
- ✓ Modification of measured habitat suitability curves (HSC).
- ✓ Assignation of depth suitability values.
- ✓ Calculation of Area weighted suitability.

The reference reach of the Nitrica River

The Nitrica River is right side water inflow of the Nitra River. Total length of the Nitrica River is 54.1km. The catchment area of the Nitrica River is 319km^2, and the origin is located between hills Homôľka (906.6m a.s.l.) and Vápeč (955.5m a.s.l.) at the altitude of 760 m a.s.l. The Nitrica River is characterized as a piedmont stream.

The reference reach of the Nitrica River is located outside of Ješkova Ves village. The reference reach is 465m long. The river bed is consists of the sections with greater depths, which are sharply cut into the stream alluvium. The stream-channel bank is covered with deciduous trees and shrubs that shade a significant channel section.

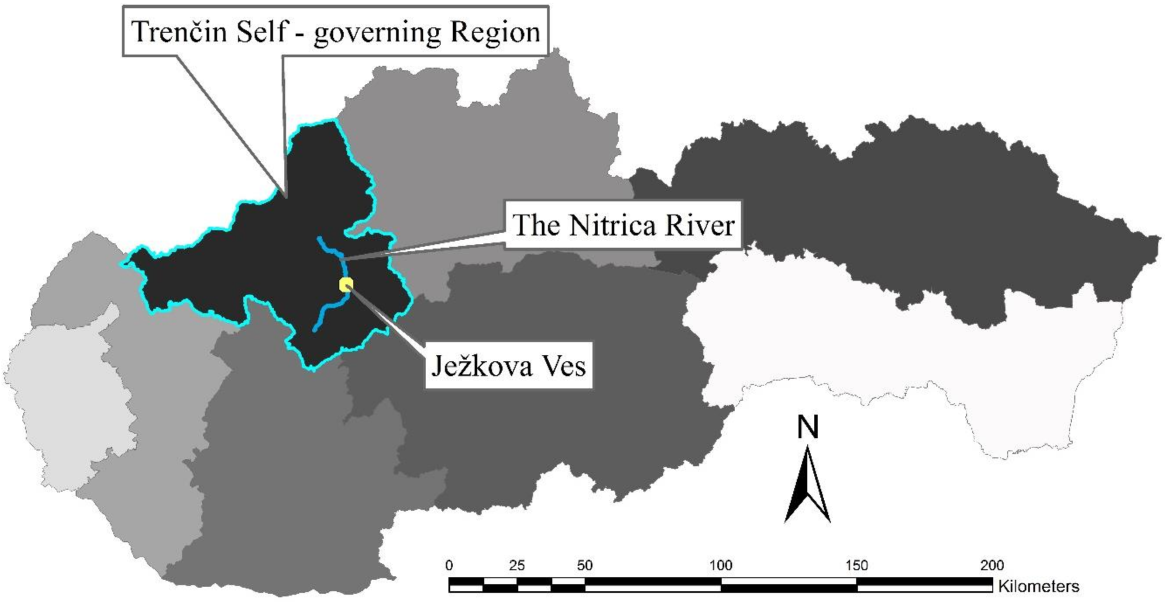

Figure 1 Reference reach of the Nitrica River.

RESULTS AND DISCUSSION

➢ Calculation of hydraulic parameters by 1D hydraulic model

The calculation of hydraulic parameters was performed using 1D model. The model was calibrated for discharge Q_{mt} = 1,350 $m^3.s^{-1}$ ≈ $Q_{180-90d}$ (Q_{mt} = discharge occurred during morphology measurement); therefore topographic and hydrometric measurements were performed for this discharge. The first modelled discharge was Q_{364d} = 0,213 $m^3.s^{-1}$ and the second modelled m-day discharge was Q_{30d} = 6,233 $m^3.s^{-1}$. For every mentioned discharge value of the average maximum depth (d_{amax}) was derived. The average maximum depth as an average of the maximum depths in every measured cross-section profiles was determined. Average maximum depths for individual discharges are:

- For discharge Q_{364d} is d_{amax} = 0.30m
- For discharge Q_{mt} is d_{amax} = 0.54m
- For discharge Q_{30d} is d_{amax} = 1.30m

➢ Measured and extended Habitat suitability curves (HSC)

Measured suitability curve is a direct output of the ichtyologic survey. Usually, there is created a suitability curve for fish species and stream measured parameters. Sufficient frequency of the minnow species during the ichthyologic survey on 20th July 2010 was the main reason for its selection as a bioindicator. The ichtyologic measurements were performed for discharge $Q_{mt} = 1.350\ m^3.s^{-1} \approx Q_{180\text{-}90d}$. Subsequently, suitability curve for abiotic depth parameter shown in Fig. 2 was created. The mentioned suitability curve has a trend to increase of the suitability from 0.10 m to 0.24 m and it has got decrease trend of the suitability from 0.24 m to 0.50 m. The top of the curve is at the depth value 0.24m, where the suitability value reaches 1. For the needs of aquatic habitat assessment for a wide range of modelled discharges was necessary to adjust the measured curve suitability. The base of the modification was to extend the top of the measured suitability curve to the left and also to the right. The value of the peak extension was derived from the differences of the average maximum depth d_{amax} in a discharge modelling.

The peak extension on the left should be based on the assumption, that Q_{364d} is a minimum natural discharge. The value of the average maximum depth for discharge Q_{mt} was 0.53 m and for modelled discharged Q_{364d} was the value 0.30 m; difference between these values is 0.23 m. However, the value for the curve peak extension from the value 0.24m to 0.01 m does not make a sense. In this case, the left peak extension wasn´t applied.

The right peak extension was based on the assumption, that Q_{30d} is a maximum natural discharge. The value of average maximum depth for discharge Q_{mt} was 0.53 m and for modelled discharged Q_{30d} was the value 1.30 m, difference between these values is 0.77 m. Subsequently, the value was used for a curve peak extension from the value 0.24m to 1.00 m.

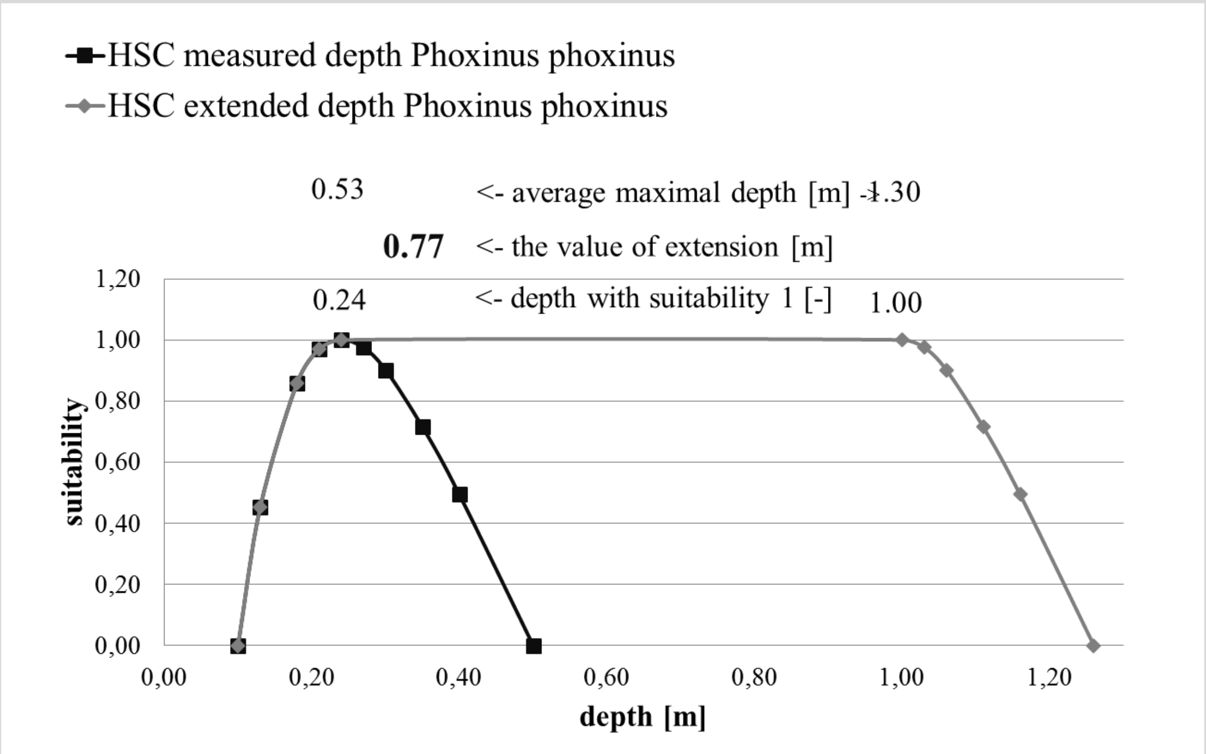

Figure 2 Habitat suitability curves for depth.

Extended suitability curve was created by increasing part starting from the depth of 0.1 m with the value from 0.00 to 0.24 m and the suitability index 1. Maximum value of suitability (1) is added to a depth range 0,24m to 1,00m. The decreasing part of the extended curve starts at the depth from 1.00m and ends at1.26m.

- Evaluation of aquatic habitat quality

A riverbed morphology was imported to the SEFA program and water depth was modelled. The depth values in the Hybica River for a modelled discharge Qmt reached the maximum value 0,88m. Figure 3 shows longitudinal profile for modelled discharge Qmt. This figure is graphic output from SEFA.
Both suitability curves were imported to the SEFA program, which was then used to assign depth suitability values based on the both, measured and extended suitability curve.

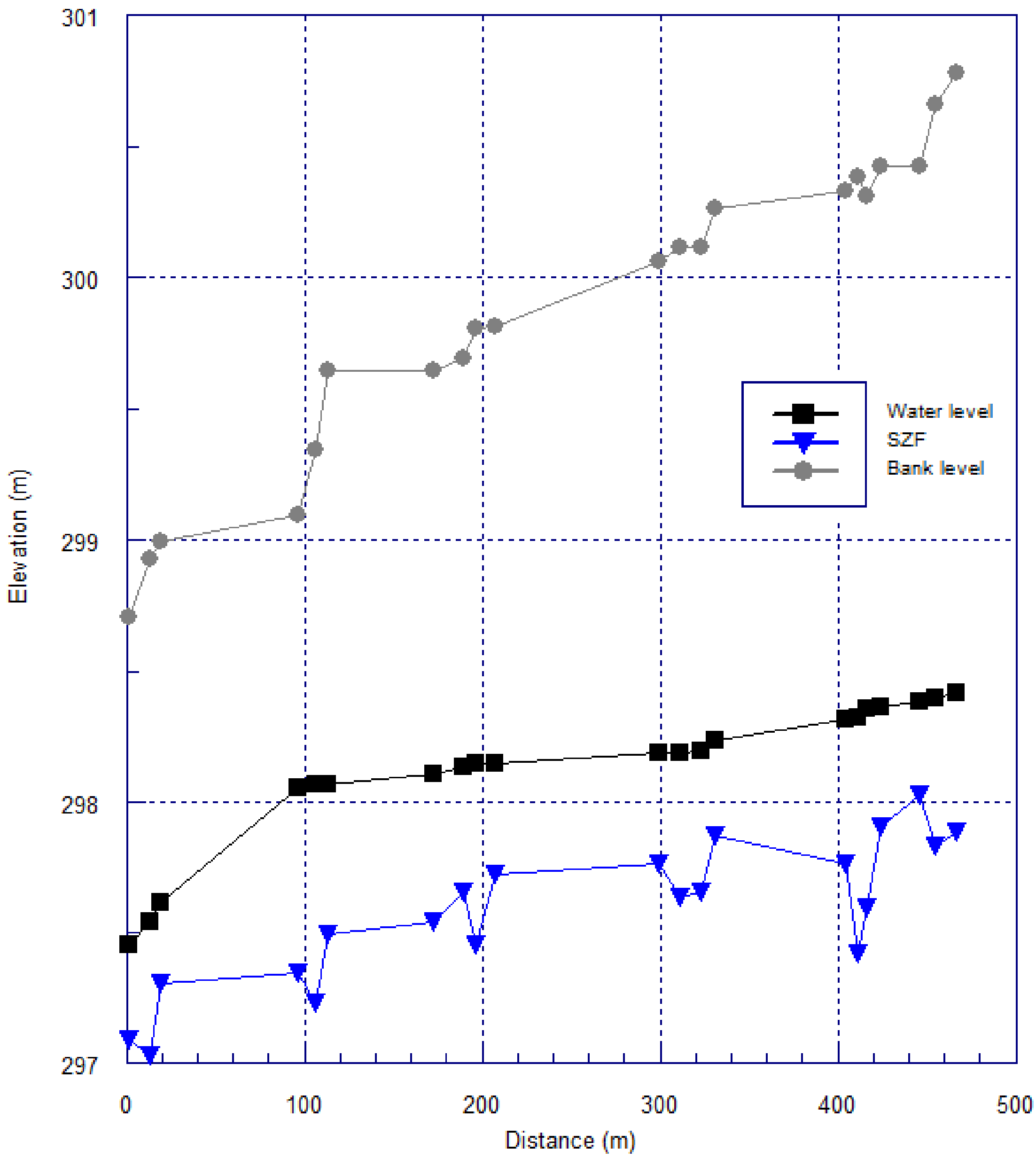

Figure 3 Longitudinal profile of the Nitrica River for Q_{mt}.

- Calculation of Area weighted suitability (AWS)

AWS value (area weighted suitability) calculation was based on the assigned values. The AWS value was calculated separately for every cell of the calculation network. The AWS value represents suitable area (m2 per m) of the stream longitudinal length that is usable for a bioindicator minnow (Phoxinus phoxinus). The final AWS values were calculated for the discharge range of 0.00 – 6.5 m3.s-1.
The results based on the measured suitability curve are indicating the increasing of AWS value at discharges 0.00 m3.s-1 to 1.00 m3.s-1. AWS values have decreasing character at discharges 1.00 m3.s-1 to 2.00 m3.s-1. Higher flows have a stable AWS value around 3.6 m2/m.
The results based on the extended suitability curve are indicating the similar increasing of AWS value from discharges 0.00 m3.s-1 to 0.50 m3.s-1. The AWS values have similar increasing character as a values of full bank at discharges 0.50 m3.s-1 to 6.50 m3.s-1.
Fig 6 shows graphic representation of the calculation results, numeric representation is shown in the Table 1.

Table 1 The Area Weighted Suitability values.

Flow	0.00	0.50	1.00	1.50	2.00	2.50	3.00	[m^3/s]
HSC measured depth	0.00	9.35	10.05	7.61	5.29	4.08	3.73	[m^2/m]
HSC extended depth	0.00	10.24	13.80	15.30	16.41	17.39	18.28	[m^2/m]
full bank	0.00	14.25	16.05	17.36	18.48	19.48	20.36	[m^2/m]
Flow	**3.50**	**4.00**	**4.50**	**5.00**	**5.50**	**6.00**	**6.50**	[m^3/s]
HSC measured depth	3.61	3.59	3.59	3.58	3.56	3.56	3.55	[m^2/m]
HSC extended depth	19.11	19.88	20.59	21.26	21.89	22.49	23.05	[m^2/m]
full bank	21.16	21.91	22.61	23.29	23.94	24.56	25.16	[m^2/m]

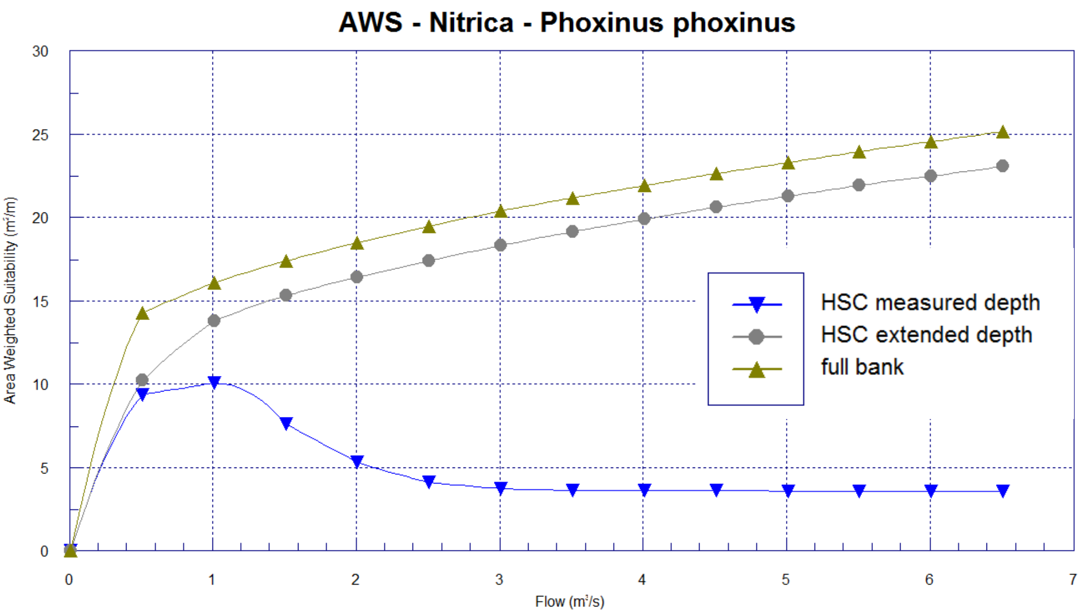

Figure 6 Values of Area Weighted Suitability on the Nitrica River.

CONCLUSION

The aim of the paper was to assess the impact of basic stream abiotic parameters on the aquatic habitat quality and to insert them into the aquatic habitat quality assessment of the mountain and piedmont streams. The created methodology was applied on the Nitrica River. From the Figure 3, we can conclude, that there is a huge difference between the qualities of aquatic habitat. The difference can be see when we assess habitat according to measured curve or we assess the aquatic habitat quality by modified curve that represents wider intervals of discharges.

ACKNOWLEDGEMENTS

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GARDEN INSPIRED BY NATURE IN URBAN CONDITION ON EXAMPLE OF THE ŁOMIANKI CULTURAL CENTRE GARDEN

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ABSTRACT

In this article the idea of Natural Landscaping [NL] is presented as a background design solutions. Principles, that the NL is characterized, represent a starting point for the concept of the garden surrounding the Łomianki Cultural Center [ŁCC]. The first stage of the work was to diagnose the habitat conditions and investor's expectations. This work led students of landscape architecture under the direction of the paper's authors. Then next step was analysis of the literature for gardens inspired by nature. Under special characteristics they were taken into account spatial solutions. But the most important step in this work was preparation of plants list that meet the requirements resulting from habitat conditions and fit within the the NL. As a result of the workshop produced several works, all of which were selected for the implementation of the presented concept. A characteristic feature of this solution is the large variety of plants - abundantly flowering perennials, ornamental grasses, plants with decorative foliage, which became part of the framework created with a ground cover shrub growth.

KEY WORDS

natural landscaping, native plants, synanthropic species

INTRODUCTION

In today's world, some already saturated with modernity, humans appear pursuit of nature and naturalness. This process clearly is visible in the search for the best solutions for the world around them: architecture, gardens. The answer to these experiments in the field of landscape architecture is the Natural Landscaping idea and gardens inspired by nature. The Natural Landscaping idea also responds to the challenges posed legal documents such as the Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, Natura 2000.

Over the years, the term Natural Landscaping has been used to describe a variety of landscaping approaches, from letting areas "go wild" to planting a selection of brilliant wildflowers. The attraction of creating a landscape with native plants lies in the promise of having nature's beauty at one's doorstep and reducing the need of watering, fertilizing and mowing [5].

Today, the idea of NL is primarily inspiring nature. These influences are used in industrial design, architecture, landscape architecture. These fashion inspiration relate eg. directly to plants, commonly called wild. These plants, often called weeds, find their place in a bold and modern design solutions. Another look at inspiring the nature is creating solutions to mimic nature and use in the implementation of species and varieties of plants related to plants occurring in natural conditions, often impossible to buy [7].

THE AIM

The aim of the paper is to present an example of an the Natural Landscaping idea in landscape architecture. The presented project is the result of the work of workshop with students of landscape architecture. The proposed solution was completed in June 2015.

METHOD

When creating the design concept draws on local vision: study the habitat conditions using pictures Phytosociological, observations usage and query the source materials and literature: basic maps, archival materials, iconography, photographic materials and literature. Analysis of these data made it possible to create guidelines for the design concept and draw up a list of plants that meet the requirements of the plants used in the Natural Landscaping and responding to habitat conditions.

design IDEA - DESCRIPTION

localization of the study area

The area covered by the project is located in Łomianki. Łomianki [wɔˈmʲaŋkʲi] is a town in Warsaw West County, Masovian Voivodeship, Poland, with 16,374 inhabitants (2008) [2]. Because the town is located between Kampinos National Park and Vistula river, and just a short distance from the outskirts of Warsaw, it is regarded as a desirable place to live for people who want to combine an out-door lifestyle while still commuting each day to Warsaw. The Kampinos National Park has hundreds of kilometers of cycling trails and the largest inland sand dunes in Europe - elk and wild boar after often to be seen there. Łomianki is characterised by big residential houses, particularly around Zachodnia street and many active community groups. There are many expats living in Łomianki, mostly because it is equidistant between the city's two international airports – the Warsaw Chopin Airport and the Modlin Airport.

The area covered by the project is the entrance area to the Łomianki Culture Center – the CKŁ. The CKŁ is a local culture institution .This place of fascinating encounters with music, theater, literature and art, built to residents Łomianki and together with them. A place that lives from morning to evening, where the doors are always open for people who have creatively come up to the reality surrounding them. Recently, the Łomianki Cultural Center was renovated and enlarged.

description habitat conditions

The area covered by the project is located in close central part of the city. The soils are highly anthropogenically changed. They are characterized by a significant share of the remains of the construction after the renovation work of the building. Another characteristic feature is a considerable degree of desiccation and contamination of salt, nitrogen and heavy metals. In addition, the feature of the project area is strong sunlight, resulting from a southern exposure and lack of overshadowing elements.

The main problems currently occurring in the study:

- plentiful sunshine the front side of the building,
- a small number of parking spaces,
- intensive use of land by fire trucks,

• non-functional communication links,
• a small amount of biologically active,
• various forms of use of the lawn in the western part of the area.

design concept

In the present design we use spatial solutions related to the Natural Landscaping idea. Natural Landscaping, also called native gardening, is the use of native plants, including trees, shrubs, groundcover, and grasses which are indigenous to the geographic area of the garden [4,5,9].

Idea and definition of Natural Landscaping.

Natural landscaping, also called native gardening, is the use of native plants, including trees, shrubs, groundcover, and grasses which are indigenous [native] to the geographic area of the garden. Natural landscaping is adapted to the climate, geography, hydrology and should require no pesticides, fertilizers and watering to maintain, given that native plants have adapted and evolved to local conditions [12, 14]. However, these applications may be necessary for some preventative care of trees and other vegetation in areas of degraded or weedy landscapes [2, 11, 16].

Native plants suit today's interest in "low-maintenance" gardening and landscaping, with many species vigorous and hardy and able to survive winter cold and summer heat [1, 4]. Once established, they can flourish without irrigation or fertilization, and are resistant to most pests and diseases. Many municipalities have quickly recognized the benefits of natural landscaping due to municipal budget constraints and reductions and the general public is now benefiting from the implementation of natural landscaping techniques to save water and create more personal time [9, 13].

Twelve design principles by David Holmgren are very useful in using the Natural Landscaping idea in different type gardens designing [1978]:

1. Observe and interact: by taking time to engage with nature we can design solutions that suit our particular situation.
2. Catch and store energy: by developing systems that collect resources at peak abundance, we can use them in times of need.
3. Obtain a yield: ensure that you are getting truly useful rewards as part of the work that you are doing.
4. Apply self-regulation and accept feedback: we need to discourage inappropriate activity to ensure that systems can continue to function well.
5. Use and value renewable resources and services: make the best use of nature's abundance to reduce our consumptive behavior and dependence on non-renewable resources.
6. Produce no waste: by valuing and making use of all the resources that are available to us, nothing goes to waste.
7. Design from patterns to details: by stepping back, we can observe patterns in nature and society. These can form the backbone of our designs, with the details filled in as we go.
8. Integrate rather than segregate: by putting the right things in the right place, relationships develop between those things and they work together to support each other.

9. Use small and slow solutions: small and slow systems are easier to maintain than big ones, making better use of local resources and producing more sustainable outcomes.
10. Use and value diversity: diversity reduces vulnerability to a variety of threats and takes advantage of the unique nature of the environment in which it resides.
11. Use edges and value the marginal: the interface between things is where the most interesting events take place. These are often the most valuable, diverse and productive elements in the system.
12. Creatively use and respond to change: we can have a positive impact on inevitable change by carefully observing, and then intervening at the right time.

The advantages of the design solutions that utilize ideas of Natural Landscaping are:

- no fertilization required,
- no additional water,
- more water available for other uses and other people,
- zero to near zero work needed for maintenance,
- no lawn mowing,
- erosion reduced to a minimum,
- natural landscaped plants take full advantage of rainfall,
- when water restrictions are implemented, natural landscaped plants will survive, while more traditional plants may not,
- increased habitat for native flora and fauna,
- where heavily forested, provides shade on homes and businesses saving energy,
- native plants rarely become invasive [3, 5].

And the disadvantages:

- not good for outdoor games that require a manicured turf,
- increased wild animal intrusion,
- in certain areas, wildfires or brushfires may be of great concern,
- may look less attractive due to reduced available range of plants to choose from,
- may be hard to find native plants which produce adequate quantities of edible matter [3, 5].

Interesting example of the Natural Landscaping idea in European landscape architecture is Landscape Park Duisburg Nord in Duisburg, Germany (designer: Latz + Partners). Designers, working on a 570-acre site of a former steel plant, approached their reuse and reclamation project with optimism. Rather than looking at the site's disturbed and complex conditions as nuisances that should be erased or camouflaged, they worked carefully to mine them for their creative potential. The transformed site creatively repurposes existing structures, and throws in a number of amenities that promote recreation and community, including a deep diving pool, a rock climbing wall, picnicking areas, hiking trails, and multiple performance spaces—all woven together to create tapestry of memorable places. The aim was to change the industrial landscape with minimal intervention, recycling and visually renewing decaying architectural objects into poetic places that pay homage to the site's past [9, access 11.05.2015].

A characteristic feature of the presented project is to use a very soft, close to natural demarcation lines plots planted with different species of plants. Referring to the natural free lines intersect and penetrate each other, form an interesting mosaic filled with perennials blooming from early spring to late autumn. The result is an effect characteristic of the Vistula river meadows.

Photo 1. State of the area before project implementation area in front of the garden inspired by nature (May 2015) [author Ewa M. Zaraś-Januszkiewicz, 10 May 2015]

Photo 2. Poster with garden design (author K. Abramowicz, P. Ćwiek and B. Drewiczewska)

Photo 3. A part of the ŁCC natural garden 4 weeks after realization (author Ewa M. Zaraś-Januszkiewicz, 20 June 2015).

PLANT SELECTION

Plants in terms of habitat requirements, and in terms of phisiolological, plants had to refer to the trend of Natural Landscaping. The first choice are plants native. Native plants are plants that occur naturally in a particular region.

Why native vegetation is so important? Native plants are adapted to the local climate and soil conditions where they naturally occur. Native plants work well for many landscaping and wildlife habitat plantings, because once established, they seldom need watering, mulching, protection from frost or continuous mowing. Native plants provide nectar, pollen, and seeds that serve as food for native butterflies, birds and other animals. In contrast, many common horticultural plants do not produce nectar and often require insect pest control to survive. Many native grasses and wildflowers protect soil with their deep and spreading root systems, helping to prevent erosion. Areas with diverse perennial native plantings have less water runoff than ground covers composed of one non-native species. In developed areas, one way to help water infiltrate into the ground rather than run off into storm sewers is to create depressions filled with native plants called rain gardens [8, 10, 13, 15].

In nature, plants occur in native plant communities, which include all the native plants in an area together with their environment. Some examples of the many communities that occur in Poland include dry xerotermic communities as Festuco-Brometea Br.-Bl. et R.Tx. 1943, wet or fresh communities connecting with Molinio-Arrhenatheretea R.Tx. 1937, oak forests, pine forests, and marshes [15]. Native plant communities are vital components of ecosystems. In order to be healthy and sustainable, an ecosystem needs to be filled with a wide array of native plants and animals. In addition to providing food and shelter to birds and animals, a healthy ecosystem provides many services to society. For instance, a healthy forest ecosystem can prevent soil erosion, reduce flooding, detoxify chemicals in air and water, improve the local climate, and store carbon that would otherwise contribute to global climate change. Also, the genetic material in many wild plants has been shown to have great value in medicine and industry [18].

Using native plants is generally encouraged. This way the Natural Landscaping gardens may contribute to urban habitats for native butterflies, birds, and beneficial insects. Well planned plantings require minimal maintenance to survive, and are compatible with adjacent land use. Trees under power lines, or that up-heave sidewalks when soils become moist, or whose roots seek out and clog drainage tiles can cause expensive damage [17].

A very important group of plants are synanthropic plants. In plants, synanthropes are classified into two main types - apophytes and anthropophytes. Apophytes are synanthropic species that are native in origin. They can be subdivided into the following:

- cultigen apophytes - spread by cultivation methods,
- ruderal apophytes - spread by development of marginal areas,
- pyrophyte apophytes - spread by fires,
- zoogen apophytes - spread by grazing animals,
- substitution apophytes - spread by logging or voluntary extension,
- anthropophytes - synanthropic species of foreign origin, whether introduced voluntarily or involuntarily; they can be subdivided into the following:
    - archaeophytes - introduced before the end of the 15th century,
    - kenophytes - introduced after the 15th century,
- ephemerophytes - anthropophytic plants that appear episodically,
- subspontaneous - voluntarily introduced plants that have escaped cultivation and survived in the wild without further human intervention for a certain period,
- adventive - involuntarily introduced plants that have escaped cultivation and survived in the wild without further human intervention for a certain period,
- naturalized or neophytes - involuntarily introduced plants that now appears to thrive along with the native flora indefinitely [8, 15].

For the implementation of the presented project we use the following species and varieties of plants. In the presented solution inspired by nature related to the potential habitat. After analyzing the choice of habitat conditions of plants that meet this tough conditions. Attempts were made to to the final result alluded to the natural mosaic of leaves and flowers, typical for the rich flowering meadows.

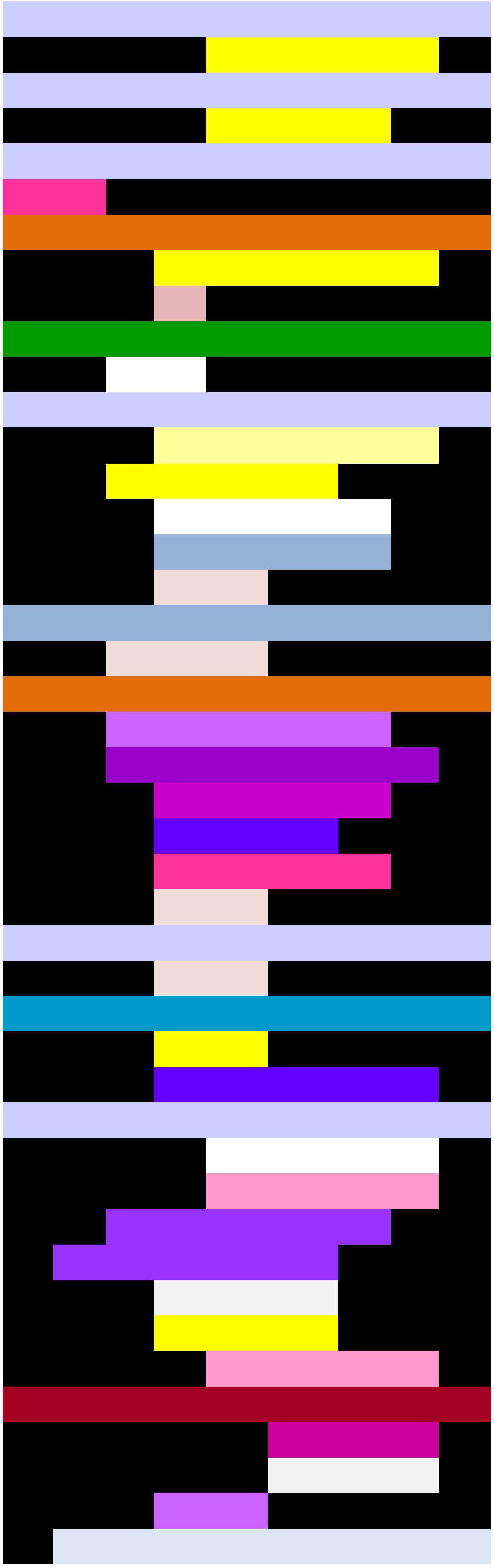
Table 1. Plant selection for the Łomianki Cultural Center garden

Plant species/varieties — Flowerin time/flower or foliage colour

III IV V VI VII VIII IX X XI

Achillea filipendulina ‘Feuerland’
Achillea filipendulina ‘Gold Plated’
Armeria maritima ‘Alba’
Armeria maritima ‘Amanda Deep Rose’
Artemisia ludoviciana

Artemisia schmidtiana
Artemisia stelleriana
Bergenia cordifolia
Buphthalmum salicifolium
Calamagrostis acutiflora ‘Karl Foester’
Cerastium tomentosum
Coreopsis verticillata ‘Moonbeam’
Coreopsis verticillata ‘Zagreb’
Dianthus deltoides ‘Albiflorus’
Eryngium planum
Festuca glauca
Festuca ovina
Geranium sanguineum ‘Aviemore’
Geranium sanguineum ‘Elsbeth’
Geranium sanguineum ‘Max Frei’
Geranium sanguineum ‘Spinners’
Geranium sanguineum ‘Rouge’
Helictotrichon sempervirens
Koeleria glauca
Lysimachia punctata
Perovskia atriplicifolia ‘Blue Spire’
Physostegia virginiana ‘Alba’
Physostegia virginiana ‘Bouquet Rose’
Salvia nemorosa ‘Blaukönigin’
Salvia nemorosa ‘Mainacht’
Salvia nemorosa ‘Snowhill’
Sedum kamtschaticum
Sedum spectabile ‘Matrona’
Sedum spectabile ‘Meteor’
Sedum spectabile ‘Star Dust’
Stachys byzantina

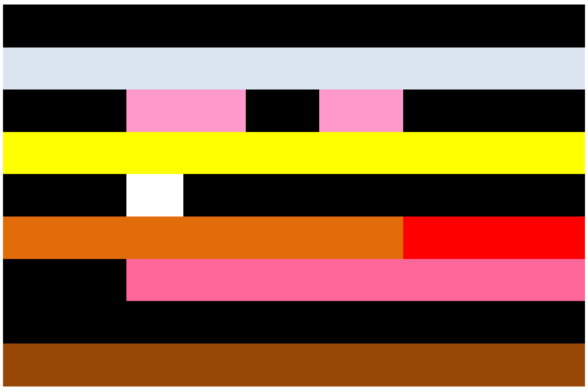


Hippophae rhamnoides 'Hikul'

Spiraea japonica 'Golden Princes'

Spiraea betulifolia 'Thor'

Rosa 'Fairy'
Pinus mugo 'Mops'



SUMMARY

Realized garden enjoys very high popularity among the the villagers. Most often emphasized is a very large variety of plants, an abundance of flowers and very natural looking garden, referring to the appearance of the Vistula meadows.

Basic notes and instructions for native landscaping projects are (basing on How to Use Native Plants for Landscaping):

- all plants need time - it takes time for native plants to get established; it's important to know from the outset that it may take a few years for native plantings to look attractive; in time, plants will spread and propagate, creating patterns that work well in each space;
- gain an understanding of the native plant communities in your area - those plant communities occur there because they are adapted to the specific climate, landscape, and soil conditions;
- understand local government regulations - some will affect how natural landscaping can be used and what kinds of ongoing management can take place;
- get to know your site - many factors determine what kinds of site preparation will be needed and which species should be used, such as: existing plants, sun exposure, soil type, drainage and soil moisture;
- look at neighboring natural vegetation - plan of native planting should to harmonize with adjacent areas as much as possible [19]

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NON NATURAL TREE SPECIES IN THE WARSAW'S URBAN FORESTS ON EXAMPAMLE OF THE MŁOCINY PARK

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ABSCTACT

The purpose of this study was to identify non-native species of trees and shrubs occurring in the Młociny Park in Warsaw, an indication of invasive species and try to solve the problem of biological invasion by establishing a strategy for dealing with the observed foreign species. Based on the results from study sites, structure of dendroflora transition was revealed. It was the presence of numerous non-native species for potential forest communities both forests. In the Mlociny Park 31 foreign species of trees and shrubs have been identified. The most common invasive species include: *Quercus rubra, Acer negundo, Robinia pseudoacacia*, *Prunus serotina*. In addition in the Młociny Park an intensive spread of *Ailanthus ailanthisima* and *Ptelea trifolita* has recorded and also a very dangerous *Reynoutria japonica* was found spreading - a species belonging to the hundred most invasive species of the world. In this study, actions and strategies have been proposed that will help to preserve the existing natural vegetation in the Młociny Park forest.

KEY WORDS

foreign species, invasive species, synanthropization, anthropological changes, urban forests

INTRODUCTION

Synanthropisation process has been for many years the subject of interest of many geobotaników (Faliński ed. 1968, 1970, 1972a, 1972b, 1974, 1976). For urban forests synanthropisation Warsaw is a particularly important issue in contemporary transformations of flora. Warsaw is one of the few European capitals, for example. Next to Stockholm and Berlin, which has forests within the city limits. Often they remain in their historical area due to historical and economic circumstances (Simonides, Solińska-Górnicka 1990a, 1990b).

Natural and semi-natural forest complexes in cities such as the Młociny Park, are now a rarity and even under the legal protection be subject to further deformation, mainly as a result of neighborhood housing estates, roads and industrial plants. There was no phytosociological studies devoted to the Młociny Park, except drawn up by Chojnacki (1991, 1982) vegetation maps of actual and potential for the whole of Warsaw and forest management plans for the forest park.

The aim of the study is to establish non-native species of trees and shrubs occurring in the Młociny Park in Warsaw and identification of potential invasive species, to determine their origin and how to spread.

METHODOLOGY

The choice of research areas was to designate the surface during the site inspection. We selected 15 research plots in the Młociny Park and in its neighborhood, including 12 surface in the wilderness, 3 surfaces in the immediate vicinity.

Figure 1. Structure of urban forests in Warsaw.

Selection criteria surface: Based on the analysis of works related to the subject of the study process synanthropisation in forest areas (Gorecki 1997) found that the majority of positions alien plants occurring within the forest complex is located on the roadside forest roads and hiking products and on the border of forest from non-forest. With this in mind, in this study was determined to be test surfaces, areas that come under the strongest pressure, areas along the boundary, along the borders of forest from non-forest (forest edge), and walking along the main road (including the nature path and trail). In addition, designated research areas in the immediate vicinity of the test object. By studying these surfaces was set min. or synanthropic vegetation located in the vicinity of the tested objects forest penetrates deep into the forest. In terms of species composition was examined in the Młociny Park eg. vegetation along the streets that are off-road borders the forest. It was because these places as places of imminent threat - a place penetration of synanthropic plants of alien species, including invasive species.

When selecting research areas geared to the homogeneity of the surface, ie., each selected area represents one plant community (eg. *Tillio Carpinetum typicum* - typical), avoiding the zones of transition from one phytocenoses to another.

Dendroflora made an inventory of native species, but non-specific for the studied forest communities and native species of our flora, including invasive species.

Research and chamber pieces: Based on Wysocki and Sikorski (2002) and Matuszkiewicz (1990, 2006) determined the species composition of forest that would exist naturally in these areas (communities of potential established on the basis of maps of potential vegetation Chojnacki (1991) and on that basis, of species written during fieldwork, designated alien species of trees and shrubs for these communities. terminology adopted by Seneta and Dolatowski (2003). Membership in phytosociological determined based on the distribution of units syntaxonomic Matuszkiewicz (2006). It was established form of life observed alien species by Raunkiær (Zarzycki and al 2002). The assessment of the participation of synanthropic species of trees and shrubs are based on geographic and historical distribution of synanthropic plants Kornaś (1968) and the classification of species, including native apophytes and from other areas geobotanical anthropophytes (Sudnik-Wójcikowska 1987). It was established expansiveness of the species and its propagation. Done diagrams and tables showing the results of the analysis summaries dendroflora structure of these objects forests.

Dendroflora investigated species composition analyzed objects without vegetation undergrowth (outside seedlings of woody plants and shrubby). Thus, the studies also included non-native species of trees and shrubs forest communities occurring in the analyzed sites.

The study was conducted for the participation in the composition dendroflora alien species indigenous, but non-specific for the studied forest communities and species of non-native flora. The group of alien species also include synanthropic species - derived from non-forest communities.

During the study distinguished from a pool of alien species invasive species (listed on the Polish list of invasive species; http://www.iop.krakow.pl) and potential invasive species, or species distinguished by large and dangerous expansive area surveyed forests.

Highlights:

• ap. - apophytes (native species)

• ant. - anthropophytes (species of foreign origin)

by ken. - kenophytes (species arrived after the fifteenth century)

 arg. - agriophytes (species is at home on the natural habitats and half natural)

arch. - archaeophytes (species arrived before the fifteenth century.)

erg. - ergasiophytes (temporarily becoming wild crops)

efe. - ephemerophytes (temporarily dragged).

Determined form of life of each species:

• M - megafanerophytes, tree growing over 5 m high,

• N - nanofanerophytes, shrubs and low trees, from 0.5 to 5 m in height.

• T - terophytes, an annual plant (this one item: knotweed knotweed *Reynoutria japonica*; included in the list of this plant species, because its appearance resembles a shrub and reaches very large, up to 3 m; in addition it is now very dangerous invasive species).

RESULTS

The Młociny Park is a forest park with an area of 103.13 hectares, located in the Warsaw district of Bielany between the Papirusów streets, Pulkowa street and Dziwożony street and the left bank of the Vistula River, at the northern boundary of the city. The area of forest is part of the District Bielany Młociny urban forests of Warsaw as the Młociny Park. In the south of the forest is an ecological site with an area of 4.82 hectares, including a mid-forest meadow along with a wrapper, forming part of the urban forest complex in Las Mlociny (Klonowska, Romaniak 2009).

The area of forest covered by various forms of protection:

• lies within the buffer zone of the Kampinos National Park,

• is located within the Warsaw Protected Landscape Area,

• it is a part of Warsaw Escarpment within which must not violate the natural lie of the land, destroy vegetation ecosystem.

For the Młociny Park vegetation are a kind of plant species forming communities of the potential for these areas - as well as an indicator species for these communities. The tables summarizing contains a summary of all alien species found in the surveyed forests and divided them by species:

• indigenous, non-specific to the communities in which there with the class membership (CHCl.)

• alien species of domestic flora, but occurring in natural plant communities within their natural range,

• species artificially obtained by breeding.

SHARE ANALYSIS alien species in forest communities the Młociny Park

During fieldwork in the Młociny Park were found 70 species of alien plant communities found in the forest, including:

about 39 native species, but non-specific for these communities.

27 alien species of Polish flora

4 species of breeding plants (garden), absent in the wild in the wild.

In terms of geographic and historical among 70 alien species distinguished 39 apophytes (56%), 31 anthropophytes (44%).

Group of 31 anthropophytes: kenophytes (5 species of 16%) and archaeophyte (1 grade 3%) and ergazjophygophytes (24 species of 78%) and efemerophyte (1 grade 3%).

Apophytes species belong to the following classes: Querco-Fagetea, Vaccinio-Piceetea, Rhamno-Prunetea, Artemisietea vulgaris, Epilobietea angustifolii, Salicetea purpureae and Alnetea glutinosae. Among all 70 alien species found in the Młociny Park 29 is in the form megafanerophytes (41%), 37 are nanofanerophytes (53%), and 4 of them take the form of both megafanerophytes and nanofanerophytes (6%). Of the four species of farmed (garden) 2 is megafanerophytes (Tilia 'Euchlora' and Malus sp.), and 2 is nanofanerophytes (Corylus xcolurnoides and Forsythia xintermedia).

39 native species occurring in the study, but nonspecific for forest communities surveyed, 17 is in the form megafanerophytes (44%), 20 to nanofanerophytes (51%), while 2 species take the form of both megafanerophytes and nanofanerophytes (4%).

Indigenous, non-specific for communities of the Młociny Park receiving the form either megafanerophytes and nanofanerophytes are *Prunus padus* and hybrids of willow species *Salix* sp. Analysis of species taking the form of megafanerophytes (29 taxa) 17 is a native species (59%), but nonspecific for communities of the Młociny Park 10 species alien to our flora (34%), while 2 species breeding (garden) (7%).

Up to 10 species of foreign origin megafanerophytes: 1 species originates from Africa, six from North America, three are from Asia, 1 is the European species.

The origin of non-native species of trees shown in the following statement:

• species of trees from Africa: *Prunus mahaleb*,

• tree species from North America: Acer negundo Acer saccharinum, Fraxinus pennsylvanica, Prunus serotina, Robinia pseudoacacia, Quercus rubra,
• species of trees from Asia: Ailanthus altissima, Juglans regia, Morus alba, Prunus mahaleb,
• tree species from Europe: *Prunus mahaleb*.

Percentage American species represent 51% of this group of woody plants, 33% Asian, and European and American 8%.

In contrast, 37 foreign species that take the form nanofanerofitów differentiate you for 20 - native species, but non-specific plant communities of the Młociny Park (representing 54%), 15 - alien species of our flora (41%), while 2 - species breeding (Garden - 5%) .

Pedigree nanofanerophytes 16 species of foreign origin is as follows: 5 species native to North America, 7 species come from Asia, 4 are European species.

The origin of non-native species of shrubs presented in the following statement:
• shrub species originating from North America: Crategus pedicellata, Physocarpus opulifolius, Prunus serotina, Ribes sanguineum, Symphoricarpos albus,
• shrubs from Asia: Berberis koreana, Cornu alba, Cotoneaster lucidus, Deutzia scabra, Prunus cerasifera, pseudosalicifolia Spiraea, Weigela florida,
• shrub species from Europe: Lonicera tatarica, Philadelphus coronarius, Syringa xjosikaea, Syringa vulgaris.

The percentage of the number of species of shrubs from different regions is as follows: 44% Asian species, the species American 31% 25% European species.

ANALYSIS OF THE PARTICIPATION OF SPECIES PRESENT IN FOREIGN DIRECT adjacent to wilderness the MŁOCINY PARK

During the study area adjacent to the Młociny Park and observation of vegetation present there were found 34 species of alien plant communities found in forest the Młopciny Park, including:

14 native species, but non-specific for these communities.

12 alien species of our flora

8 species of cultivated plants (garden) does not occur in the wild from the wild.

Thus, in terms of geography and history of the 34 alien species distinguished 14 apophytes, which represents 41% of this group of plants and 20 antropophytes, representing 59%.

Group of 20 species antropophytes constitute represented kenophytes (14 species representing 49% antropophytes) and archeophytes (1 genre - 4%) and ergazjofigophytes (12 species - 43%) and ephemerophytes (1 genre - 4%). Species apofitów from the following classes: *Querco-Fagetea, Vaccinio-Piceetea, Rhamno-Prunetea, Artemisietea vulgaris, Epilobietea angustifolii, Salicetea purpureae* and *Alnetea glutinosae*.

Plants 34 alien species 11 is in the form megafanerophytes (trees - 44% of that group of plants), 21 to nanofanerophytes (shrubs - 51%), and 2 of them take these two forms (5%). Of the eight species of breeding (garden) 7 is megafanerophytes and 1 takes the form megafanerophytes and nanofanerofitów.

Of the 14 native species, but nonspecific for forest communities surveyed, 6 takes the form megafanerophytes and 8 is nanofanerophytes.

When analyzing a mega fanerophytes (11 taxa) 6 is a native species, unspecific communities of the Młociny Park, and 5 species alien to our flora.

Among the five species of foreign origin megafanerophytes 3 from North America, one from Asia, one is a European species.

The origin of native species of trees shown in the following statement:

• tree species from North America: Acer negundo, Quercus rubra, Robinia pseudoacacia,

• species from Asia: *Morus alba*,

• species originating from Europe: *Aesculus hippocastanum*.

Analyzing the fanerophytes species (21 taxa) 8 is a native species (38% nanerophytes), but non-specific plant communities of the Młociny Park, 6 species alien to our flora (29%), while 7 species breeding (Garden - 33%). Origin of 6 species nanofanerophytes is as follows: two from North America, 2 are from Asia, two are species Europe.

The origin of alien shrubs species are in the following statement:

• shrub species originating from North America: *Prunus serotina, Ribes sanguineum*,

• species from Asia: Fallopia aubertii, Prunus cerasifera.

• shrub species from Europe: Philadelphus coronarius, Syringa vulgaris.

SUMMARY

On the basis of the Młociny Park field research stated:

• within the phytosociological classes featured the largest group of foreign species and synanthropic are representatives of the class: *Querco-Fagetea* * (12 representatives) - the communities of eutrophic deciduous forests and Rhamno-Prunetea (11) - *Communities* of shruby formation functionally related to the forest,

• then, in descending order: *Epilobietea angustifolii* (6) - nitrophilous communities of, therophytes, perennials and shrubs initiate secondary succession (regeneration) of forest after the destruction of trees by logging, fire, windthrows etc., Vaccinio-*Piceetea* * (3) - coniferous forests habitats poor and acidic, *Salicetea purpureae* (3) - scrub and forest communities willows narrowleaf, in river valleys, *Artemisietea vulgaris* (2) - nitrophilous communities stately perennials and vines on ruderal habitats and on the banks of reservoirs, *Alnetea glutinosae* (1) - broad-leaved willow thickets of alder share.

It should be recalled why the above list also includes a class of forest (*Querco-Fagetea, Vaccinio-Piceetea*). Well, among inventoried alien plant species it has also been found native forest species, but occurring not typical for such habitats. Eg. hornbeam species of riparian habitats, or species of riparian habitats coniferous or broadleaved.

All occurring in the area of the Młociny Park potential forest communities belong to *Querco-Fagetea*. Therefore, the occurrence in their area representatives of other classes evidence of degeneration of these communities. Also within the class *QF* it comes to obliterate the differences between communities and to penetrate species from one community to the different neighboring communities. Therefore, eg. in the riverine communities we meet hornbeam species. Examples are maple (*Acer platanoies*) and linden (*Tilia cordata*), commonly occurring in riparian habitats.

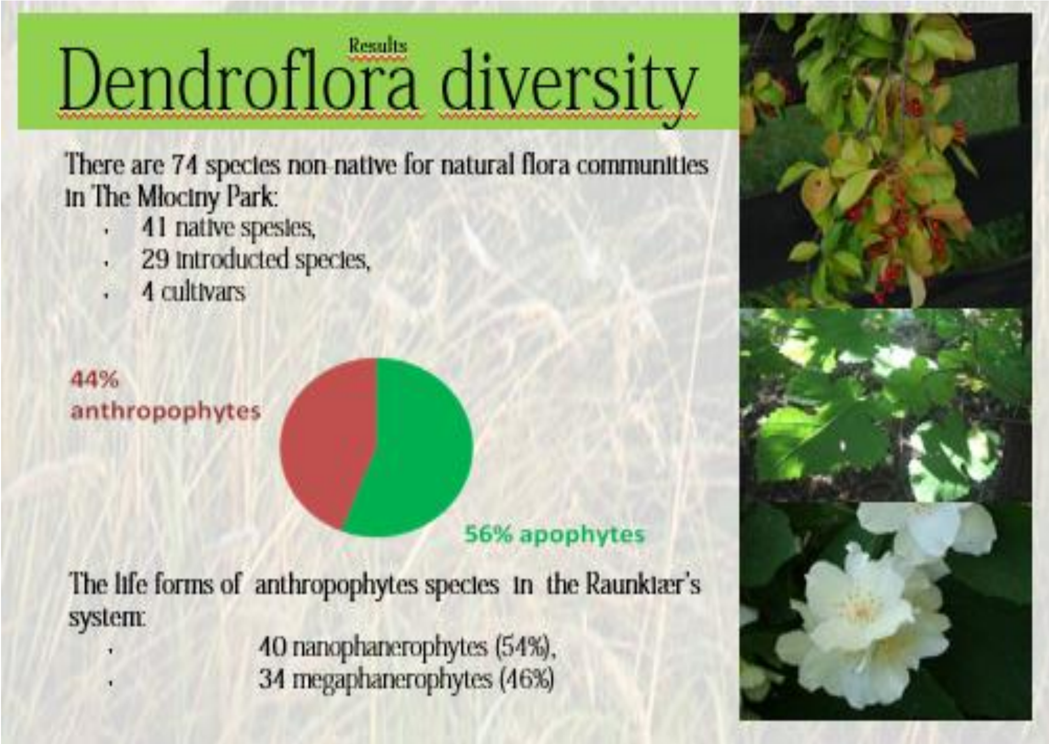

Figure 2 Structure of dendroflora diversity in the Młociny Park

Based on the study of vegetation neighborhood the wilderness and the uroczyska defined list of alien species: non-forest apophytes (synanthropes) and forestry (contrary to habitats communities in the forest, which are adjacent) and antropophytes, which penetrate the immediate vicinity, and cover the reserve into forest: apofity: *Euonymus europaeus*, *Juniperus communis, Malus sylvestris, Picea abies, Populus* x*canescens, Prunus spinosa, Pyrus pyraster, Rhamnus cathartica, Ribes nigrum, Rosa Canina, Rubus* sp. (decorative raspberry), *Rubus* sp. (decorative blackberry) *Sambucus nigra, Viburnum lantana*; anthropophytes: *Acer negundo, Forsythia* x*intermedia, Morus alba, Philadelphus coronarius, Prunus cerasifera, Prunus serotina, Quercus rubra, Ribes sanguineum, Robinia pseudoacacia, Syringa vulgaris*.

Thus, the above mentioned species that are found in the Młociny Park, their source of inflow to, inter alia, in the immediate vicinity.

Other alien species occurring in the wilderness are the result of forest management and the unconscious seed dispersal by animals and visitors forest inhabitants of Warsaw. Another important source of spread of alien species is adjacent to a large rail route (route discharge from Warsaw No.7).

• Most species of exotic (alien Polish flora) occurring in the Młociny Park native to North America and Asia. This applies to both trees and shrubs as well. Among these species have been identified substantial majority of invasive species.

• Alien species non-specific for a given community, exotic species and native species of synanthropic (derived from non-forest communities) occurring in the Mlociny Park can be divided into 5 groups (including the list of omitted belong to the same community forestry):

a) species which occur singly in community, occasionally, together with the amount recorded surface:

Berberis koreana, Berberis vulgaris, Cornus alba, Corylus xcolurnoides, Cotoneaster lucidus, Crataegus rhipidophylla, Deutzia scabra, Forsythia xintermedia, Fraxinus pennsylvanica, Juglans regia, Ligustrum vulgare, Malus sp., Morus alba, Philadelphus coronarius, Physocarpus opulifolius, Picea abies, Populus alba, Populus tremula, Populus xcanescens, Prunus avium, Prunus mahaleb, Prunus serotina, Prunus spinosa, Pyrus pyraster, Ribes alpinum Ribes nigrum, Ribes sanguineum, Rosa canina, Rubus sp., Salix alba, Salix caprea, Salix sp. Syringa xjosikaea, Tilia 'Euchlora', Viburnum lantana, Weigela florida;

b) species which are to a limited extent, but large tracts, together with the number recorded surface:

Acer campestre, Ailanthus altissima, Spirea xpseudosalicifolia, Symphoricarpos albus, Syringa vulgaris, Prunus cerasifera Prunus spinosa.

Some of these species are found only 1 out of 12 respondents surface. However, their expansiveness is very large. They occupy a large surface gradually expanding its acreage occurrence. In the future, it is possible their gradual spread into new areas.

c) species which are abundant (some for almost the entire forest area):

Acer negundo, Euonymus europaeus, Malus sylvestris, Prunus cerasifera, Ptelea trifoliata, Pyrus pyraster, Quercus rubra, Rhamnus cathartica, Robinia pseudoacacia, Rubus sp., Sambucus nigra, Sorbus aucuparia, Tilia cordata, Tilia platyphyllos,

d) invasive species:

Acer negundo, Robinia pseudoacacia, Quercus rubra, Prunus serotina;

e) species expansive (potential invasive species):

Acer capmestre, Ailanthus altissima, Ptelea trifoliata, Sambucus nigra, Spirea xpseudosalicifolia, Spiraea salicifolia, Symphoricarpos albus, Syringa vulgaris.

As a species can be considered expansive field maple (*Acer campestre*), which as a species specific to one of the teams of the forest occurs throughout the area, in other communities.

• most of alien species is present (in order from most abundant occurrence of alien species to the least numerous) along the western edge of the forest, along the southern edge of the forest, along the road bypasses around - west.

On the basis of these observations, it can be said that the most distorted in terms of the genre structure dendroflora (number of species and area occupied by plants synanthropic), a collection of the Młociny Park is gathering fresh mixed forest of pine and oak *Pino-Quercetum typicum* (now replaced by the forest and scrub communities replacement and its forms of degenerative with a large share of neophytes).

• least alien species there: along the road bypasses around - east, along the eastern border, along the forest road branches.

These are areas located in the eastern part of the forest, so close to the Vistula River valley, and the most urbanized areas of the city. Ward Road runs through the middle of the forest and is much less frequented compared to other forest roads

• expansiveness of invasive species is dependent on environmental requirements and the method of propagation and spread.

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MODEL RAINGARDENS - PLANTS FOR URBAN STREET AREAS ON EXAMPLE OF ŁOMIANKI - SMALL CITY IN POLAND

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ABSTRACT

The theme of this article is to present several design solutions associated with the use of rain gardens in urban spaces, green areas. The article is devoted to the idea of rain gardens, its definition and determination of the place of these elements in the structure of urban green areas.

Rain garden is determined plantings of plants in the ground or a container that remove contaminants from flowing rainwater collected from the surface of roads, yards and roofs [8].

Thanks to the rain gardens less water flows from impervious surfaces (pavements, streets, parks, squares) into drains, because the plants retain it in the landscape, thereby increasing the water retention. Although the rainy garden resembles an ordinary garden, planted in the special wetland plants. Their roots or rhizomes retain contaminants from the collected water by itself, for example. Heavy metals and compounds of the protein-fatty acids. The surface of the garden, thanks to the carefully selected layers of sand and gravel, retains impurities in the water.

Rain gardens are an example of a relatively simple to make and that does not require its bioretention operation, which allows you to stop and pre-treating rainwater runoff. They are made as the low ground, overgrown with vegetation, using subsurface drainage. On the surface of the rain garden recommend placing a layer of litter (mulch). It allows you to conduct heat, humidity and soil permeability [8]. Also it acts as a layer accumulating heavy metals, oils and petroleum substances and prevents the proliferation of weeds. In addition, protective function for the soil against rain and wind, making humus layer is not damaged. Rain gardens are used mainly for infiltration from small surface area of up to 1 hectare or less. For these reasons, suitable as a solution acceptable to runoff from roofs and driveways on private estates and heavily urbanized areas, like parking places and pedestrians driving. Increasingly, a common solution is to combine the manufacturing site of the largest runoff (eg. the outflow of drainage pipe) with a rain garden using infiltration ditches, or trenches filled with gravel [7].

The conclusions from the literature were the basis for the creation of some interesting design solutions presented in the article. When creating projects take into account existing habitat conditions and expectations of the residents of the city Łomianki, which has become a testing ground for the design work.

KEY WORDS

rain gardens, plants resistant to fluctuations in water levels, urban green areas, street green areas

INTRODUCTION

What is a rain garden? Rain gardens are becoming increasingly popular in the home landscape. A rain garden is a natural or dug shallow depression designed to capture and soak up stormwater runoff from your roof or other impervious areas around your home like driveways, walkways, and even compacted lawn areas. They can be used as a buffer to shoreline areas to capture runoff from the home landscape before it enters a lake, pond, or river. The rain garden is planted with suitable trees, shrubs, flowers, and other plants allowing runoff to soak into the ground and protect water quality.

In addition to adding beauty to your home landscape, rain gardens can also help protect water quality, by reducing stormwater runoff from your house lot. Stormwater runoff is considered one of the main sources of water pollution nation-wide. As watersheds become developed, urbanization and an increase in paved surfaces such as parking lots, driveways, and rooftops increase stormwater runoff causing rainwater to run off quickly into storm drains and surface waters [5].

The EU strategy for the conservation of biodiversity for the period to 2020 includes a commitment from the European Commission to develop a strategy on green infrastructure, which is an important step towards protecting natural capital. This document was in May 2013 presented by the Commission, and its contents discussed at the conference: "Green infrastructure: the involvement of regions, cities and society" on 4 November 2013.

Rain garden is determined plantings of plants in the ground or a container that remove contaminants from flowing rainwater collected from the surface of roads, yards and roofs. Thanks to the rain gardens less water flows from impervious surfaces (pavements, streets, parks, squares) into drains, because the plants retain it in the landscape, thereby increasing the water retention [9]. Although the rainy garden resembles an ordinary garden, planted in the special wetland plants. Their roots or rhizomes retain contaminants from the collected water by itself, for example. Heavy metals and compounds of the protein-fatty acids. The surface of the garden, thanks to the carefully selected layers of sand and gravel, retains impurities in the water [7].

Rain gardens are so importaint element of green areas symstems in cities because of some main reasons. Two of the most important environmental issues are water quality and stormwater control. Rain gardens enhance local water quality by allowing water to be naturally filtered by soil instead of being piped, untreated into large bodies of water. A simple, yet effective method to enhance water quality and control stormwater is through the use of rain gardens[1].

As cities and suburbs grow and replace forests and agricultural land, increased stormwater runoff from impervious surfaces becomes a problem. Stormwater runoff from developed areas increases flooding; carries pollutants from streets, parking lots and even lawns into local streams and lakes; and leads to costly municipal improvements in stormwater treatment structures [6]. By reducing stormwater runoff, rain gardens can be a valuable part of changing these trends. While an individual rain garden may seem like a small thing, collectively they produce substantial neighborhood and community environmental benefits [3]. Rain gardens work for us in several ways:

- increasing the amount of water that filters into the ground, which recharges local and regional aquifers;

- helping protect communities from flooding and drainage problems;
- helping protect streams and lakes from pollutants carried by urban stormwater – lawn fertilizers and pesticides, oil and other fluids that leak from cars, and numerous harmful substances that wash off roofs and paved areas;
- enhancing the beauty of yards and neighborhoods;
- providing valuable habitat for birds, butterflies and many beneficial insects [4].

THE AIMS

The aim of this study was to develop a comprehensive design solution for third-year students of stationary studies 1 ° of Landscape Architecture for the areas of street town Łomianki – small city in central part of Poland [the Masovia region]. The main task was to create a selection of plants, recruiters from different groups, utility and good for them appropriate technical solutions that enable their development without involving large sums.

MATERIALS AND METHODS

The starting materials was a basic map and documents provided by the Office of the City and Municipality Łomianki, the development of natural and other source materials. An important element of the work on design solutions was to analyze the materials of literature concerning spatial solutions of rain gardens.

Students and authors of the article work began with the vision field. The collected materials were analyzed. The next step was the development of various project proposals for areas of street main traffic artery of the city Lomianki - Warszawska street. Then focused on selection of plants.

RESULTS

In natural landscapes there's very little stormwater runoff because most rainwater filters down through the soil or evaporates back into the atmosphere. In developed landscapes' compacted soils, impervious surfaces like asphalt and the removal of vegetation result in a huge increase in stormwater runoff. Runoff flows over developed surfaces, enters storm drains and is piped to the nearest stream. The fast-flowing polluted runoff scours away stream banks, widens and deepens the channel, and blankets downstream areas with the dislodged sediment. The deepened stream channel lowers the water table so that nearby vegetation may suffer drought or even death. Rain gardens try to re-create the natural water cycle and reduce water quality problems. A rain garden is a shallow, landscaped basin that pools stormwater runoff on its surface allowing it to slowly infiltrate into the soil. Infiltration through the soil removes solid and dissolved pollutants. Some of the filtered stormwater recharges the groundwater while some is held in the pore spaces between the soil particles and rocks. Both groundwater and pore space water are available to plants. The Structure of rain gardens consists of several standard features [3].

Beyond its environmental use, rain gardens provide attractive landscaping and a natural habitat for birds and butterflies, while encouraging environmental stewardship and community pride. In addition, using native plant species in your rain garden will be an excellent way to increase native populations in a developed area. Characteristic feature for raing garden is the level of planting. It must be dug down or planted slightly below-grade to catch the runoff in a shallow basin. Ideally, a rain garden is also planted with a variety of native grasses, forbs and other herbaceous or woody plants that are adapted to the soil, precipitation, climate and other site conditions. These native plants have deeper root systems that facilitate the efficient recharge of our aquifers and also sustain the plants through the draughts that sometimes occur in summer period [1].

Next element, very importaint for rain gardens, is plant selection. The success of rain garden depends on selecting the right types of plants. Habitat conditions are a key role [4]. These conditions may contribute to unusual 'microclimates' due to increased heat or exposure and it is necessary to choose plants accordingly. Native plants – or plants that are indigenous to this climate or region - can thrive without a lot of care, extra water, or extra fertilizer. For esthetic purposes select plants that have various heights, leaf color and shape, and that bloom in a wide array of colors throughout the seasons. Non-native invasive plants overtake gardens and may escape into surrounding areas [1].

Native plats are recommended for rain gardens for a number of reasons. They live through droughts and downpours, and survive the winters without special care. Fertilizer will make them grow bigger, but they grow beautifully without it. Pests munch on them and the plants bounce right back without chemical pesticide sprays. Native plants also have relationships with local butterflies, insects, birds, animals and other plants that they have developed by living together over thousands of years. Planting natives helps provide habitat for local wildlife [2].

The best solutions in designs are a combination of native species and of non-native plants. Although many non-natives also do well, there are some unique benefits to using natives.

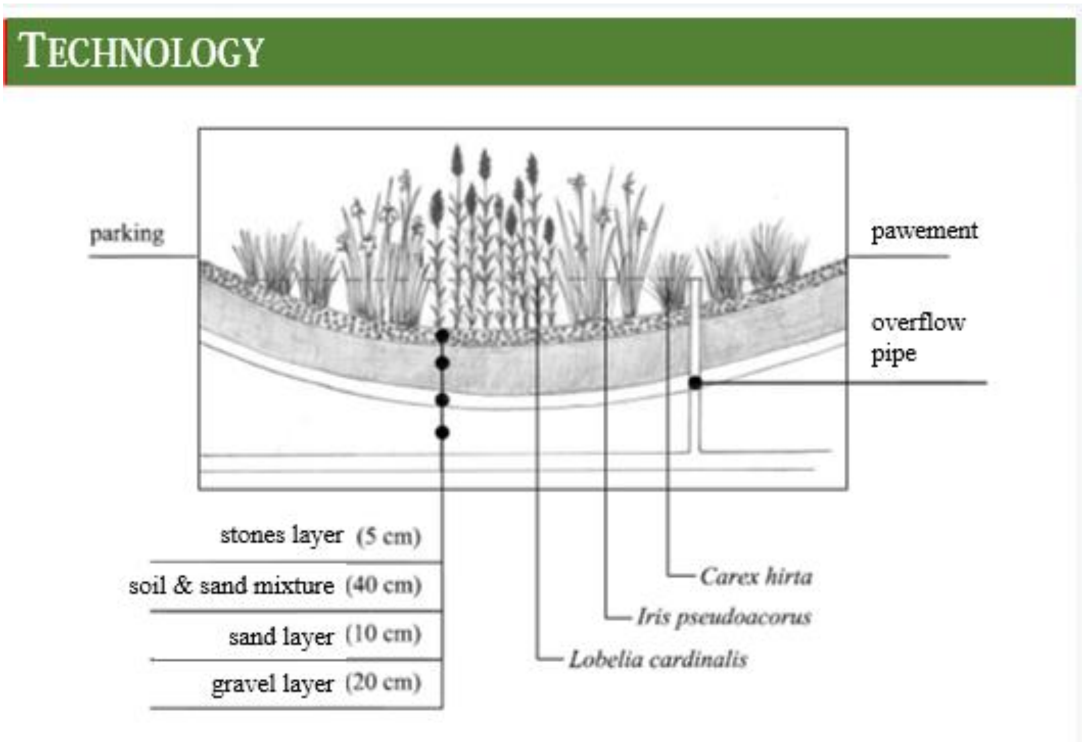

Figure 1. Technology of rain garden, wchih was used in proposed ideas.

It is best to use native, non-invasive species that are resistant to the stress from both brief periods of pooling as well as dry periods between rainfall events [3]. A variety of plants with large root structures will make your rain garden more effective and less susceptible to disease. It is also better to use plants with a developed root structure instead of starting plants by seed. Seeds will have a hard time establishing in the conditions of a rain garden and will also leave the soil exposed and prone to erosion [5].

Based on the knowledge gained during studies of different sources: literature, maps and materials kartogrqaficznych, iconographic analysis of site conditions and social expectations design ideas were formed presented below.

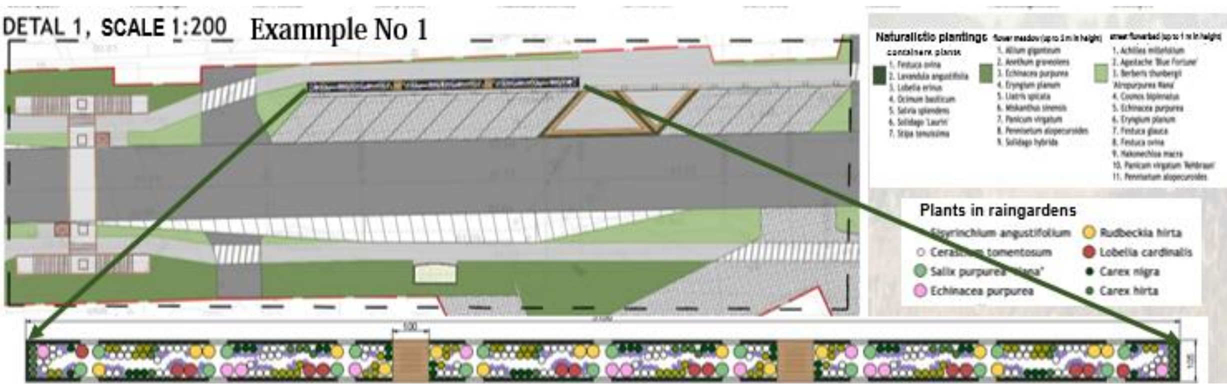

Figure 2. First idea – rain gardens connected with parking places.

Oresented idea has a high simplicity solutions. For the proposed piece of Warszawska street it was proposed large of naturalistic meadow. In a confined space and difficult soil conditions proposed gardens with perennials boxes: *Festuca ovina, Lavandula angustifolia, Solidago* 'Laurin', *Stipa tenuissima* and elements of the seasonal nature of *Lobelia erinus, Ocimum basilicum, Salvia splendens*. For larger spaces flowery meadows were used. One in the first set (with a height of plants up to 2 m in height) were: *Allium giganteum, Anethum graveolens, Echinacea purpurea, Liatris spicata, Miscanthus sinensis, vurgatum Panicum, Pennisetum alopecuroides* and *Solidago hybrida*. In the second set, characterized by up to 1 meter, were: *Achillea millefolium, Agastache* 'Blue Fortune', *Berberis thunbergii* 'Atropurpurea Nana', *Cosmos bipinnatus, Echinacea purpurea, Eryngium Planum, Festuca glauca, Festuca ovina, Hakonechloa macra, Panicum virgatum* 'Rehraun', *Pennisetum alopecuroides*.
The essential elements of the rain garden, the rain is: Sisyrinchium angustifolium, Cerastium tomentosum, Salix purpurea 'Nana', Echinacea purpurea, Rudbeckia hirta, Lobelia cardinalis, Carex nigra and Carex hirta.

Figure 3 Second idea – rain gardens inspired by the Vistula river

This concept is based on the figure formed by the Vistula meandering on flat, lowland areas around Warsaw. Rain gardens (with similar species composition as in Example No1) in irregular patches interleaved with other systems rebate and groups of shrubs

CONCLUSIONS

In summary, the rain garden can be an interesting alternative to the objects of landscape architecture within urban green areas. Just remember a few rules, at their creation.
In the analysis of pre-rain gardens should be examined:

- soil and water conditions;
- directions and sources of rainwater;
- the location of the nearest receivers rainwater (trench drains, rivers, etc.).
- the size of a sealed surface that generates runoff;
- the amount of available space for the construction of the rain garden;
- sun exposure [1].

Rain garden design is mainly based on the calculation of the amount of runoff and the depth and size of the garden of the rain and the selection of plant species. For the calculation of the volume of runoff is assumed size of the area which will generate an inflow of water into the garden of the rain and the amount of rainfall occurring in the area. Due to the frequent lack of rainfall data derived from a longer period of monitoring, the calculation assumes the annual amount of rainfall occurring in the area. In the calculation of the catchment area include the size impervious surfaces (roofs, driveways, etc.) And 20% of vegetated, after which the rain water flows towards the garden. Under domestic gardens rain sizes typically range from 10 to 30 m2, for the purpose of draining the surface of the communication they are more sizes in the range of 90-100 m2. In both cases it is recommended that the length of the garden rain is at least 1.5 times greater than its width. Thus, rain gardens are usually in the shape of beans or regular ellipse. They are also common solutions, where rain gardens are carried out in the

form of long strips along the greened-over streets, improving upon the landscape values of the area, while fulfilling the role of a drainage system for pedestrians or driving routes.
At the location of the rain garden should be taken into account [2] .:
- Distance from the property (min. Recommended distance is 4 m);
- Proximity to vacation destinations such residents. Terrace (the recommended location near places to stay for residents);
- The slope of adjacent land (trailing direction should be toward the rain garden)
- Terrain (recommended area varied little in terms of altitude).

We not recommended for rain gardens location:
- Directly on the foundations of the building;
- Close to septic tanks;
- When the slope of adjacent land is greater than 12%;
- There is little or impermeable land;
- With high ground water level (the bottom of the rain garden should be at least 1 m above the seasonally occurring highest level of ground water);
- A short distance trees are cultivated, where falling leaves can reduce capacity by gardens and sometimes initiate processes of decay [1].

In addition to reducing and filtering stormwater runoff and increasing groundwater recharge, rain gardens provide many other benefits including:

Provide habitat for wildlife and, with the proper plants, increase the number and diversity of birds and butterflies for those who enjoy watching tchem [6].
Provide an attractive and creative alternative to traditional lawn landscapes. Require less maintenance than lawns because they do not need to be mowed, fertilized, or watered once established.
Increase property values with creative landscaping designs. Reduce storm drain overload and flooding if adopted on a community or neighborhood scale [5].

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GREEN INFRASTRUCTURE IN OPEN LANDSCAPE ON EXAMPLE OF HISTORICAL REMAINTS OF THE DUTCH SETTLEMNETS IN THE ŁOMIANKOWSA VALLEY [PART OF THE VISTULA VALLEY]

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ABSTRACT

The Mennonite culture, associated with the presence of Dutch settlers in the time of XVI – XIX centuries, has had large impact on the cultural landscape of Mazovia region. The Dutch settlers had developed a specific type and arrangement of buildings and cultivation. Dutch settlements have preserved to this day and are the valuable part of the cultural landscape of the region. The purpose of research has been to recreate the Dutch rules of landscaping, including the participation of trees, and the formulation of the preservation principles of the cultural landscape and elements of green infrastructure associated with Mennonite heritage. Methodology included the analysis of source material and spatial arrangement of settlement units (about 19 units), together with the structure of mature trees. Building layouts associated with roads, specific forms of mid-field plantings and dendroflora accompanying households and sacred objects have proved to be typical elements of the Dutch tradition in terms of spatial order and species. Tree species directly related to the historical principles of shaping space are primarily alluvial forests species growing in the river valleys. In order to protect the building against the flood water and ice from the Vistula River, willows and poplars have been planted.

KEY WORDS

Mennonite culture, Dutch colonization, cultural values, green infrastructure, Mazovia region

INTRODUCTION

The cultural landscape is an environment in which social life takes place. There is a close cultural relationship with nature, expressing, inter alia, the need to protect the human environment, preserve natural areas and creating ecological corridors between them, preventing fragmentation of areas of natural character. Cultural values are sometimes invisible in the landscape and difficult to define. Similarly sometimes it underestimated the importance of certain elements of nature, of a natural or anthropogenic influence favorably on the structure and functionality of the countryside, as it happens in the case of trees and copper, including those associated with other sequences of canals and drainage. They are often distinguished only intuitively. It is important in the perception of cultural landscape and its consistency with the natural the natural environment to increase awareness about the area, its history and traditions.

Mazovia has a rich and very diverse history. The physiognomy of the landscape of Mazovia is the result of natural conditions, the turbulent history of the region and the diverse traditions of the peoples living in this area. Appearance of the present village of Mazovia is often associated with planting willows along the road in the knotted form. The symbol "headed willow" is easily recognizable and synonymous with Mazovia and old Polish tradition. Often it appears in the logo associated with Mazovia. As it turns out, it is part of Mazovia stranger, though well-rooted in the mentality of people.

Knotted willows beside the Vistula apparent monotonous landscape of Mazowsze can see what kind of storm it. These are the hills, on which stand the houses are different from the typical Mazovia peasant cottages. You can also be found abandoned cemeteries, churches closed by simple architecture and modest interior, often destroyed and not used by anyone. They are leaving in oblivion traces of Dutch settlement. Dutch settlements are an example of successful cooperation between man and nature (especially rivers), proof of the possibility of human science by prying nature and adapt to it in the way of management. The Dutch colonists represent the type of economy that is most closely associated with the nature of all Polish citizens. The settlement is characterized by a ponadregionalność (Fijałkowski 2001), which eventually became the hallmark for this region.

The aim of the study was to identify the remains of Dutch colonization in the central part of the cultural landscape of Mazovia (the northern part of the former Warsaw Earth) as components of green infrastructure Mazovia.

MATERIAL AND METHOD

The topic was based on analysis of source materials, iconographic (testing chamber) and on fieldwork carried out in 2008-2013. The study area included the central and northern part of Mazovia. Fieldwork involved 19 settlements, which according to historical data was reported settlement Olęder (Szałygin 2009).

Within the current administrative borders of Warsaw were: Choszczówka, Kepa Tarchomińska, Henryków, Słodowiec, Pelcowizna, Kepa Nadwiślańska, Kepa Zawadowska. In the district Nowy Dwor within the municipality Czosnów were: New Kazuń, Kepa Czosnowska, Debina, Cząstków, Czosnow, Borki, Łomna and the municipality of Nowy Dwor Mazowiecki: Kepa Nowodworska, Holendry Sosnowska Kepa. In the commune Lomianki, in the district of Warsaw West were: kępa kiełpińska, Sadow, Deans Forest.

Field studies relied on to verify and supplement the information obtained during testing chamber. In particular, attention was paid to:

• the state of preservation of the cultural landscape associated with elements of green and blue infrastructure - water facilities and flood as low levees, field roads and paved invested on pedestals - trytfach systems of canals and ditches run parallel to the river, depression terrain with ponds, houses invested on artificial pedestals - terpach, row planting of trees and shrubs, especially white and fragile willow (*Salix alba* and *S. fragilis*) and white poplar (*Populus alba*) and poplars and aspens (*Populus nigra* and *P. tremula*)

• condition of the systems ruralistycznych, in particular arrangement of fields and runners with a distinctive system of long streaks and an indication of their borders in the form of row planting of trees and shrubs,

• the state of preservation of the cultural landscape associated with the system stall: rows of willows ogławianych, fascine fences, building pens characteristic patterns associated with specific elements of the architecture of the houses, ornamental gardens and system utility. Also included is the presence of places of worship - cemeteries and churches.

Green infrastructure is understood in this paper as a collection / system areas with natural ecosystems and semi-natural and other surfaces biologically active substances produced by human activities, including tree plantings, shrubs and green areas within the meaning of the Nature Conservation Act 2004 (as amended).

RESULTS

The Dutch settlement - historical and individual characteristics

The history of the Dutch colonization on the lands of Mazovia can be divided into several stages. The first step is early settlements olęderskiego from the seventeenth century and early eighteenth century (Myga-Friday 2012). The beginning of colonization olęderskiego Mazovia probably dates back to the seventeenth century (although in some publications are traces of settlement already from the fourteenth century, Zaraś-Januszkiewicz 2012). This settlement is closely linked with the history of modern Warsaw, primarily parts of the northern border of the Earth in Warsaw and the central part of the city directly connected with the Vistula River valley. A special role is played here Lausitz (Urzyce, Urzecze) - unfortunately, forgotten ethnographic region of the central part of Mazovia, stretching on both banks of the Vistula River between the former mouths of Pilica and Wilga, and the current mokotowskimi Siekierkami and right-bank Saska Kępa (Baranowski 1915, Kneifel 1971). In 1628 the first settlers arrived olęderscy to Saska Kepa, then called Kacza Kępa and Dutch Baranowski (1645.) In today's Zyrardow.

The second phase is the stage of intensive settlement olęderskiego covering the period from the second half of the eighteenth century to the mid-nineteenth century, culminating in the years 1800-1806 (Myga-Friday 2012). At that time the area of Mazovia flocked colonists from Flanders, Friesland and Germany. In the 100 years they settled or created more than 170 villages. The second phase od the Dutch settlement is related to the process of shaping a fundamental feature of the cultural landscape settler-rural and agricultural. Separation of this trait expressed in the original form of settlement and uniqueness appearance of the buildings.

Village completely inhabited by the mennonites 1764, he was Kazuń (now Kazuń New) and 1778 years King Stanisław August Poniatowski confirmed the agreement alderman Kampinoski with Olędrami to lease wolves. In 1781, we established a settlement on Kepa Nowodworska in Śladów and Secymin. However, only about half of the eighteenth century began a massive influx of colonists. Foreigners were resettled mainly of wetlands riparian forests, "on muddy land on the Vistula River, bushes overgrown and inaccessible" (Beyer 1953 Heymanowski 1969).

After the third partition of Polish camera Prussia led the German peasants in areas of the Vistula. Almost at the same time Mazovia olędrzy, also called the name of religion Mennonites, threatened by Prussian militarism (conscription) abandoned their farms, pretending to emigrate to Russia. The turn of the eighteenth and nineteenth century was a time of settlement of population mixing Mazovia clearly indicating on the outnumbered German Lutheran ethnic group. An end to settlement olęderskiego was the enfranchisement of peasants during the January - confirmed by Tsar Alexander II in 1864. According to estimates, in Mazowsze it was then 191 villages inhabited by Olęder settlers. Until the end of

World War II survived the Mennonite community in Kazuń (Marchlewski, 1988, Szałygin 2009).

Residents of the Dutch settlements the first wave of migration, which is derived from Friesland and the Netherlands were generally less affluent than the colonists coming to Mazowsze in the early nineteenth century, coming from the depths of Germany, with whom they shared a common religion. Both of them because they were mostly Lutherans. What they shared was also a community language. The Mennonites had produced their own traditions, whose basic media were German (Plattdeutsch or archaic dialect of Low German with the influence of other Germanic languages), or Evangelical Mennonite confession. Each village had its own school, a teacher, a cemetery, and sometimes even the church. Although different from the indigenous inhabitants of Mazovia, the Dutch together with the Poles shared the plight and misery of rural life, helping needy (Ciesielska 1958). However, existing differences meant that the inhabitants situated on the plateau affluent neighborhoods considered to be someone better than the old Dutch settlers. They used to say about them maliciously, that are born blind. In one of the stories on this topic the Dutch wealthy settler asks: "Is it true that you, the people of the valley, you are blind even nine days after birth, like puppies?". "It is true," replies the Dutch. "But when a kid starts to finally see, he can spot the mountain hare, like you, even by a six board". This joke contains a play on words, "Sandhase" signifies both the variety a hare and a missed throw (http://zielona.org/Oledrzy_na_dawnym_Mazowszu, date of access 10.09.2012). Memories of those who still remember the old settlers Olęder, say a lot about how they lived and what kind of people they were. They were first and foremost masters of the land reclamation, digging ditches, ponds and pouring dike. They built locks, dams, pumping stations, windmills drainage, levees, watchtowers maintained Shaft and all devices on standby throughout the year. They were ruled by its own separate law called. The Dutch of emphyteusis, or long-term lease on the land swampy and neglected for tenancy in cash, constitutes a variation of the rights of Chelmno. Cultivated cereals, bred horses and cattle breeds mainly milk products (lowland cattle breed black-and-white Friesian). They engaged in fruit-growing and weaving wicker baskets, and their goods dispatched to Warsaw ships that once sailed regularly on the Vistula River. Thanks to them in the Warsaw area flourished horticulture, fruit and wicker (Rusiński 1939 Mężyński 1961).

Life on the river, which regularly spilled, required the inhabitants of the village of courage and intelligence. An expression of creativity was the idea and the construction of pens the Dutch and its location on a specially constructed pedestals for roads and homesteads. With this being raised even in times of massive flooding roads and homes remained unabated, and settlers moved around in boats between the houses, instead of moving on cars.

The third phase of settlement olęderskiego lasted from the mid-nineteenth century until World War II (Myga-Friday 2012). It was a time of strong mixing of the population this region. At this time, new villages were founded only sporadically.

Beginning of the end in accordance existence of Poles and the Dutches were the years 1939-1946. In September 1939, Polish military authorities interned some Protestant settlers. The summer of 1944 the Nazi occupation authorities issued evacuation orders for all Germans, including the Dutch settlers. The second phase of the evacuation of the Dutch, or rather escape took place in winter 1945, when it moved west, the Soviet offensive. Those who did not manage to escape were driven out in 1945-1946 (Szałygin 2009).

The period since World War II lasted only a Mennonite community in Kazuń. The postwar years brought nearly total destruction of culture the Dutch Mazovia. The trauma of the occupation and Communist propaganda fueled the hatred of the German revisionists allegedly remaining at the service of US imperialism, fear of returning former neighbors who would reclaim the farm and the land occupied by local or repatriates from the east. Efforts were made to annihilate the memory of former neighbors the Dutch and erase all traces of their existence. Cemeteries vandalized, demolished old German school. Over the years it has degraded distinctive landscape created by the settlers, and with it distorted ecological functioning of floodplains.

Cultural heritage after almost 400 years coexistence the Dutch and the Poles, it would seem, should be extremely rich. Such a conclusion supported by the fact that the presence of Mennonite settlers greatly influenced the landscape and changed his physiognomy. However, the period immediately after World War II brought considerable devastation of what remains of the "beavers of God," as they were called olędrzy by the creators of the exhibition at the Ethnographic Museum in Warsaw (it took place on 26.06-31.10.2010 r.). A legacy of Dutch settlers systems are primarily rural complexes, individual farms, cemeteries and churches.

Stage of Dutch settlement called. contemporary (Myga-Friday 2012), taking place after 1990, unfortunately, it is characterized by very strong poolęderskiego landscape changes, associated mainly with changes in ownership of land. These changes are very dynamic and radical, often irreversible. Fades generated by decades of presence Dutch landscape with a network of canals, trees and other elements included in the system fields. Processes of suburbanization, suburban colonization, particularly strongly reflected in the physiognomy of pomennonickich areas. There is the concept of chaos ruralistycznego (Myga-Friday 2012). The most that chaos occurs in after Dutch riparian areas. Destroyed or overgrowing are elements of small architecture and engineering water as dikes, ditches, bridges, as well as terpy, or artificially piled up hills, occurring in areas floodplains and the treated areas polderisation (the word is derived from the Dutch language, Mazovia as Polonised and colloquial you will hear the word clogs) and trytfy - artificial hills for roads, retention ponds are disappearing too. Cut, destroyed, neglected stands are typical for the Dutch settlement - stands of poplars and willows are particularly important to the landscape this region.

the village layout

Systems village

Part of Mennonite culture that has survived in the least changed much yet, there are spatial layouts villages, fields and runners. Due to the large diversity of Dutch colonization in different regions and in different periods it is difficult to speak of a single type of village or farm buildings. Everything depended on local factors (the terrain and the nature of the "wydzieranych" nature of land under cultivation or farming) and the origin of settlers (Szałygin 2009).

In the area of the northern and central parts of the earth Warsaw most common type of the village is zeilendorf, in fact ulicówka marsh with a distinctive belt system and a highly fragmented field of pens (Myga-Friday 2012). Farms were located along the river and lying parallel to the road. Each settler received a narrow strip of land situated across the river. These bands, commonly referred to as streaks, formed a very distinctive arrangement of runners (the generic name of arable land, meadows, pastures, orchards, chmielników and other crops).

Among the surveyed villages typical arrangement of zieldorf with well-preserved legible layout of fields and runners, and with elements of green infrastructure was recorded in the following places:

• in the southern part of New Kazuń - layout of the village is easy to read outside the areas related to the military base, in very good condition is the arrangement of fields, running routes with artificial planting willows, today knotted and terps, which originally were located farms,

• in Cząstków and Czosnów - layout of the village is clearly below the building, where balks are visible artificial planting of willow and poplar, ponds and drainage ditches, roads on clear increases in leading towards the embankment, often planted with trees, satisfactory is the state of preservation of the landscape within the cultural runners,

• in Borki where cultural landscape is preserved in very good condition, with visible runners golf, inline artificial planting of poplars and willows ogławianych especially well today, fascine woven fences with workarounds, drainage ditches and the remains of the original

Dutch architecture.

In Łomna, Kepa Kepa Nowodworska Kiełpińskie and preserved ponds and drainage channels seen in the depressions field within meadows and pastures north towards the Vistula River. They are accompanied by the remains of the row plantings, mainly willows and white, until recently knotted. These are the only remnants of the activities of Dutch settlers.

Completely degraded landscape with only traces of poholenderskiego settlement is typical for hummocks Czosnowski, Dębiny, courts, deans of Forestry and Dutch Sosnowska Kepa. A similar situation presents itself in the case of the village absorbed through Warsaw. The exception is Kepa Zawadowska. Founded in order to develop the wasteland of the Vistula in the estates of the Potockis family. The first mention of the settlement comes from the Dutch in 1819. In 1832. Built a school, a chapel, a cemetery was established (Szałygin 2009). Currently there are no building survived (the last was demolished in 1998.). Despite the inclusion of the land in Warsaw preserved readable landscape typical Dutch settlement - planting willows, also ogławianych and poplars, tracts of fields, fragments of the old shaft and the remains of the cemetery at Syta street in Warsaw, invested on terpie, enclosed metal fence.

Each settler occupied area of similar quality. Drainage ditches were built between parcels were abroad and always accompanied row plantings. Today, these woodlots are one of the most valuable elements of green infrastructure linking the valley with floodplain and above situated, are an important ecological corridor for many species. Farm area was large, reached about 30 hectares, or 2 drag nowopolskie (about 60 acres). Holding had a width of 100 -150 m and their length extended up to 2 km away. Thus, these "strings natural" often have extensive form and reached a considerable distance from the river. In each village land was secreted into the public, often exempted from the payment of the lease. The area earmarked for the construction of a school, inn or cemetery (Fijałkowski 1998).

Zieldorf villages located in the vicinity of rivers today have the same spatial distribution that has developed with the arrival of new settlers (Zaraś-Januszkiewicz 2012). Communication reclamation and artificial plantings are usually in good condition and are often the only evidence of the presence of visitors from Friesland and the Netherlands (Ratzlaff 1971

Długowska 2011 Zaraś-Januszkiewicz 2012). This condition is characteristic of the settlements far from major cities and administrative centers. Thanks to developments that can be observed here, do not impinge on a good assessment of the behavior of traditional solutions, which are also valuable elements of green infrastructure. These readable in space and landscape solutions are canals, dams and dikes, dams, drainage ditches and artificial reservoirs, as well as places associated with the so-called. chruściane fences - fascines wyplatanki between nasadami willow and poplar. Very clear road circuits remaining tracts of wild and often accompanying inline planting of poplars and willows which form important corridors connecting zone of the river and floodplains of the above areas situated.

By contrast, settlements near major urban centers completely lost their original character (Baranowski 1915) mostly due to absorption through urban areas, as happened with the oldest settlements Dutch incorporated in the territory of Warsaw.

If the main task of the colonists was grubbing-up of forest land, the owner was spent for them a defined space, and the settlers themselves chose the right place for felling and there located their farm. This led to the formation of the so-called. Built colony and as a result the village had distributed nature - a camp. The villages scattered characterized by a focused structure, but with a distinctly lax building (2/3 pens created in the space clearly focused structure, the distance between farms ranged between 50 and 70m, however, did not exceed 100m, Szałygin 2009). Form and layout of farms and villages were connected with economic activities, such as deforestation in the floodplain of the river. The owner commissioned the settlers grubbing-up of densely overgrown part of its land occupied by forest or recycle. Settler he chose a place and pace of work within this area (Wozniak 1970). Farm land occupied an area close to a square or polygon (Rusiński 1938).

Homesteads

In the farms they are associated mainly artificially heaped up hill terpy where erected buildings and trytfy - artificial hill as the shafts on which the road was located. In order to protect the building against encroachment of the waters and ice of the Vistula River, planted willows and poplars. High and dense plantings were a protective layer against swift current (Szałygin 2009 Zaraś-Januszkiewicz 2012).

Buildings usually pay attention observer thanks to an impressive arrangement of space, economical use of space terpów, but mainly due to its size (large size homes, especially in the type Langhoff 30x15x8 m, with a decent bypass among orchards and gardens, with rich decoration). Houses, if they were wooden, built mainly of tree species occurring in the environment. Prevailed houses made of pine, oak or poplar less. In connection with the construction of farms and where sediment can be observed colonial settlers impact on the expansion of the area of felling (Schumacher 1907, Zaraś-Januszkiewicz 2012).

The Dutch farm ruled according to their own principles of spatial. Apartment house residential part was directed toward the river. From the front, from the side of a small residential gardens were located and decorative, whose task was not only decorating the provision of fruit and vegetables, but also retaining the rich nanosów during floods. Flood waters, penetrating to the corral had two tasks. First of all, they had a fertile field, what helped rows of trees and shrubs and fences fascines installed between them. The second task was, in a sense be cleared. the Dutch they greeted as if the flood waters open door. Water eluted impurities from parts of the animal and carried nanos fertile fields. Therefore, the first turn was part of the apartment. Only then will the water was breaking into the business part.

Homesteads in the study area remained mostly in rudimentary form.

The most common element of these farms are in the type langloff house, situated on a small hill. These objects have already been inventoried (Szałygin 2009). As compared to the 2009 listed buildings and homesteads have been slightly altered as a result of the lack of renovation work. Their condition deteriorated slightly, but remained unchanged typical architectural features of the settlement, expressing, inter alia, in the form of buildings, building decorative elements (final, shutters, etc.), arrangement of buildings within the enclosure. Unfortunately, they did not survive in any of these examples even pieces of home gardens. It would be difficult to reproduce the placement of these gardens, primarily due to changes in the use of adjacent land (mainly the introduction of routes, thereby often reversing the functionality of some farms and even entire spatial systems).

Photo 1. Old Duch channel (author Ewa Zaraś-Januszkiewicz, 2014)

Photo 2. Country road with knotted willows (auhor Ewa Zaraś-Januszkiewicz, 2014)

Photo 3. Group white poplars, typical for the Dutch settlement, for midfield shelterbelts (author Ewa Zaraś-Januszkiewicz, 2014)

SUMMARY

The most characteristic features of the landscape, created by the Dutch settlers in the areas included in the green infrastructure, or that could create such a system include:

• floodplains and polders used once and today as pastures or farmland,

• wooded and forested areas of embankment,

• characteristic poplar and willow plantings associated roads and hydro technical devices, such as canals and ditches.

Settlements or individual habitats appearing on the lowest terraces, with full infrastructure in the form of increases in homes (terps) and roads. The most characteristic feature of trees was and to this day is knotted willow; shoots obtained in the process of topping were used to create fascine fences, fortifications banks of the drainage channels and reservoirs in the fields, as a material for weaving baskets, but also contribute to steamers and powidlarni (specialty of Dutch settlers were jam beet produced in a separate place for this purpose built), teeth cleaning cloths for horses and fuel (Dolatowski et al 2000).

With their legacy pomennonickiej in the contemporary landscape of Mazovia is every day less and less. One reason for this was primarily World War II and the ratio of the population speaking German sounding language, after World War II. However, in other Polish towns, where such settlements also occurred (Żuławy Wiślane), heritage of the Dutch settlers is more respected.

The Dutch homesteads disappearance also favors local politics often poor and allowing the formation of new investments in areas where physiognomy is the result of activities of the Frisian settlers. Examples of such areas with unique cultural landscape are the floodplains along the river. And that's what they are in the best condition. Much worse situation presents itself in the case of farms, churches and cemeteries. Buildings and economic circumvent most often wear out or were intentionally destroyed. The congregations were often converted for residential buildings. And the cemeteries devastated.

By far the most lasting character are integrated landscaping, associated with existing today pedestals, which today are invested roads. Along the roads, as well as along more often preserved irrigation channels and field ponds today preserved typical of the settlement planting of willows and poplars. They provide extremely valuable elements of the landscape, bearing signs not only culturally valuable items, but also priceless natural. especially appreciated today due to draw attention to the issue of green infrastructure.

But you can not allow this to irrevocably disappeared from our landscape. After all, these people formed the landscape of the Vistula River Valley. Thanks to the farming culture of the region was at a higher level. For this reason, you must surround them with due care and respect.

The Dutch culture was a very high degree harmonized with nature area of river valleys, in the flood plains, and depressions field. The Dutch hardly changed environment, but trying to fit their culture to difficult and changing natural conditions. You can talk about a particular type of green infrastructure (green) cultural landscape associated with the activities of the Dutch. Protecting the cultural landscape also preserves the particular type of ecological and cultural infrastructure. What's more, some of the conditions / terms of shaping the landscape by the Dutch can be made in the contemporary landscape design.

Generally, the best state of preservation have the characteristics of spatial organization in the form of preserved village systems (habitats and runners). Mostly in a good or average condition are elements of the structure of the cultural landscape as road systems, locating habitats on artificial hills, planting willow and poplar and elements of drainage systems. The strongest transformations are visible in the vicinity of large cities. For this state of affairs responsible, inter alia legal factors allowing a sustainable development floodplains, raising levees in exchange for a system of polders, the formation of sludge homes in the suburban area. And the disappearance of certain professions and move away from the agricultural use of land. Unfortunately, the most serious threat to these valuable cultural, natural and geographical expansion areas of Warsaw.

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DIVERSITY OF ALIEN TREES AND SHRUBS SPECIES ALONG PASSAGEWAYS IN THE BIELAŃSKI FOREST RESERVE IN WARSAW

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ABSTRACT

The aim of the study is to determine the diversity of species of trees and shrubs along the Bielański Forest passageways Field studies were performed in 2009-2013 along the passageways in the Forest Bielański, a part of the Warsaw urban forests system. The research surfaces were in the form of belts. It was done phytosociological classification of alien plant species including invasive species. Among the synanthropic plant species dominate species derived class *Rhamno - Prunetea* and *Epilobietea angustifolii classes*, which shows significant degeneration of forest communities. The largest share of alien species represent areas located in the western parts of the forest - urbanized neighboring urban areas, which are many alien species. The plant species from *Rhamno - Prunetea* class were the largest group in the outer part of forest complex. Reduction of the migration routes and elimination the potential foothold for spreading alien species are needed.

KEY WORDS

Bielański Forest, urban forest, synantropization, alien species.

INTRODUCTION

In the forest ecosystems of Europe, including Polish, human activity has already pointed out very early. You probably already from the Neolithic Age (2000-800 BC) forests were not only used, but also transformed through forestry and agriculture [Ellenberg, 1963]. The forms of forest use have evolved over the years: from gathering, the economy glow, cattle grazing by raking mulch until after felling and artificial forest regeneration. The totality of influences and human impacts on the natural environment is referred to as anthropogenic pressure. This is an important factor shaping the contemporary faces of the Earth's vegetation [Olaczek 1972], and one of its effects is synanthropisation plant communities.

The team synanthropisation factors is a form of human impact on the environment (ie, a combination of factors related to one type of activity) or form .: usage such as tourism, whose components result in a fairly homogeneous effects, such as trampling or ruderalizacja habitats [Faliński 1972]. Bielański Forest Vegetation has long been studied many botanists. Already in the interwar period, most studies on flora Forest owe a professor of botany forestry and dendrology Roman Kobendza [1932], associated with the University of Life Sciences. He made the first attempt phytosociological intake of plant communities in the forest Bielański. His work continued in the 60s, among others: Maria Alberts, Hanna Kulikowska, then Mieczyslaw Witkowski [Sudnik-Wójcikowska 1982]. Since the 80s after years of existing vegetation Forest Bielański be under the permanent control of members of the Institute of Botany at the University of Warsaw. Detailed studies of the flora and plant populations led and lead min: Barbara Sudnik-Wójcikowska [1982], Barbara Solińska-Górnicka [1989, 1990], Eve Simonides [1989, 1990], Jan Chojnacki Wojciech Mroz [1984].

THE AIMS

The aim of the study is to determine the variety of species of trees and shrub along the routes Forest Bielański.

The study sought replying to set out specific research objectives: identification and classification Phytosociological alien plant species including invasive species (both native species, but nonspecific for forest communities and species completely alien our flora) and to determine the type of action to preserve native species consistent natural habitat in the forests.

MATERIAL AND METHODS

Field studies were performed in 2009-2013 along the routes in the Forest Bielański in Warsaw, forming part of the urban forest system Warsaw. Research areas designated as belt width:

from 30 to 50 m (depending on conditions on the ground) along the borders of forests and forest communities to pass in non-forest, 20 m along the main roads (on both sides of the road). The study was conducted at 20 research plots in the Reserve Forest Bielański including 14 surface area of the reserve, 6 areas in the buffer zone and close proximity. Naming species of trees and shrubs were considered Senet and Dolatowskim [2003]. Membership phytosociological plant species was determined by dividing the classification of syntaxonomical Matuszkiewicz [2009]. Estimates of the contribution of synanthropic species of trees and shrubs are based on geographic and historical distribution of synanthropic plants Kornasia [1968] and classification of species, including native apofitów and from other areas geobotanical antropofitów [Sudnik-Wójcikowska 1987].

Bielański Forest Reserve lies in the district of Zoliborz is the most valuable reserve a landscape that is Warsaw. In the surroundings of the reserve, on top of a hill called Mount racks, stands the historic monastery Camaldolese were established at the time of Władysław IV. On its site is the tomb of Staszic. Las Bielański and Kampinoska Forest and Forest Młociński are a relic of the Forest Mazowsze, which until the fourteenth century covered Mazovia. Bielański Forest Reserve protects a unique structure of the forest, mostly deciduous, with fragments of beautiful hornbeam and riparian forests. Las Bielański combines like no other a green area of Warsaw, natural, climate, landscape and historical.

The beginnings of Las Bielański associated with the history of the village Polków, which was owned by the prince, and after the capital was moved to Warsaw to the Polish partitions belonged to the king. Since the nineteenth century, Las Bielański served mainly recreational functions and was a popular meeting place. After World War II Bielański Forest is within the city of Warsaw. It was built in the Cultural Park, which housed the famous Carousel in Bielany. Unfortunately, this has resulted in a significant degradation of the forest environment. During this period he was popularly called Lasek Bielański. In 1973 the Forest Reserve was created Bielański a landscape, whose statutes allowed for the elimination of the Park of Culture.

Las Bielański occupies the site of diverse surface. Plain glacial carved valley cuts through the stream Bielański. Originally source of the stream were in the area Wawrzyszew and its natural outlet to the Vistula River was near the monastery hill. There's a water pipe are stacked to move mills and created ponds that have survived almost until the end of the nineteenth century. After the drainage of Bielański stream was channeled and connected to the collector. Due to decreasing ground water level, flow with time became periodically drying an watercourse, and now rarely appears in the water. The existence of this former watercourse provide stately old alders growing on the dried-up riverbed.

Rudawka River is one of the few surviving even permanent watercourses within the left-bank Warsaw. Originally, the source of this river were in the area at the Bois Circle. Currently, there are only the last section of the road, passing through the lowest flood terrace in the Forest Bielański. During the drainage works carried out here Rudawka river was regulated, its bed was straightened to speed up water drainage, which later resulted in adverse consequences for vegetation decline in groundwater levels. Nearby regulated watercourse Rudawki in the forest can be seen the old bed of the river, designated podmywanego the edge of the shore and a number of old trees. On the eastern side Rudawki still in the thirties was damp meadow hay. At the uppermost terrace Bielany is still relatively well preserved hornbeam and oak forest, and more specifically the somewhat poorer and drier character - hail high. The tree stands are the old oaks here: common oak and less frequent in the vicinity of Warsaw sessile oak and hornbeam. In addition, there is here in admixture linden, Norway maple and Scots pine, a species which is here retreating, because the lack of natural regeneration.

Las Bielański, or rather its part is situated on a glacial plateau, where the edge is steep escarpment. In a place where there is an observation deck, its height is about 100 meters away, while it rises to a height of about 20 meters above the water of the river Vistula. Historically, the escarpment was undercutting by the current of the river. Vistula riverbed was then much wider and went further west. Vistula escarpment cuts beyond the left bank of Warsaw in a southeasterly direction. It is clearly visible at the height of the Citadel, Old Town, Baths. On some sections of the escarpment has been destroyed or is at risk because of ill-built, and it is one of the corridors of natural Warsaw and together with the valley of the river Vistula is part of wedges aeration city. Once on the mouth of the slope were numerous sources. Some of them encased in using drinking water.

RESULTS

Based on the survey in the reserve Bielański Forest 49 alien species and 37 native species in the buffer zone were found. Also awarded against the native species habitat, species of non-native flora (exotic), alien species resulting from treatment of breeding, invasive species.

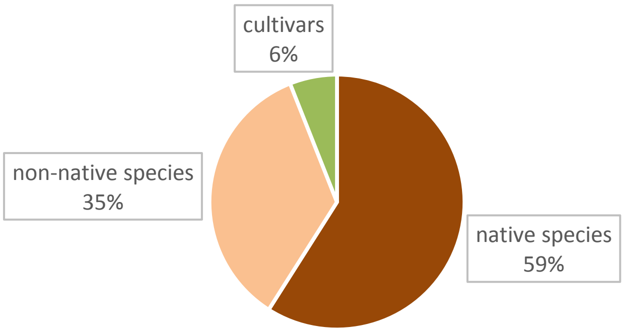
Within distinguished phytosociological classes synanthropic species the largest group was from the class *Rhamno-Prunetea* (9 species). 5 species represents nitrophilous communities (*Epilobietea angustifolii*), initiate secondary succession (regeneration) of forest after the destruction of trees by logging, fire, windthrows. *Epilobietea angustifolii*, 4 species of communities eutrophic deciduous forests *Querco-Fagetea*, 3 species of nitrophilous communities stately perennials and vines on ruderal habitats and on the banks of reservoirs (*Artemisietea vulgaris*), 3 species belonging to scrub and forest communities willows narrowleaf in river valleys (*Salicetea purpureae*), 2 species of coniferous forest habitats poor and acidic (*Vaccinio-Piceetea*) and 1 species representing a broad thickets of willows involving alder (*Alnetea glutinosae*). One of the most common species from the class Rhamno-Prunetea intermediate was hawthorn (*Crataegus* x*media*), which is a hybrid hawthorn single and dwuszyjkowego the characteristics intermediates. All members of this class form a rather natural forest communities overwrap. As such, there are also inside the Bielański forest complex, mainly along roads. The main representative of the class *Epilobietea angustifolii* was elderberry (*Sambucus nigra*). In the area also cover the largest group represented synanthropic species plant species from the class *Rhamno-Prunetea*. This may indicate the existence of a process of penetration of species and plant cover in the immediate vicinity of the reserve to the interior of the forest.

Based on the study of vegetation neighborhood of the reserve and the reserve set out a list of alien species: apophytes non-forest (synanthropes) and forestry (non-compliant with the habitats of forest communities which are adjacent) and antropophytes, which penetrate the immediate vicinity, and cover the reserve into the woods .

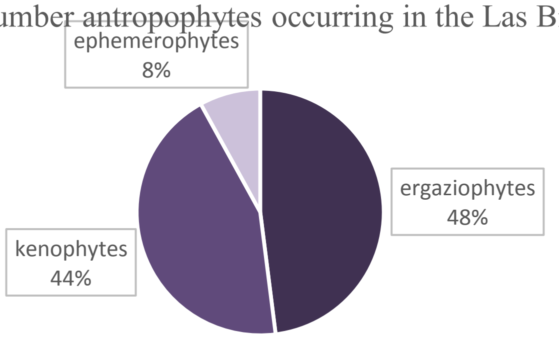
Among those species the highlights: Acer pseudoplatanus, Betula pendula, Crataegus xmedia europaeus Euonymus, Ligustrum vulgare, Malus sylvestris, Populus tremula, Prunus avium, Prunus spinosa, Pyrus pyraster, Sambucus nigra, Tilia cordata. Anthropophytes are represented by Acer negundo, Aesculus hippocastanum, Prunus cerasifera, Prunus serotina, Prunus sp., Quercus rubra, Ribes sp, Robinia pseudoacacia, Spiraea japonica, Symphoricarpos albus, Syringa vulgaris. Most exotic species occurring in the Bielański Forest are native to North America. This applies to both trees and shrubs as well. These species have been identified large majority of invasive species (80%). Alien species non-specific for a given community, exotic species (Polish Foreign flora) and native species of synanthropic (derived from non-forest communities) occurring in the Bielański Forest Reserve can be divided into 5 groups. Distinguished alien species that occur singly, occasionally Acer saccharinum, Berberis vulgaris, Betula pendula, Caragana arborescens, Euonymus verrucosus, Fagus sylvatica, Hedera helix, Ligustrum vulgare, Malus sylvestris, Parthenocisus inserta, Philadelphus coronarius, Prunus serotina , Prunus sp., Reynoutria japonica, Rhamnus catharica, Ribes nigrum, Ribes sp., Ribes uva-crispa, Sorbus intermedia, Spiraea japonica, Vitis riparia, Syrynga vulgaris. Then diagnosed species which are of limited range, but for large stretches of Crataegus pedicellata, Crataegus xmacrocarpa, Crataegus media, Prunus spinosa, Symphoricarpos albus, Tilia 'Euchlora', Tilia tomentosa, Quercus rubra, Robinia pseudoacacia, Sambucus nigra. These species having a tendency to fouling large areas and occurrence in clumps on the reservation. Diagnosed species which occur frequently (some for almost the entire surface of the reserve: Acer negundo, Aesculus hippocastanum, Crateagus xmedia, Euonymus europaeus, Prunus cerasifera, Pyrus pyraster, Quercus rubra, Robinia pseudoacacia, Sambucus nigra. Invasive species are represented by Quercus rubra, Robinia pseudoacacia, Acer negundo, Prunus serotina and Reynoutria japonica.

Prunus serotina, *Reynoutria japonica* are very dangerous species, easily spreading invasive species on a global scale. The same even their occasional, individual appearance in the reserve may in the future lead to significant invasiveness. Distinguished expansive species (potential invasive species): *Sambucus nigra*, *Aesculus hippocastanum*, *Symphoricarpos albus*, *Prunus cerasifera*. It has also been conditionally supported the existence of the species, the so-called. native species occurring on their respective sites, but outside its natural range and native species eliminated from the wrong habitat, and stood on the corresponding habitats. These include *Acer platanoides*, *Acer pseudoplatanus*, *Berberis vulgaris*, *Betula pendula*, *Crataegus* x*macrocarpa*, *Crataegus XMedia*, *Euonymus europaeus*, *Euonymus verrucosus*, *Fagus sylvatica*, *Hedera helix*, *Ligustrum vulgare*, *Malus sylvestris*, *Pinus sylvestris*, *Populus alba*, *Populus nigra*, *Populus tremula Prunus avium*, *Prunus spinosa*, *pyraster Pyrus*, *Sorbus intermedia Sorbus Sorbus*, *Tilia cordata*, *Rhamnus cathartica*, *Ribes nigrum*, *Ribes uva-crispa caesius Rubus*, *Rubus ideaus*, *Salix alba*, *Sambucus nigra*.

Picture 1. Participation of native species, non-native and cultivars in the forest standof the Bielański Las



Picture 2. Participation of kenophytes, ergaziophytes and ephemerophytes in the total number antropophytes occurring in the Las Bielański



Picture. 3. The origin of non-native species of trees and shrubs

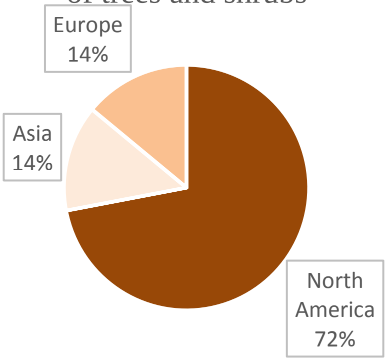


Table 1 List of species in the Bielański Forest beyond natural occurrence.

Native species [outsie their communities]	Non-native species	Cultivars
Acer platanoides (Q-F) Acer pseudoplatanus (Q-F) Berberis vulgaris (Epi.ang.) Betula pendula (Epi.ang.) Crataegus xmacrocarpa (Rha-Pru) Crataegus xmedia (Rha-Pru) Euonymus europaeus (Rha-Pru) Euonymus verrucosus (Rha-Pru) Fagus sylvatica (Q-F) Hedera helix (brak danych) Ligustrum vulgare (Rha-Pru) Malus sylvestris (Art.vul.) Pinus sylvesris (Vac-Pic) Populus alba (Sal.pur) Populus nigra (Sal.pur.) Populus tremula (Epi.ang.) Prunus avium (Rha-Pru) Prunus spinosa (Rha-Pru) Pyrus pyraster (Rha-Pru) Rhamnus cathartica (Rha-Pru) Ribes nigrum (Alne.glu.) Ribes uva-crispa (Art.vul.) Rubus caesius (Art.vul.) Rubus ideaus (Epi.ang.) Salix alba (Sal.pur.) Sambucus nigra (Epi.ang.) Sorbus aucuparia (Vac-Pic) Sorbus intermedia (brak danych) Tilia cordata (Q-F)	Acer negundo Acer saccharinum Aesculus hippocastanum Caragana arborescens Crataegus pedicellata Parthenocissus inserta Philadelphus coronarius Prunus cerasifera Prunus serotina Quercus rubra Reynoutria japonica Robinia pseudoacacia Spiraea japonica Symphoricarpos albus Syringa vulgaris Tilia tomentosa Vitis riparia	Prunus sp. (ornamental cultivars) Ribes sp. (ornamental cultivars) Tilia 'Euchlora'

Alien species that occur singly, occasionally:
Acer saccharinum, Berberis vulgaris, Betula pendula, Caragana arborescens, Euonymus verrucosus, Fagus sylvatica, Hedera helix, Ligustrum vulgare, Malus sylvestris, Parthenocisus inserta, Philadelphus coronarius, Pinus sylvestris, Populus alba, Populus nigra, Populus tremula, Prunus avium, Prunus serotina, Prunus serotina and P. padus, Rhamnus catharica, Ribes nigrum, Ribes sp., Ribes uva-crispa, Salix alba, Sorbus intermedia, Spiraea japonica, Vitis riparia, Syrynga vulgaris.
Species which are of limited range, but for large stretches of:

Crataegus pedicellata, Crataegus xmacrocarpa, Crataegus xmedia, Prunus spinosa, Symphoricarpos albus, Tilia 'Euchlora', Tilia tomentosa, Quercus rubra, Robinia pseudoacacia, Sambucus nigra.

These species having a tendency to fouling large areas, and the presence of clumps in the reserve.

Species that occur frequently (some for almost the entire surface of the reserve):

Acer negundo, Aesculus hippocastanum, Crateagus xmedia, Euonymus europaeus, Prunus cerasifera, Pyrus pyraster, Quercus rubra, Robinia pseudoacacia, Sambucus nigra.

These are the species most commonly found almost throughout the reserve, in all forest communities

Invasive species:

Quercus rubra, Robinia pseudoacacia, Acer negundo, Prunus serotina.

These species are listed on the Polish list of invasive plants (http://www.iop.krakow.pl). Their occurrence in the reserve is due to the fact that in the past served as The Las Bielański - Park of Culture, thus planting these species shall not be prohibited. As well as the environmental awareness of foresters was then another ...

Prunus serotina, *Reynoutria* sp.- they are very dangerous, easily spreading invasive species on a global scale! The same even their occasional, individual appearance in the reserve may in the future lead to significant invasiveness.

Expansive species (potential invasive species):

Sambucus nigra, Aesculus hippocastanum, Symphoricarpos albus, Prunus cerasifera.

Species: Sambucus nigra, Symphoricarpos albus was considered dangerously expansive and even invasive in the reserve, taking into account the space that they occupy most of the forest communities. These are huge tracts of single species that do not allow even the development of other plant species in a given location. Elderberry (*Sambucus nigra*) has appeared on as many as 10 of the 14 surveyed areas in the reserve! Common horse-chestnut (*Aesculus hippocastanum*) in the form of adult specimens and the number of individual seedlings seen in many communities. Snow berry (*Symphoricarpos albus*), while encountered in groups nawt covering an area of 50m2.

Photo 1. Localisation of the Bielański Forest.

Photo 2. Weekly fete in the Bielański Forest.

DISCUSSION

The presence of alien species in the Bielański forest reserve is a serious signal of degeneration occurring forest communities there, and neophitisation process. Fortunately degeneration is not a phenomenon involving the whole community, but only its elements. In the case of the analyzed object has the character of a fully human activities. Recognized among alien species red oak (*Quercus rubra*), white black locust (*Robinia pseudoacacia*), *Acer negundo*, black cherry (*Prunus serotina*) or tree-of-haven (*Ailanthus altissima*) in spite of the effective appearance are undesirable species in forest ecosystems. The result is neophitysation process displacement by alien species of indigenous plants, as well as addressing their ever-increasing acreage to adverse changes in the natural environment. An example is to change the chemical properties of soils by acting on them excessively locust white. According to a study conducted Reserve dendroflora Kabacki in 2002 found that in the context of progressive neophitysation process, of 34 species of trees and 28 species of shrubs, found 14 species of foreign origin. The study focused primarily within the exclusions stand, and little at the external borders of the forest. These studies did not take into account the area where the Kabacki forest reserve borders the Culture Park Powsin and settlements adjacent to the reserve. In studies of the composition of dendroflora omitted so they were therefore very important centers are a source of many alien species and non-specific flora the Kabacki Forest and may constitute a serious threat to her [Brogowski et al. 2003]. In contrast, studies about the Kampinos forest showed the presence of 24 species of trees and shrubs 7 species of foreign origin [Otręba, Ferchmin 2007].

Elimination of alien and invasive species appears to be a seemingly simple. The most spectacular form of defense against new infestations is to prevent intentional and accidental introductions. In turn, the best "weapon" against those species whose introduction could not be prevented, there are immediate and complete eradication. Species that look decoratively in gardens or parks, such as the Siberian Peashrub (*Caragana arborescens*) do not look favorably with mixed forest vegetation, just do not fit in the landscape. This issue also applies to many other alien species. Undoubtedly, this phenomenon can not be left without control. Native vegetation - its appearance, physiognomy and characteristics of the landscape, it creates should be subject to continuous monitoring and protection. It should begin efforts to reduce the occurrence of such species, even when you are not a strong threat to native communities, or completely eliminate them, when he threatened (invasive species).

Forest management in buildings, as analyzed in the work should lead educated and prepared for such situations employees. It also can not allow a situation that was observed during field research: garbage directly into the forest truncated (the cuts correction in the gardens) branches, especially if it concerns a very expansive species like *Rhus typhina*. It is very irresponsible. To prevent such actions should be carried out educational campaigns informing users of the forest about the consequences of such behavior and learning how they should behave so as not to contribute to the spread of these negative phenomena. Proper diagnosis and prevention of the spread of invasive plants in Poland is of utmost importance. Especially on forest protected areas (national parks, reserves, protected landscape areas, river valleys, NATURA 2000), which are residual positions natural communities. Keep in mind that the main premise of the introduction of trees was to find the best species, which under the circumstances would give the best results incremental and economical. The development of silviculture also favored the introduction of trees outside the natural range (larch, spruce), but we must remember that the map ranges have been developed in the last century, and bringing different species had and still have a place in a variety of ways over the entire surface. The same thing happens spontaneously in nature. It is right to promote the establishment of native species can not receive such a positive experience. Larch, spruce or even beech. The conclusion from such a position of the Regional Directorate of State Forests in Gdansk may be one: look, what is clear what species are highly undesirable, as a species affects the habitat and stand and how his acclimatization [Solarz 2007].

Thus, if complete elimination of alien species, exotic is impossible, in some cases, there is still a chance to reduce their numbers in small areas, especially those where their presence can produce extremely negative effects on local wildlife. Are just objects such protected areas (national parks, reserves and protected landscape areas). However, as shown by the past experience of different countries, if an alien species such as *Acer negundo* create a stable population, in most cases its effective control is virtually impossible and must be reconciled with the fact that it has become a permanent part of the ecosystem [Solarz 2007].

It is important not only from the point of view of maintaining native plants and local ecosystems, which is one of the most important nature protection purposes, but also to prevent economic losses "in the US in 1100 invasive species every day is another 1700 hectares. The annual cost of fighting these plants exceeds US 24.7 billion dollars. Available online list of alien plants, together with an assessment of their environmental impact, distribution, trends in the distribution and degree of difficulty of combat includes as of now nearly 400 species. In state forests alien plants cover over 1 million hectares. It is planned to create teams of experts aimed at combating invasive plants "[http://www.lonicera.hg.pl/news/ochpsw05a.html access 11.10.2011].

Photo 3. One of the routes in the Bielański Forest.

Photo 4. The diversity of landform features in the Bielański Forest.

CONCLUSIONS

1. Among the species of synanthropic plants species dominate from the class *Rhamno-Prunetea* and *Epilobietea angustifolii*, which indicates a significant degeneration of forest communities

2. The biggest part of alien species represent areas located in the western parts of the forest - adjacent urbanized urban areas, which are many alien species.

3. The area also cover the largest group represented synanthropic species plant species from the class *Rhamno-Prunetea*. This may indicate the existence of a process of penetration of species and plant cover in the immediate vicinity of the reserve to the interior of the forest.
4. Before the alien species, including invasive, does not protect any of tried and tested forms of nature conservation, including reserve protection if it does not limit itself migration routes and eliminate potential foothold for the spread of alien species.

SUMMARY

The intensity and the forest use forms have evolved over the years, especially in the case of urban forests. All these forms of human intervention in forest ecosystems contributed to the development and shaping of today's forest communities. The aim of the study is to determine the diversity of species of trees and shrubs along the Forest Bielański passageways, identification and phytosociological classification of alien plant species including invasive species, to determine the type of activities aimed at the preservation of native species compatible natural habitat in the forests. Field studies were performed in 2009-2013 along the passageways in the Forest Bielański, a part of the Warsaw urban forests system. The research surfaces were in the form of belts with a width of 30 - 50 m along the borders of the forest and forest communities go to non-forest, 20 m along the main roads. Based on the analysis of works related to the subject of the study process synanthropisation in forest areas it was found that generally the majority of positions alien plants occurring within the forest complex is on the verge of forest roads and hiking products and the border of the forest from non-forest. Among the synanthropic plant species dominate species derived class *Rhamno - Prunetea* and *Epilobietea angustifolii*, which shows significant degeneration of forest communities. The largest share of foreign species represent areas located in the western parts of the forest - urbanized neighboring urban areas, which are many alien species. The plant species from *Rhamno - Prunetea* class were the largest group in the outer part of forest complex. This may indicate the occurrence of the plant species penetration process from the outer part of forest to the interior part. Improper forestry, unaware of seed dispersal by animals and forest visitors had an impact on the spread of alien species. Before the alien species, including invasive, does not protect any of the tested forms of nature, including the protection of a reserve, if not reduce the migration routes and do not eliminate the potential foothold for spreading alien species.

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HRADENIE BYSTRÍN A STRŽÍ, ZABUDNUTÁ KAPITOLA?
TORRENTS AND GULLIES CONTROL - FORGOTTEN STORY?

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ABSTRAKT

Hradenie bystrín a strží má dlhoročnú tradíciu nielen u nás ale aj vo svete. Opatrenia, ktoré sa pri hradení využívajú, pretrvávajú celé generácie, najmä pokiaľ sú správne naprojektované, postavené a prevádzkované. Dodnes sa stretávame s týmito opatreniami, ktoré sú v bezchybnom stave a plne slúžia svojmu účelu. Vzhľadom na zmenu prístupu človeka ku krajine v priebehu rokov, nastali aj v tejto oblasti zmeny. V súčasnosti sú platné legislatívne nástroje, či už na národnej alebo medzinárodnej úrovni, ktoré upravujú hradenie tokov a výrazným spôsobom ich ovplyvňujú. V príspevku poskytujeme historický a súčasný prístup k tejto problematike u nás aj v zahraničí.

KĽÚČOVÉ SLOVÁ

hradenie bystrín, objekty, povodne, erózia

ABSTRACT

Torrents and gullies control has a long tradition not only in our country but also in the world. Measures that reimbursement is in use persist for generations, especially if are properly designed, constructed and operated. Even today, we can find measures, which are in perfect condition and fully serve to its purpose. Due to changing in the approach of the man to the country over the years, there have been changes in this area as well. Nowadays, the existing legislative instruments, whether at national or international level, governing disbursement flows and significantly affect them. In this article we provide historical and current approach to this issue in our country and abroad.

KEY WORDS

damming of torrents, measures, foods, erosion

ÚVOD

Slovensko ako hornatá krajina sa v minulosti musela zaoberať s ohrozením prírodným fenoménom ako bol odtok dažďových vôd z hornatých povodí. Aj napriek tomu, že tieto oblasti neboli intenzívne obhospodarované a prístupové cesty do nich ešte nepredstavovali významný príspevok k eróznej činnosti, základné fyzikálne princípy odtoku vody z povodia spôsobovali v miestach koncentrácie odtoku – v bystrinných korytách, intenzívnu eróziu. Tak sa značná časť eróznych účinkov vody vo forme splavenín, vznikajúcich priečnou a pozdĺžnou eróziou, dostávali do nižších polôh, kde sedimentovali a spôsobovali problémy či už v tokoch nižšieho rádu, alebo na rovinatých územiach. Transport veľkého množstva dnových sedimentov pri vyšších prietokoch v bystrinách mal niekoľko nepriaznivých vplyvov. V prvom rade to bola dnová erózia, následne svahová erózia v dôsledku zosunu podmytých svahov, poškodzovanie pôdy v miestach sedimentácie splavenín v deflačných kužeľoch a zanášanie tokov, do ktorých bystrina zaúsťovala, kde vznikali ďalšie problémy zanášania prietočného profilu a následne vybrežovanie vody z koryta. Všetky nepriaznivé vplyvy v záujme obyvateľstva sa začali riešiť v rámci verejno-prospešných prác, v záujme udržania kultúrnej krajiny schopnej poskytovať človeku bezpečnú existenciu.

PREHĽAD PROBLEMATIKY

Hradenie bystrín vzniklo v oblasti, kde bystriny spôsobovali extrémne stavy ohrozenia, teda vo vysokohorských regiónoch v alpských krajinách. Problémy boli známe už v priebehu 13. a 14. storočia, keď erózia nadobúdala čoraz väčšiu intenzitu v dôsledku intenzívnej ťažby dreva pre priemyselnú činnosť. Tento trend pokračoval aj v ďalších storočiach či už v dôsledku valašskej kolonizácie a tlakom pasenia na odlesňovanie území, ale aj potrebou rekonštrukcie krajiny po ústupe Turkov z obsadených území strednej Európy. Úbytok rozsahu zalesnených území bol dôsledkom intenzívnej ťažby a transportu dreva pomocou pltí po Váhu, Hrone a Ipli až do konca prvej polovice 20. storočia.

Už v 17. storočí sa začali realizovať zalesňovacie práce na území dnešného Slovenska, ktoré mali za cieľ obnovu vyťažených lesov a zlepšenie odtokových pomerov z povodí. Rovnako v riadiacich orgánoch štátu pochopili potrebu riešenia kritických stavov, a tak bol vydaný rakúsky zákon O neškodnom odvádzaní horských vôd č. 117/1884. Začiatkom 20. storočia sa zrealizovali niektoré stavby zamerané práve na eliminovanie vplyvov extrémnych prietokov a zastavenie erózie pomocou hradenia strží a výmoľov. Význam boja proti vodnej erózii v podmienkach Slovenska sa prejavil po zriadení žúp r. 1923 aj vo vytvorení osobitných oddelení pre lesnícko-technické meliorácie a zahrádzanie bystrín (LTM-ZB). Do r. 1995 bolo v správe lesného hospodárstva SR 23 639 km prevažne malých tokov, čo bolo 52,6 % celkovej dĺžky vodných tokov SR, z nich bolo upravených 480 km, z toho v intravilánoch obcí 166 km. Po r. 1998 malo zostať v správe lesného hospodárstva 11 461 km tokov. V súčasnosti Slovenský vodohospodársky podnik, ktorý sa stal správcom všetkých vodohospodárskych tokov a ich povodí, nemá dostatočné kompetencie, ani dostatok finančných prostriedkov na preventívne protipovodňové opatrenia, najmä v povodiach. Opatrenia prezentované v Programe revitalizácie krajiny a integrovaného manažmentu povodí SR z roku 2010 a navrhované prehrádzky nespĺňali ani základné požiadavky na protieróznu, prípadne protipovodňovú ochranu (Valtýni 2012). V 90. rokoch FAO vydalo svoju publikáciu Hradenie bystrín a stabilizácia dna koryta toku (Cardenas deLlano F.L., 1993). V mnohom zdôrazňuje princípy prezentované prof. Skatulom v jeho publikácii z roku 1960. Prof. Skatula sa detailne zameral na komplexné biotechnické postupy súvisiace so sprístupňovaním územia, protieróznou a protipovodňovou ochranou s racionálnym využívaním prírodných zdrojov a ich ochranou. Jeho doménou bol región Vysokých Tatier a experimentálnym územím Račkova dolina, kde navrhol kamennú prehrádzku (1938) na akumuláciu splavenín a stabilizáciu dna. Ešte v 60. rokoch sme sa pokúšali nájsť jeho prírodné hydraulické laboratórium, v ktorom podľa ústneho podania robil modelový výskum predchádzajúci vybudovaniu uvedenej prehrádzky. Zaujímavá bola aj jeho doktorská dizertačná práca: *„Zásady, podle kterých by mělo být řešeno zahrazování bystřinných oblastí tatranských po stránce hospodářské, technické a právní"*, ktorou získal vedeckú hodnosť doktor technických vied. Podrobne sa problematikou hradenia bystrín v podmienkach

Slovenska zaoberal Valtýni (2012), kde analyzoval všetky vplyvy a účinky bystrín, ich nebezpečenstvo a spôsob eliminácie tohto nebezpečenstva pomocou komplexných biotechnických opatrení. Rozsiahly komplex vo forme sústavy priečnych objektov v kombinácii s terasami z vŕbových plôtikov bol vybudovaný v rokoch 1926-1927 v Haluziciach - Haluzická tiesňava, podľa projektu prof. Skatulu. V súčasnosti je táto sústava zapísaná ako Technická pamiatka. V roku 2011 bola vykonaná oprava poškodených objektov - prehrádzok a prahov (Obr. 1) a naďalej slúži svojmu účelu.

Zahrádzanie bystrín v lesoch vo verejnom záujme zabezpečuje správca vodného toku. Podobne aj pre lesníckotechnické meliorácie sú opatrenia na protieróznu ochranu lesných pozemkov, najmä na zabránenie vzniku lavín, svahových zosuvov, strží, sutín a na odstraňovanie ich následkov, a tiež na zlepšenie kvality lesných pôd, najmä obnovu ich chemického zloženia a vodného režimu, alebo aj na zakladanie lesných porastov na zlepšenie protieróznej, protizosuvnej, vodohospodárskej a vodoochrannej funkcie lesa. Dnes sa dostávame s opatrenia pre lesníckotechnické meliorácie aj do území kde sa pôvodne vykonávali veľmi obmedzene – do uvoľnených vojenských priestorov cvičísk na území celého Slovenska.

Obrázok 1 Sústava prehrádzok v Haluziciach - Haluzická tiesňava (foto: Kaletová)

Významné stavebné diela hradenia bystrín boli naprojektované v horských oblastiach v Strednej Ázii. Ich význam je daný klimatickými pomermi a tým že horské oblasti sú významným zdrojom vody pre poľnohospodárstvo v nížinách (Калыбекова Е.М., 2010).

Súčasné trendy v hradení bystrín

Oproti pôvodným riešeniam hradenia bystrín je riešenie konkrétnej lokality komplexnejším projektom. Je potrebné pre riešenie zohľadniť podstatne viac podkladov a aspektov:

- Hydrologické a klimatické – je to zmena klímy prejavujúca sa práve v horských a podhorských oblastiach zmenou intenzity a výskytu zrážok a tiež aj zmenou povrchov zástavbou alebo zmenou porastov výrubom alebo prírodnou katastrofou. Preto sa tieto nové odtokové pomery musia zohľadniť pri návrhu nových zariadení ale je stále nedoriešená otázka vplyvu týchto nových prietokov na už vybudované diela. Nie je jasný postup pre prehodnotenie nových dostupných meraní s väčšou dĺžkou merania na prevádzku diel vyhotovených pred desiatkami rokov. Nevýhodou je aj nedostupnosť nameraných údajov v štátnej sieti, ktoré sú získateľné len za veľmi vysoké poplatky. Do hydrologických podkladov patrí aj znalosť pohybu sedimentov a aj napr. mŕtveho dreva v koryte toku (Jurík, 2011). Je to zásadný poznatok na správne rozhodnutie riešenia.

- Ochrana pred povodňami – pre všetky toky aj pre tie v horských oblastiach sú pripravované plány manažmentu povodňového rizika a mapy ohrozených území. Problematikou sa zaoberal Slovenský vodohospodársky podnik ale postup podniku Štátne lesy nie je dobre jasný a publikovaný. Pritom hustota tokov v horských oblastiach je podstatne väčšia ako mimo lesa. V lesoch nie je väčšinou ohrozenie budov alebo obcí, ale môžu byť poškodené najmä cesty alebo zariadenia vodohospodárskej infraštruktúry.
- Ekológia je dnes zásadnou podmienkou pre kvalitné riešenie zásahov do bystrín. Podľa veľkosti projektu pribudli podmienky zákona 24/2005 zo 14. decembra 2005 o posudzovaní vplyvov na životné prostredie a o zmene a doplnení niektorých zákonov. Podľa znenia zákona sú to väčšinou projekty zaradené aj ako Objekty protipovodňovej ochrany pre ktoré je potrebné spracovať dokumentáciu pre posúdenie vplyvov bez limitu, teda pre každý aj najmenší projekt. To bolo problematické pre Program revitalizácie krajine a integrovaného manažmentu povodí SR, kde sa pre niektoré už vybudované súbory objektov takáto dokumentácia nespracovala dodnes. Podmienkou pre ekológiu návrhu je aj požiadavka Smernice 2000/60/EU – Rámcovej smernice o vodách ktorá presadzuje udržanie kontinuity toku pre vodné organizmy a tak je veľký problém navrhnúť vyšší objekt zamedzujúci prirodzenú migráciu organizmov. Pre posúdenie riešenia je potrebné poznať celkové oživenie toku a sem podľa Smernice o vodách patria poznatky o rastlinách v koryte a v brehovom pásme, poznatky o bentických organizmoch a samozrejme aj poznatky o rybách.
- Ekonomika je podobne ako pre všetky opatrenia v krajine významným kritériom návrhu. Financie pre lesotechnické meliorácie ako aj pre vodohospodárske projekty sú uprednostňované pre veľké projekty, z dôvodu možnosti čerpania zo Štrukturálnych fondov EU alebo podobných finančných zdrojov. Zákon 326/2005 z 23. júna 2005 o lesoch v paragrafe 26, článku (2) (3) sa uvádza: Lesníckotechnické meliorácie sa vykonávajú najmä ako úlohy programu starostlivosti o lesy alebo ako opatrenia príslušného orgánu štátnej správy lesného hospodárstva. Náklady na lesníckotechnické meliorácie vykonané na základe rozhodnutia orgánu štátnej správy lesného hospodárstva vo verejnom záujme uhrádza štát. Tým by malo byť financovanie jednoduché ale v praxi to nie je až tak jednoduché a financovanie stavieb je vždy významným problémom pre realizovanie stavby.
- Sociálny rozvoj. Je to zdanlivo nesúvisiaca problematika, ale systém všeobecne prospešných prác, ktoré organizujú obce často vykonávajú aj opatrenia súvisiace s vodnými tokmi nad obcami. Upravujú sa tvary koryta, odstraňujú brehové alebo sprievodné porasty a niekedy sa aj mení materiál dna koryta necitlivým bagrovaním alebo nasadením dozerov (Jurík, 2013). Obce na to využívajú vlastnú možnosť schvaľovania projektov, ale pre zásahy ovplyvňujúce povodňové ohrozenie tieto rozhodnutia obciam neprináležia. Preto je nasadenie ľudí z obcí minimálne konfrontovať so správcom toku a je potrebné získať jeho písomný súhlas.

Program revitalizácie krajiny a integrovaného manažmentu povodí SR preferoval prírode blízke opatrenia, ktoré boli už aj v minulosti v hojnej miere budované a využívané v lesoch Slovenska. V Európe stále prebieha výstavba rôznych opatrení v rámci hradenia bystrín a strží rôznych veľkostí a konštrukcií. V Českej republike bola v roku 2014 vydaná metodika Technická protierozní opatření - Hrazení bystřin a strží, ktorá obsahuje praktický postup pri návrhu opatrení používaných pri hradení strží a bystrín. V Rakúsku boli po povodňových situáciách vybudované veľké prehrádzky, ktoré objemom zachytenej vody môžeme porovnať s poldrom (obr. 4). Aj známe turistické miesta (napr. Kaprun, Chamonix) sú chránené sústavou veľkých prehrádzok.

V rámci dokumentu Best practices on flood prevention, protection and mitigation (European commision,2003) boli prezentované opatrenia v rámci hradenia bystrín a strží ako súčasť protipovodňovej ochrany. Tento dokument tiež uvádza, že je potrebné udržiavať priečne objekty v dobrom stave.

Obrázok 2 Sústava vysokých prehrádzok nad mestom Kaprun, Rakúsko (foto: Kaletová)

Kým na Slovensku je verejnosť proti výstavbe betónových protipovodňových opatrení v krajine (kde patria aj vysoké prehrádzky), v zahraničí sa stále budujú. Jedným z argumentov odporcov je zlý vzhľad v krajine a vysoké investičné náklady. Čo si však odporcovia neuvedomujú je, že ochrana života a majetku nemôže byť estetická, ale účinná. Aj vodná nádrž, polder alebo prehrádzka môže byť zaujímavým krajinotvorným prvkom (obr. 2, obr.3). Pri ich riešení by sa mali vždy používať lokálne alebo minimálne prírodné materiály (obr. 4).

Obrázok 3 Prehrádzka nad mestom Chamonix, Francúzsko (foto: Kaletová)

DISKUSIA

Úlohy riešené v rámci projektov hradenia bystrín a strží sú aktuálne aj v súčasnej dobe. Vývoj v krajine je stály proces, ktorý nie je možné zastaviť, len spomaliť, resp. upraviť na akceptovateľnú mieru. Rozdiel oproti minulosti je v biologickom prístupe k riešeniu hradenia bystrín a strží. Zatiaľ čo v minulosti pri hradení sa nebral veľký ohľad na priechodnosť stavby pre migrujúce živočíchy (či už vodné alebo suchozemské), v súčasnosti je zabezpečenie kontinuity toku nevyhnutnosťou. Nové stavby sa navrhujú nižšie, prípadne s priechodnou časťou.

Vzhľadom na prijatie Smernice 200/60/ES, tzv. Rámcová smernica o vodách je potrebné zabezpečiť dobrý stav vôd. Jedným z hodnotených kritérií je aj priechodnosť riek a morfologické podmienky. Pre veľmi dobrý stav „Priechodnosť rieky nie je narušená antropogénnou činnosťou a umožňuje nenarušenú migráciu vodných organizmov a transport sedimentov“. Nariadenie vlády SR 269/2010 Z. z. v prílohe obsahuje popis priechodnosti tokov v dobrom stave (II. trieda) ako „je umožnená nenarušená migrácia organizmov a transport sedimentov. Maximálna výška migračných bariér je do 0,5 m.“, pre veľmi dobrý stav je max. výška 0,3 m. Tieto limity platia pre všetky typy vodných útvarov.

Vzhľadom na vyššie uvedené skutočnosti je potrebné pri najbližších úpravách vodných tokov brať tieto limity do úvahy a v prípade potreby voliť skôr iné opatrenia na stabilitu dna vodného toku, napr. balvanitý sklz.

Kým v minulosti boli budované najmä drevené (menšie) a kamenné (väčšinou väčšie) prehrádzky, v súčasnej dobe sa do popredia dostávajú prehrádzky zložené z gabiónu alebo betónové. Prehrádzky budované pri ústí údolia slúžiace na zachytenie povodňových prietokov a neseného materiálu sú budované kombináciou železa a betónu.

Obrázok 4 Hrádza vodnej nádrže obložená kameňom v Rakúsku (foto: Kaletová)

Na Slovensku sa do popredia dostávajú najmä prehrádzky zložené z gabiónových košov. V tomto prípade sa mení geometria priečneho profilu. Koše sú na seba ukladané postupne tak, že vytvárajú formu schodov. Pre zvýšenie ich stability sú pri dne najširšie a v korune najužšie. Pri výpočte je potrebné brať do úvahy prietočnosť samotného telesa hrádze, ktorá sa vzhľadom na veľkosť a uloženie vnútorného materiálu môže meniť. V priebehu času sa priestor medzi výplňou môže zaniesť a v prípade zvýšeného prietoku zvýšiť celkový tlak na teleso prehrádzky.

ZÁVER

Pokiaľ je opatrenie správne naprojektované, zhotovené a prevádzkované, ich miesto v krajine má nezastupiteľné miesto. Ak niektorá z týchto činností nie je vykonaná podľa predpisov alebo vôbec, zvyčajne to má nepriaznivé účinky na ochranu človeka, jeho majetku a krajiny.
Špecifické ciele ochrany pri hradení bystrín a erózie horských oblastí riešime plánovaním a realizáciou opatrení na ochranu komplexných procesov v povodí a ploche spolu s riešením iných druhov ochrany a nebezpečenstvami pre prírodu a ľudí. Koncepcie zahŕňajú kombináciu technických, hospodárskych činností v lesoch a aj samotných tokoch, biologické, priestorové a organizačné opatrenia v celom povodí. Výsledkom je okrem zamedzenia škôd predovšetkým zachovanie a zlepšenie ekologického stavu toku a jeho bioty. Významnou súčasťou sú aj opatrenia pre zachovanie alebo reaktiváciu ochranných účinkov lesov a vegetácie, ako aj prirodzené rozšírenie retenčné plôch, ktoré slúžia zadržiavanie povodní, sedimentov, ale súčasne vytvárajú biotopy pre organizmy, napr. pre obojživelníky a hmyz..

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SUITABILITY OF SOIL-ECOLOGICAL CONDITIONS FOR POMEFRUIT PRODUCTION AND THEIR SPATIAL PRESENTATION WITHIN THE AGRICULTURAL SOILS OF SLOVAKIA

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ABSTRACT

Soil, climatic and orographic conditions of the environment significantly influence the production of fruit species and their quality. The paper deals with the categorization of agricultural soil in terms of their suitability for cultivation of pomefruit. Spatial presentation of appropriate cropping conditions is based on the system of soil-ecological units, which is in the form of a geographical database reflected in the information system of agricultural soils of SR. On the basis of selected 120 apple tree varieties and 50 pear tree varieties it is presented the three-level categorization of soil ecological conditions of the very suitable, suitable, less suitable and unsuitable sites. Spatial expression of the suitability of growing apples and pears pointed to the unused potential of the soil and environmental conditions for their cultivation.

KEY WORDS

soil-ecological conditions, suitability for cropping, pomefruit, apple, pear

INTRODUCTION

Today increasingly resonates an adverse fruit production development prior to reduced area of intensive orchards, whose priority is to produce sufficient temperate zone fruits from its own production. Production of high quality fruit has always been dependent on climatic and soil conditions, which have significant effects on production and economic assumptions. Although a considerable role is given to the genetic and breeding measures, also the diversity of soil and climatic conditions and significant geomorphological heterogeneity in different regions have various degrees of suitability for growing different kinds of fruit. (Hnidzík, Hričovský, 1989) New breeded pomefruit varieties planted in dense planting system with early bearing varieties are also more demanding on soil quality and nutrient (Janick, Paull, 2008). Soil is an indispensable yield-creating factor that is directly related to efficiency and profitability of farming. Objective results of agrarian country categorization for the fruit production is therefore only be achieved by harmonizing a sufficient amount of analyzed data and parameters of soil. Aim of growing different fruit crops is to achieve the quantity and quality of production, which must be in harmonization of demands fruit plants to environmental conditions, which include climatic, orographic, edaphic and biotic factors. While some parameters of soils can be somewhat changed, the orographic and climatic conditions must be respected and adapt to them. Different soil types in Slovakia, the presence of three climate zones, located at the junction of the Pannonian, West- and East-flora and fauna create favorable conditions for growing many fruit species in temperate zones with different ecological requirements. Soil quality in relation to other environmental factors significantly affects the production process and the efficiency of a crop which is documented by a series of works (eg. Vilček, Bedrna, 2007; Džatko, 2002 Demo, Hričovský, 2002). The suitability of soil and environmental conditions for the cultivation of pome fruit and spatial differentiation within the agricultural soil in Slovakia are the subject of the present paper.

MATERIAL AND METHODS

For the avoidance of climatic regions was used Guide for use of maps valuated soil-ecological units (Džatko, Sobocki et al., 2009) through which individual environment parameters were evaluated. Depending on the degree of suitability a four-stage categorization system for growing pomefruit species was created, while 120 varieties of apples (*Malus domestica*), 50 varieties of pear (*Pyrus communis* L.) (Blažek, 2001, Nesrsta, 2011).

As first suitability parameter of environmental conditions a suitable climatic region of Slovakia was selected. As key-indicator purposefully clusters favoring production of preferred soil subtypes and soil types based on grain size were selected. Among other selected parameters were: optimal slope-codes, exposure, soil skeletality and the depth of the soil profile.

RESULTS AND DISCUSSION

Those requirements were implemented in the soil, climatic and orographic conditions of the environment which are included in the code of valuated soil-ecological conditions. On the basis of this approach a defined suitability pomefruit growing conditions within the agricultural land of the SR was defined, focusing on suitable site and soil conditions essential for achieving required fruit quality and profitability of the production. Suitability of soil and environmental categories of conditions for the cultivation of apples and pears were summarized in Table 1.

Table 1. Suitability of soil and environmental conditions for apple and pear production.

1. zone: very suitable	- area with very warm conditions (00, 01, 03-04) warm lowlands (Nt) - optimal conditions with regard to all soil and organic parameters - growing the most demand varieties
2. zone: suitable	- lowland area with warm and temperate climate (02, 04-05) lowlands (N) - one parameter of BPEJ less convenient but with appropriate production techniques a high-quality yield can be achieved - production of demand varieties
3. zone: less suitable	- upland areas involving temperate to slightly cool climate (02,05, 06-08) of uplands (P) - two or more parameters of BPEJ are less suitable - production of less demanding varieties
4. zone: not suitable	- highlands in the area of moderate cold to cold climate zone, moderate humid and very cold and humid climate (08, 09, 10) - highlands (V) in a very rugged territory, and significantly sloped terrain - unsuitable for intensive fruit production - production of fruit crops as supplementary component

Assessment parameters for apple production

Apple trees are among the most tolerant fruit with the most varieties, which is also reflected in the choice of soil and environmental conditions. As the first parameter from BPEJ the climatic region was selected, from which for apples from very warm (00), dry and lowland region to moderate cool and moderately humid region (08) were selected. Among very suitable to suitable zones a very warm, dry, lowland regions to a relatively warm, dry, fold, continental (05) climate regions were selected. For apples not suitable regions cool, humid (09) and very cold, moist (10) regions were selected.

Table 2: Suitable apple varieties following table 1.

1. zone: very suitable	summer varieties: Vista Bela
	spring varieties: Dione, Gala and clones
	winter warieties: Braeburn, Florina, Gloster, Golden Delicious, Goldspur, Granny Smith, Mutsu, Pinova, Glockenapfel, Starking
2. zone: suitable	**summer varieties**: Daria, Discovery, James Grieve Red, Júlia, Mio, Quinte
	spring varieties: Akane, Delén, Denár, Jonalord, Lord Lambourne, Doris, Nabella, Šampión, Vesna, Vitan
	winter warieties: Angold, Biogolden, Cox orange, Dalila, Dione, Domino, Dublet, Durit, Fany, Fuji, Heliodor, Jolana, Jonagold + clones, Jonagored, Jonagored Supra, Jonalord, Karmína, Luna, Melrose, Meteor, Mikra, Moonlight, Ontario, Opal, Otava, Pilot, Pinova, Rajka, Red Jonaprince, Resista, Rubín, Rubinola, Rubinstep, Rucla, Shalimar, Slovakia, Spartan, Svatava, Topaz, Unitop, Viktoria
3. zone: less suitable	**summer varieties**: Ametyst, Atlas, Dima, Hana, Lena, Miodar, Mivibe, Nela, Priesvitné letné, Zita, Zlatava
	spring varieties: Diadem, Dolores, Florijam, Oldenburg, Prima, Wealthy
	winter warieties: Aneta, Banánové zimné, Blaník, Bohemia, Clijo, Delor, Diamant, Dulcit, Gold Bohemia, Flordika, Goldlane, Goldstar, Hrivna, Idared, Jarka, Jonathan, Lipno, Lotos, Melodie, Nabella, Orion, Patriot, Produkta, Rondo, Rosana, Rozela, Selena, Sonet, Tábor, Vanda, Viktoria, Vltava, Vysočina

Those soil factors that affect fruit by physical, chemical and biological properties were following selected. Within the parameters of soil granularity very appropriate and suitable soil conditions included moderate clayey (02) and moderate to lighter sandy soils (05) were classified. Less appropriate for apple trees were heavy loamy clay soils (03). Among soil types, soil subtypes and soil varieties in Slovakia are significant production differences, it was therefore necessary to accept that in selecting the soil variability. Within the classification system from the major soil units (MSU) 36 MSU were selected apple trees, which were categorized according to the characteristics of suitability zones. Although apples are very tolerant for various conditions, for intensive production are unsuitable very heavy, gleyic soils and also very light, sandy, salty, solonetz soil types and significantly with imissions polluted soils (Hanisko et al., 2013). Among not suitable soils were also classified leptosols, lithic (extreme skeletal soils) and peat soils.

Markedly practical significance for fruit crops is the slope of terrain, which determinates the water erosion efficiency and solar radiation intensity. Although the majority of the agricultural land of Slovakia is situated in the plains to 3 °, the slope factor crucially affects the use of land for the selected fruit species. For that reason in category of less favorable sites with a gentle slope (02) from 3 ° to 7 ° were classified. The category of the most suitable areas are planes without erosion(00) and with a slope-range from 0 ° to 1 °, and planes with erosion (01) of 1 ° to 3 °.

An important role in site selection plays an exposure. Particularly significant difference in the production potential of soils is on the southern slopes, respectively optimal, compared to sites lying on the northern slopes. Within a very appropriate and suitable zones planes (00) to southern exposure (01) was chosen, less suitable eastern and western exposure (02) was evaluated.

From soil granularity categories are the best for apples soils without soil granularity, among less suitable soils slightly skeletal (skeleton content in the surface horizon of 5-25% in the subsurface horizon of 10-25%) were placed. When choosing a soil depth parameters, among the best placed were selected soils deeper than 0.60 m (00), less suitable soils were classified medium deep soils from 0.30 to 0.60 m (01) and shallow soils to 0.30 meters (02).

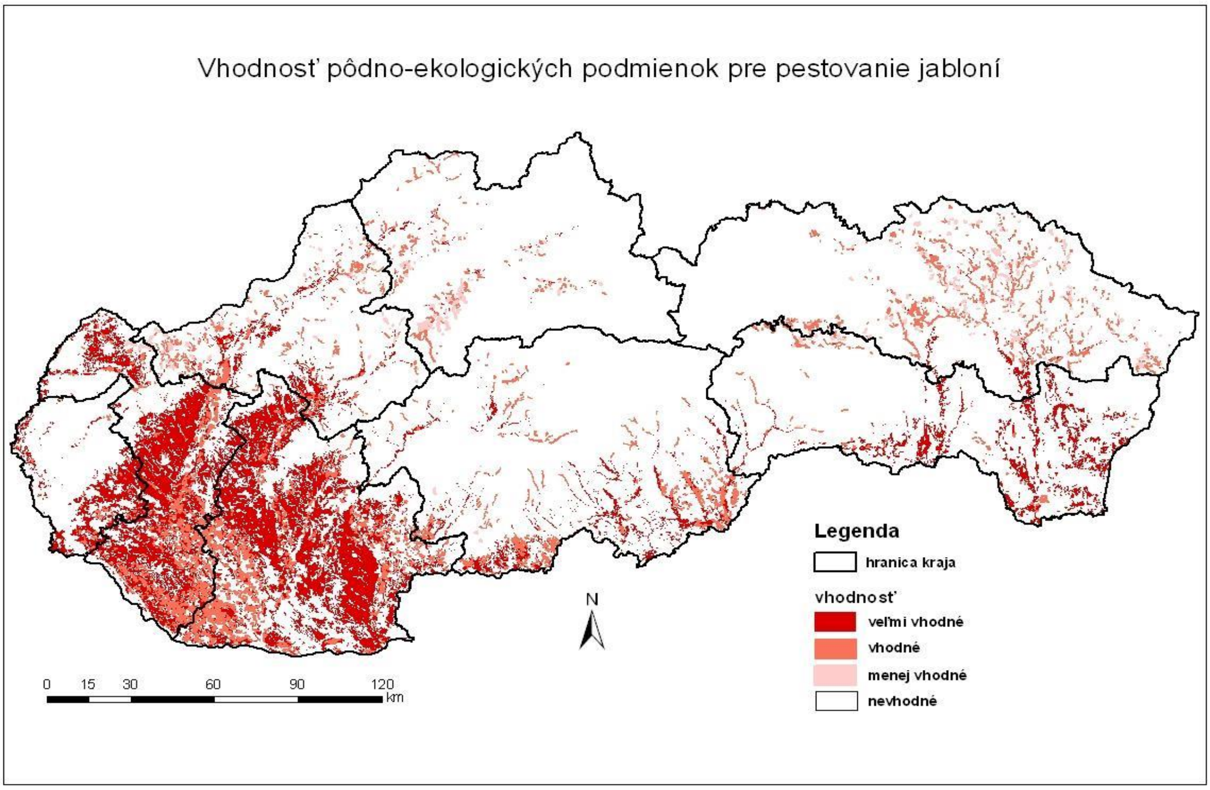

Figure 1. Suitable site conditions for apple production in Slovakia.

Assessment parameters for pear production

Pears are generally moderately thermophilic, but the selection of appropriate soil and climatic conditions had to be taken into account because pears are more exacting than apples. Pears don´t tolerate a higher carbonate content in the soil, especially on quince rootstocks (Blažek et al., 1998). They are less resistant to winter frosts, especially winter varieties of pears requires a warmer conditions to wood maturity, where at the same time are also better soil conditions. Therefore, it is necessary for winter varieties, including asian pears (*Pyrus pyrifolia* Burm. F.) give priority to cultivate them in the warmest parts of Slovakia. To higher regions are more suitable the autumn varieties (Hričovský, 2008; Paprštejn et al., 2005; Hričovský, Řezníček, 2003, Sus, 2000).

Simillary to apples, the first parameter from BPEJ the climatic region was selected, from which the site characteristics from very warm (00), dry and lowland regions to moderate warm and moderate humid region (07) was selected. To a range from very suitable to suitable areas climatic regions to warm, very dry, foldy, continental (04) were selected and to less suitable areas climatic regions rather warm, slightly dry uplands, continental (05) to the slightly warm, slightly humid regions (07) were selected. Unsuitable for pears regions from moderate cool, moderate wet (08) were assigned, because it was necessary to take into account the frost resistance of pear roots, which moves around to -9°C, with a significant contribution determined by the type of soil. Subsequently a cold and wet regions (09) and very cold and wet (10) classified among sites unsuitable for intensive pear production, because of flowers and young fruits sensibility to late frosts. (damage from -1°C)

Table 3: Suitable pear varieties following table 1.

1. zone: very suitable	**summer varieties**: Júlová, Williams Christ
	spring varieties: Bosc, Charneu, Diana
	winter warieties: Astra, Bohemica, Alexander Lucas, Grafin von Paris
2. zone: suitable	**summer varieties**: Clapps, Alfa, Isolda, Laura
	spring varieties: Armida, Confrence, Vila, Bojnická jesenná
	winter warieties: Beta, David, Decora, Dicolor, Dita, Erika, Grosdemange, Harbo, Jana, Konvert, Luna, Petra, Vladka, Vonka
3. zone: less suitable	**summer varieties**: Alica, Radana, Milada
	spring varieties: Blanka, Elektra, Jizera, Karina, Morava, Nitra, Zlata, Ivana, Korvinova **early winter varieties**: Bojnická vianočná, Gracie, Pribinova
	winter warieties: Delta, Bojnická zimná

Whereas pears are not as tolerant of soils as apple trees, it was necessary first of all take into account the permeability of the soil because in heavy and wet soils and during the main growing season, leaves turn yellow and shoot growth is limited. In dry soils have pears a tendency to show symptoms of stony pear pit virus disease (Hričovský et al., 1997; Nečas, 2010).

In the past, the most recommended soil types for pears were brown soil, degraded black soil and fluvisol (Demo-Bielek, 2000 Hnidzík-Hričovský, 1989). In the view of the current elaboration of soil types, subtypes and varieties, representing 100 major soil units (MSU) in Slovakia, it was for pears 32 MSU selected, that were also classified according to the characteristics of each zone of suitability. Selection of appropriate parameters of grain, slope-, exposure, depth and granularity of soils are identical with apple trees.

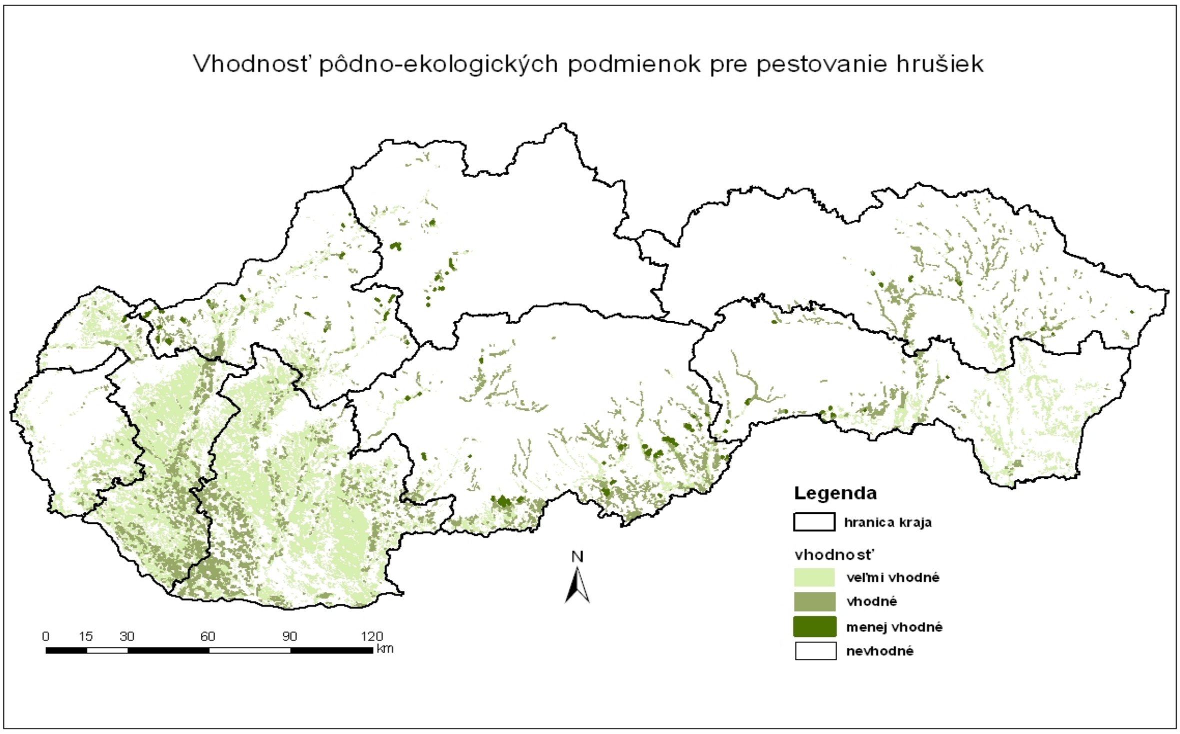

Figure 2. Suitable site conditions for pear production in Slovakia.

Agricultural land areas enable with profit to grow the majority of apple and pear varieties. However, there are sites where we do not recommend pomefruit production. Evaluation of soil-ecological conditions of Slovakia through realistic pomefruit production confirms the already known fact that the highest crop can be expected in the lowlands and with the increasing altitude, the production potential of soils decreases, while also economic profitability of production decreases. This fact also correspond to the categorization of suitability of soil and environmental conditions for growing apples and pears and share of the above categories, as illustrated by the results of Tables 4 and 5.

Table 4: Apple production potencial in ha in Slovakia.

Regions	very suitable zone	suitable zone	less suitable zone	production potential in total
Bratislava region	41 996.38	1 981.60	-	43 977.98
Trnava region	175 786.68	26 485.02	208.97	202 480.66
Trenčín region	29 542.46	8 778.31	1 124.57	39 445.34
Nitria region	259 303.87	38 237.20	-	297 541.07

Žilina region	3 613.59	4 505.85	2 435.30	10 554.74
Banská Bystrica region	46 603.33	15 117.88	101.86	61 823.06
Prešov region	9 899.30	14 714.01	3 177.33	27 790.63
Košice region	57 842.48	3 540.22	346.20	61 728.90
Total	624 588.08	113 360.08	7 394.22	745 342.38

Table 5: Pear production potencial in ha in Slovakia.

Regions	very suitable zone	suitable zone	less suitable zone	production potential in total
Bratislava region	41 996.38	1 981.60	-	43 977.98
Trnava region	175 785.30	26 485.02	34.63	202 304.95
Trenčín region	29 274.85	7 468.54	517.46	37 260.85
Nitria region	259 131.27	38 236.91	-	297 368.18
Žilina region	2 088.48	814.84	441.31	3 344.62
Banská Bystrica region	34 033.53	25 626.93	1 514.53	61 174.99
Prešov region	8 438.55	9 813.46	196.45	18 448.46
Košice region	50 788.63	9 144.42	370.90	60 303.95
Total	601 536.98	119 571.71	3 075.28	724 183.98

Following the data of Table 4, the potential assessment is very appropriate, suitable and less suitable areas for the cultivation of apple trees are highest in the Nitra region (297 541.07 ha) and decreases in the order: Nitra region> Trnava region> Banská Bystrica region> Košice region> Bratislava region> Trencin region > Prešov region > Zilina region (10 554.74 ha). Following the data in Table 5 potential assessment for very adequate, suitable and less suitable areas for growing pears is the highest in the Nitra region (297 368.18 ha) and decreases in the order: Nitra region> Trnava region> Banská Bystrica region> Košice region> Bratislava region> Trenčín region>

The area of very suitable and suitable growing areas of mentioned pomefruit species is far outweigh of real acreage of orchards, which records ÚKSÚP Bratislava and is only 0.31% for apples and 0.01% for pears. This fact points out that in Slovakia there is a real potential for fruit production increase. Based on the results of this work a potential share of very suitable areas to less suitable areas for growing apple trees is 745 345.38 ha and in the case of pears 724 183.98 ha, as illustrated by the map outputs.

COCNLUSION

The spatial presentation in the form of thematic maps and respecting the suitability of soil and site conditions finds use in optimizing the decision-making process in connection with creating business plans and in the planning of orchards establishment and efficient use of land resources.

Optimal soil and environmental conditions within the agricultural land allow including the mentioned fruit species into production also under organic farming systems, where soil quality is the major presumption of successful fruit production. To increase the number of orchards within the production areas of agricultural land can be seen as a contribution to enhancing biodiversity and agricultural used environment, as confirmed by Šarapatka (2008). Although site conditions allow expansion for pomefruit production, among factors that apparently also decide if to increase the production are included also a tradition, technological equipment, including post-harvest treatment of fruit and of course also a supplier-customer relations. Development of suitability categorization of soils for apple and pear production and spatial presentation in the form of thematic maps can contribute to more effective regionalization of these fruit species.

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AGRICULTURAL LAND USE ISSUES AND THE FREQUENCY OF FLOOD EVENTS ON THE EXAMPLE OF DŁUBNIA RIVER

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SUMMARY

This publication discusses the subject of the essence of maintaining agricultural land use in the context of the limitations of flood events, on the example of Dłubnia River. The reason for undertaking this research is the fact of the coexistence of two phenomena - decline in agricultural use of land in the southern Poland and increase of the incidences of local flooding there. This problem is particularly felt by residents of small localities, whose estates are located in the vicinity of rivers and mountain streams. For a detailed analysis GIS tools, which will help unambiguously to define mutual relation of the observed phenomena in the area of research were used. The publication reports the preliminary results of a broader research of the influence of abandonment of agricultural use of land on the intensity of floods in Poland.

The authors put forward the thesis of the need for proper management of agricultural in precisely defined coastal areas and show that in the test case the great importance to limit flooding in the area of research has proper human intervention in the environment.

KEY WORDS

flood risks, spatial analysis, agricultural use of landscape, river network

INTRODUCTION

According to the Water Act (Ustawa, 2001), flood is the temporary occupation of land by the water, which under normal circumstances is not covered by it, caused by a spate of water in natural streams, ponds or canals. Such situations can occur in river basins due to three factors: heavy rainfall (rainfall flooding), the rapid melting of snow (snowmelt flooding), blocking of the water outflow by ice (ice jams flooding). Another criterion for the classification of floods is based on defining its coverage area. We can distinguish: local, regional and national floods.

The defence against flooding is based on such undertakings, which protect people and their environment against flooding waters of bursting their banks streams and rivers. The danger associated with it threatens mainly cultivated land, transport connections and settlements. It can be stopped or limited by: stopping and retention of flood waters, planned and orderly discharging of water and the use of protective measures in the potential flood area. Over the past 20 years there has been an increase in abandonment of agricultural use of land, which is particularly dangerous in the case of riverbanks space and may have an impact on growth of statistics of the occurrence of local flooding in Southern Poland. This applies both to their frequency, range as well as balance of harm. This problem is particularly evident in areas where the extent of the hundred years flood, is currently listed on the flood hazard maps, as the several years flood (Mika, Siejka, 2014).

The purpose of this paper is to show the relationship between agricultural land use in the vicinity of rivers, and minimization of flood risk on example of the influence area of the Dłubnia River. The genesis of the causes of floods lies in the destructive activities of man, who transformed locally the natural environment so, that the conditions for the formation of flood waves in the river valleys are quite different from those that occurred a few centuries earlier. According to (Plany Zarządzania Ryzykiem Powodziowym, 2012) - due to the development of catchment the runoff is much faster and more intense, making wave hydrograph grow much faster than for areas where no human intervention is observed in the environment. Development of river valleys (often including floodplains) causes that the flood losses are much greater.

Dłubnia River covered with the research area is one of the tributaries of the Vistula River, and its catchment area does not appear directly on flood risk maps. Both the geographical location as well as the topography of the river course is close to the rivers such as Skawa, Prądnik or Paleczka (Mika, Siejka, 2014), which cause more locally flood danger. What could be the reason? May the agricultural and forestry use of land be the factor that eliminates the risk of flooding?

Natural and artificial factors influencing the course and formation of floodings

The whole effects of floods are affected by many factors. In addition to the severe rainfalls forming as a result flood wave these are also factors such as: geological structure, soil (its permeability and water absorption), terrain relief (inclination of slopes, width of the floodplains), the river network system (its density, inclinations, widths and shapes of riverbeds), vegetation (affecting the infiltration, protecting against denudation of soils and shallow landslides, development of catchment (regulation of watercourse beds, embankments, retention reservoirs) (Ciepielowski,1999).

Factors, that should be considered when forecasting floods, include both soil retention and appropriate use of lands adjacent to watercourses. Agricultural activity varies greatly retention capacities of the soil. The agrotechnical operations are significantly important here. According to (Chełmicki, 2000) "*... increase of retention is obtained by using deep plowing, disturbance of impermeable layers in the soil and subsoil, organic fertilization, liming, proper selection of plants and crop rotation. The human influence on vegetation is of the greatest importance. This results in changes in interception retention. The interference may include changes in species composition of crops or the conversion of some plant communities to others (eg. forests for pastures or meadows). Also the suitable soil cultivation is of great importance - plowing along contour lines increases retention and reduces the destructive erosion of water activity, while the elimination of the furrows and hollows, as well as creating furrows running in line with the slope decline reduces water detention..."* Soil retention depends also on its initial conditions. An important fact is that it decreases with time duration of the rain. According to (Ciepielowski,1999) human activity is also very important in terms of the catchment retention. In the study area a significant advantage of the agricultural and forestry land development in the immediate vicinity of the river Dłubnia was found. Disturbances in the field of water conditions in a given area can be introduced also by an inappropriate manner of building and land development. Another factor often adversely affecting the retention of the soil is the regulation of rivers − because it reduces the retention of river valleys and floodplains, increases the rate of runoff. In the case under examination, there were no significant regulation treatments throughout the course of the river, and the process of building and land development in zoned sectors shows no anthropogenic changes (Fig.1-3). Additional disorders may be introduced by irrigation works. Water reclamations mostly lower retention of agricultural land, because they lead to rapid drainage of rainwater from the area. As reported in (Dubicki et al., 1997):"... *The impact of the forest on flood formation process is complex. Forests, particularly natural, have high retention, which can be reduced by the modern cultivation. A large part of the first stage of precipitation is retained, as a result of interception by the treetops and the forest floor. This effect is however reduced during prolonged rainfall. In the impact of forest on the outflow from the catchment not only the degree of afforestation is important, but also the distribution of forests in the catchment area. The forest causes a delay in the culmination of a wave, so it can prevent the interference of culmination waves in the main river and tributaries. Deforestation can significantly increase the culmination, leading to the imposition of waves. The increase in surface runoff, and consequently increase of the flood risk is caused by leaving stubble and not applying secondary after crops..."*. In the case of the impact area of the river Dłubnia natural plant conditions were found over its entire length, what was confirmed by the field observations (Fig.1,2).

Ciepielowski researches (Ciepielowski, 1999) show, that the forest retention capacity is approx. 10% higher than other areas. Retention of the forest relies not only on increasing ground water retention. The forest is also a regulator of the outflow of water in rivers. Increases the low water levels and lowers the high ones. Water reserves, stored during the rain in the forest litter, distribute their outflow evenly over extended period of time, so that the peak of the flood wave flattens, and in periods of drought it powers outflow in the rivers.

According to (Ciepielowski, 1999) it should be remembered, that the forest affects the size of the surface runoff, and thus the flood wave, only to a certain extent. Cases of the great floods of 1934, 1997 and 2001 show, that after several days of precipitation occurs the saturation of the whole absorbent layer and the retention effect of forest areas ceases to function. In the case of intensification of floods forest does not have the possibility of reducing the culmination of the wave. The ability of the forest to affect the catchment water balance depends on the type of forest stand and how it is used. Afforestation of upper parts of the river basin affects the outflow alignment and reduction of erosion by reducing rubble transportation. In contrast, the forest located in the lower part of the catchment may cause concentration of the flow and formation of the flood wave. Parameter determining the correctness of dislocation of forests in the catchment area is the index of development of the forest cover. It is the ratio of forest cover area of the river basin to the whole basin area. In the case of the investigated area the ratio is equal 14,19 % in zone I, 18% in zone II, and 14,83% in zone III.

Agriculture affects directly or indirectly the size of water resources. Direct effect refers to water consumption. However the indirect impact involves changes of: infiltration and surface runoff conditions, retention capacities of cultivated soils and volume of water consumption by plants. In the US and the Netherlands the study of the impact of plant cover on surface runoff were carried out. The aim of this study was to determination of the retention and surface runoff dependence on the coverage of herbaceous vegetation. Results showed, that with the full coverage area with grass the size of outflow is less than 2% of the sum of registered precipitation. However, in the case of low vegetation cover the surface runoff makes up 73% of the volume of precipitation. Thus, according to (Chełmicki, 2000) in order to reduce the size of the run-off fallows and stubbles should not be left.

The content of humus is another factor significantly increasing retention capacity of the soil. According to (Chełmicki, 2000) „*Studies have shown that the increase of humus content of 1% corresponds to the growth of soil retention of tens of millimetres. Such soil replacement is of course practically not feasible, but it is worth remembering, that even a small change in the structure of soil may significantly increase its capacity to retain water. Experts estimate that if soil retention were increased of 20 mm on the half of arable land area in Poland, it would be possible to additionally store in the soil 2 km^3 water per year. This is a significant value, because it is approx. 3% of the surface runoff from Polish territory.*

A major role in the terms of the range of destructive effects of water on account of floods, play structures and devices made by man. These include: walkways, bridges, culverts, which constitute an obstacle in the outflow of waters in the case of flooding. Rivers and mountain streams flowing through built up areas are also causing great harm. Overflowing their banks they destroy the streets together with buildings. The following images (Fig. 4,5,6,8) present the photographic documentation of the selected points on Dłubnia river located in and around major logistical bridges and water culverts. This documentation was prepared in order to preliminary assess flood risk factors based on the monitoring of the state of land development at these sites and identification of areas of agricultural use of land abandonment basing on the field investigation.

Figure 1. The natural coastline of the river Dłubnia in Michałowice.

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Figure 2. Vegetation characterizing the upper course of the river Dłubnia.

Figure 3 Vegetation characterizing the middle course of the river Dłubnia.

Figure 4. Engineering constructions on the river Dłubnia (Bridge in Michałowice).

Figure5. Local technical solutions (small bridge 1) for communication on both banks of Dłubnia (in extreme cases posing a threat of flooding).

Figure 6. Local technical solutions (makeshift bridge 2) for communication on both riverbanks of Dłubnia (in extreme cases posing a threat of flooding).

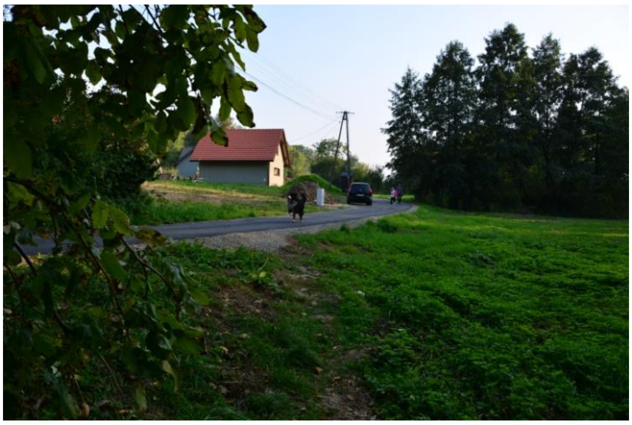

Figure 7. Buildings line separated from the river by the belt of coastal vegetation, pastures, settlement road and a wide green belt (typical land development within the area of research).

Figure 8. Land development in the direct impact zone of the river Dłubnia in the vicinity of a large engineering object (bridge in Michałowice).

Basic research - the case study

The scope of the research covered area located within 500 meters (in both directions) from the axis of the river Dłubnia, flowing in the northern part of the Malopolskie Voivodship. This area covers a topographic map sections in the scale of 1: 5000 in the PUWG 92 system (code

EPSG:2180) of numbers: M-34-64-A-b-2-4, M-34-64-B-a-1-1, M-34-64-B-a-1-2, M-34-64-B-a-1-3, M-34-64-B-a-1-4, M-34-64-B-a-2-1, M-34-64-B-a-2-3, M-34-64-B-a-2-4, M-34-64-B-b-1-3, M-34-64-B-b-1-4, M-34-64-B-b-3-1, M-34-64-B-b-3-2, M-34-64-B-b-3-4, M-34-64-B-b-4-1, M-34-64-B-b-4-3, M-34-64-B-d-2-1, M-34-64-B-d-2-2, M-34-64-B-d-2-3, M-34-64-B-d-2-4, M-34-64-B-d-4-1, M-34-64-B-d-4-2, M-34-64-B-d-4-4, M-34-64-D-b-2-2, M-34-64-D-b-2-4. Area range of Dłubnia river and performed analysis are presented in figure 9. Dark blue line shows the course of the river Dłubnia from the spring to the borders of the city of Krakow, the area around the river (light blue) presents the analysed use zone. In addition, up to 500 meters from the axis of the watercourse, squares intersecting the 500 meters zone are marked, reflecting used for the analysis sections of the orthophotomap (Fig. 9).

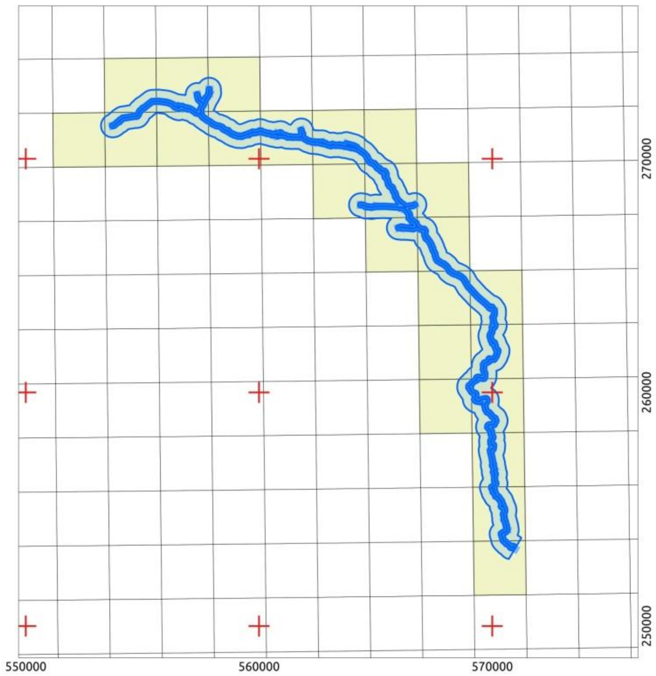

Figure 9. The research area

The analysis was performed basing on usage identification on an orthophotomap from years 2009-2015. The systematic of usage determining assumed application of the modified hierarchy applied in the project Corine Land Cover technical guide (Bossard et.al.2000). The modification consisted in adjusting land use classes CLC to the requirements of land and buildings cadastre after the amendments in September 2014 (Rozporządzenie, 2001).

Examination of the use of areas along the river was made in several zones (Fig. 10).

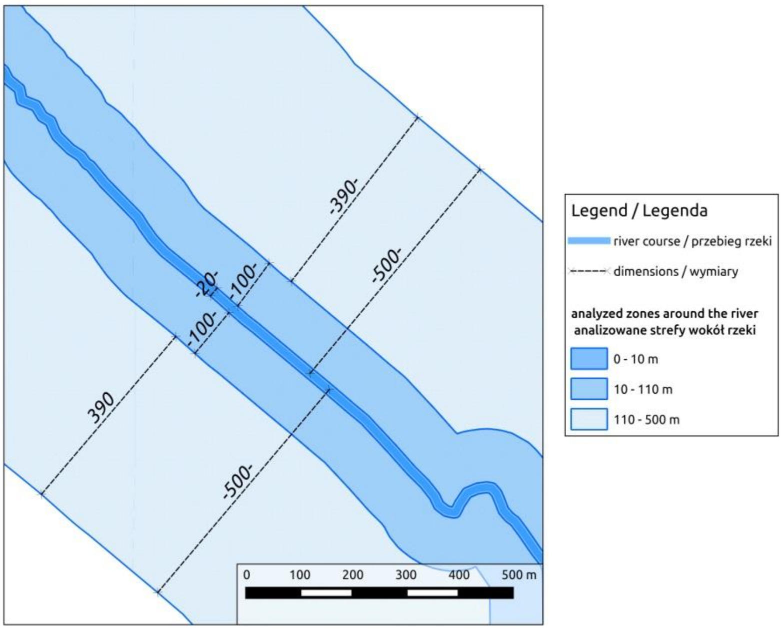

Figure 10 Zones of analysis determination at the river Dłubnia.

First a polygon, digital map of land use was drawn (for an area up to 500 meters from the axis of the watercourse) and then the classification of land use was performed. Quantum GIS program was used for this purpose. The land use map was used for further spatial analysis. The study area was divided into zones, marking each of the objects with corresponding signature. In the case where the subject was located in many areas simultaneously – it was divided by a separation line (Fig. 11)

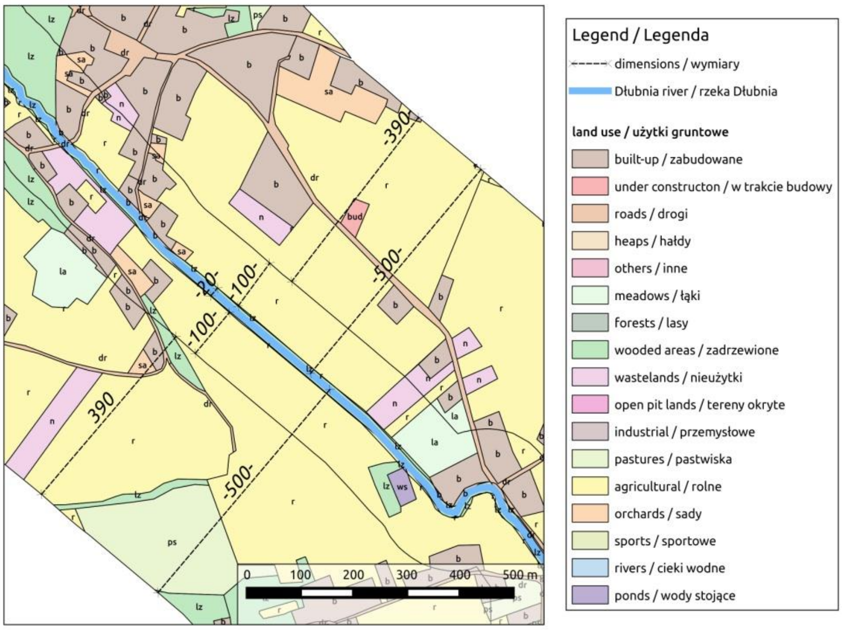

Figure 11. Classification of use and zoning.

The aim of the spatial analysis was to obtain numerical data on the distribution of land area for each zone. The first zone - the smallest one, included a strip of 20 meters around the axis of the watercourse. The second zone is an area 100 meters from the outer boundary of the first zone – the nearest territory to the river. The third zone extended from 110 to 500 meters from the axis of the watercourse – coastal areas, which may constitute reserve retention. The surface data were calculated analytically, from coordinates with the adjustments of surface due to the adopted map projection and stored in the database with an accuracy of $1m^2$.

Detailed analysis showed that in the field of research for the first zone - riverbanks (up to 10 m) the tree coverage is dominating (57,58%). Another way of land development in this zone is a forest (14,19%). The few smaller percentage of land in the designated zone is used for agriculture (12,49%). The above-mentioned land uses represent a total of 84.26% of the study area. Other methods of usage in this zone are marginal. Analysis of the coverage in the next zone - (10 to 100 m) showed an overwhelming dominance of agricultural use of land (45,44%) . Covered with trees areas represent 18% of the surface coverage and built-up areas 14,63%. Presented methods of usage together represent 75,25% of the area. Other ways of using occur irregularly and insularly. Further studies demonstrated, for the direct provision retention zone (from 110 to 500 m), significant dominance of agricultural use (57,58%). Built-up areas in this zone represent 11.65% of its surface, and the forests and covered with trees land in total 14.83%. The presented methods of use together represent 90.39% of the surface area.

Results of the analysis showed superiority of the surface of agricultural land within 500 meters (in both directions) from the axis of the river Dłubnia. The coastline of the river has natural character. No cases of excessive interference of human activities on the environment were found in the zone I. These factors will contribute to a reduction of flood events in the study area. Research confirms the thesis, that minimizing human intervention in the direct vicinity may reduce the risk of flooding in a given area. However, it still depends on many factors such as the decline of land, soil and climatic conditions, afforestation, etc. It seems that the full picture of the phenomenon could be obtained only after a thorough analysis of a larger number of cases of rivers with similar hydrogeological characteristics, which the authors intend to take in the future. The results of comprehensive research will permit to set the general conclusions. This analysis can be a contribution to the way of verification of thesis on the effect of appropriate land use on the extent of flood events in selected areas.

CONCLUSIONS

According to Sumisławski (Plany Zarządzania Ryzykiem Powodziowym, 2012) in Poland we should change the way of thinking about flood safety. Cataclysm greater than expected may always come. In this situation it is necessary to think and act in the direction of flood process management, and not just restrict activities to the removal of flood losses.

Floods are a natural phenomenon, which always has been and will be a threat to the health and lives of people, their property and the natural environment. The total elimination of flooding is impossible, but the current state of knowledge allows for reduction of such hazards.

The study area deliberately included the potentially unthreatened by floods river Dłubnia, to subject it to testing for the determination of the factors that help reduce flooding. It was assumed initially that one of the factors might be the agricultural use of land. On the map of areas at risk of flooding the area has not been taken into account (www.gugik.gov.pl). Also on the map of areas where occurrences of floods are likely this area is not listed (www. kzgw.gov.pl). It was taken into account only on the map of the historical flooding (www. kzgw.gov.pl).

The study showed that both in the second (10m - 100m) and in the third zone (110 m - 500 m) agricultural use of land dominates. The spatial analysis, also proved, that built-up and covered with trees areas in the third zone take a percentage larger area than in the second zone.

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DEVELOPMENT OF THE SIZE AND SHAPE OF THE PLOTS UNDER THE INFLUENCE OF VARIOUS HISTORICAL LAND CONSOLIDATION AND THEIR IMPACT ON WATER RUNOFF FROM THE TERRITORY

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ABSTRACT

In recent years, the global trend is to reduce the risk of flood events. In this study, we aimed to assess the role of the historic landscape arrangement in terms of land use. Generally, the best measure against flooding and to improve water quality is considered high proportion of stable culture such as forests and grasslands. In the past, however, especially in the areas at higher altitudes were used as arable land for the cultivation of traditional crops such as cereals. The objective of this study was to compare by the means of hydrological modelling in SWAT model (Soil and Water Assessment Tool) the reactions of selected watershed to changes in the structure of land use. Thus, responses were examined in terms of catchment flows and concentrations of nitrate anions as the dominant ion of agricultural pollution. The results of the study show that the reaction of the catchment is not based just on the land use but rather on the layout of the individual plots and the way of agricultural management. Paradoxically better results in terms of both quantity and quality of water were achieved at higher percentage of arable land, while complete grassing.

KEY WORDS

SWAT, land use, historical landscape, discharge, pollution

INTRODUCTION

Floods are natural phenomena which cannot be avoided. Their irregular occurrence and variable range adversely affect the perception of the risk it poses, which complicates the systematic implementation of preventive measures [7]. Floods pose Czech Republic's largest direct risk of natural disasters, such as not among the regions where the reflected seismic and volcanic happening or weather extremes type of tornadoes and hurricanes [10]. Floods, however, cause serious crises that accompany not only extensive material damage, but also loss of life of people affected by the devastation and vast cultural landscape including environmental damage [2].

The main reason for studying the historical development of the landscape is the fact that understanding the past, we can better understand future developments. The theme of land use and landscape structure is extremely wide, as well as a very important and timely topic in all scientific disciplines related to landscape [8-9]. According to [12] the last sixty years the dramatic changes in land cover and other changes are expected in the future. Both the landscape and the river systems in large parts of Europe and elsewhere have undergone major changes in the past, and there is no doubt that these environmental changes have altered the flooding conditions in this region [11]. The changes led the scientists and also the managers to the question how it is possible to restore or improve the stability of the landscape and to prevent the flood risk. Obviously there is only one way that means the need for behaviour change and landscape protection. From this point of view the only possibility is the change in the use of agricultural land in the way of the transformation to the more ecological form according to the common agricultural policy of the European Union. Based on this land managers can use financial support for the implementation of measures to increase the stability of the agricultural landscape.

The modelling of landscape processes is becoming more and more frequent appropriate instrument for analyzing the behaviour of landscape segments and systems. We can analyze at the same time for example short-term response to a sudden or a one-time stimulus (precipitation, calamitous deforestation, gradation of phytophagous insects, change in morphology of river channels, etc.) or long-term response to the effects of selected factors (changes in land use, soil chemistry, the development cycle of large forest, the secondary succession, etc.) [2].

The aim of this study was to compare by using the hydrological model the discharge rate (in a precise sense flood risk) in the small sub-mountainous catchment under different types of land use and land arrangement. The different scenarios are based on an analysis of historical landscape arrangement and its land use as described in historical map documents.

MATERIAL

Jenínský stream catchment spreads out by the borders with Austria not far from Dolní Dvořiště. It belongs to cadastral territories of Jenín and Horní Kaliště. According to regional geomorphologic division of the Czech Republic the area is situated in the Šumavské podhůří unit. Jenínský stream belongs to moderately genial climate region B10. The subsoil is formed by moldanubic pluton. The main rock types are the white mical biotitic gneiss and crystal diorite. From soils it prevails here dystric-cambisol, modal-kryptopodsol, modal-podsol, modal and fluvic-gleysol and gleyic-cambisol. Jenínský stream is the right side affluent of Rybnický stream. The spring of Jenínský stream (hydrological rank number 1-06-01-138) is located 3 kilometres from village Jenín by the peak Žibřidovský vrch. The catchment area is 4.683 km^2. Almost the whole catchment is artificially drained and it is used as the extensive pasture but only during summer period. The catchment is equipped by automatic weather station and by ultrasonic probe for water level measurement.

METHODS

For the modelling of runoff semi-distributed model with continuous daily time step SWAT (Soil and Water Assessment Tool) was chosen. This model was designed for medium to large basins [5, 6]. This is partially physically based model, which allows the simulation at a very high degree of spatial resolution by distribution of the catchment into a large number of small facets. The program is designed using the ArcViewGIS interface as a module AVSWAT [1, 3]. ArcGIS is used primarily to define the hydrological units and work with related tabular and spatial data [4].

Scenarios

In this study there are modelled three different scenarios compared with the current state. The scenario 0 represents the current type of land use, the permanent grassland. The scenario 1 represents the oldest variant of the land use arrangement from the mid 19th century. The scenario 2 represents the arrangement from the period after Second World War and the Scenario 3 represents the arrangement from the 1980 of 20th century. The scenarios differ mainly in the arable land percentage in the Jenínský stream catchment and also in the arrangement of individual plots.

Historical land use was described approximately from the mid 19th century, based on different types of cadastral and non-cadastral evidence. The study is supported by maps and written notes of Stable and Land Cadastre, Land books and records kept after the Second World War - maps and written parts of Estate Records and Uniform evidence of soils. The current status of the territory is then documented using orthophotos. The study was supported by the software ArcGIS that was used for map creating in individual time sections.

Comparison of different periods is shown in Table 1.

Table 1. The results from analyzing the land use type in different time periods

	ARABLE LAND	GRASSLAND	PASTURE	FOREST	WATER	URBAN AREA
SCENARIO 0	0.00 %	1.29 %	83.93 %	13.67 %	0.25 %	0.86 %
SCENARIO 1	68.50 %	10.28 %	7.62 %	11.80 %	0.68 %	1.12 %
SCENARIO 2	10.67 %	28.23 %	48.20 %	11.20 %	0.68 %	1,02 %
SCENARIO 3	79.43 %	4.88 %	1.53 %	12.98 %	0.19 %	0.99 %

RESULTS

At first there were assessed the size and shape of land in different monitored periods. The first reporting period, which characterizes the arrangement of land in the middle of the 19th century, the land was arranged in the form of so-called belt plots. This is a land shape in which the length predominates over the width. The average size of land is then around 2 150 m^2.

In the second reporting period the shape of the land was preserved, but plots are slowly beginning to join into larger units, especially within the mountain pasture cooperatives. Land area compared to the previous period slightly increased, at 3 649 m^2.

The last evaluation period of 1980 is characterized by collectivization of agricultural land, and thus increasing their size and changing their shape. The land area of approximately 98 239 m^2 and have a squarish shape.

Currently, there are preserving the shape of the land, however due to user operations on land is increasing areas of the parcels that are cultivated in one functional unit, to 152 493 m^2. The shape is irregular but it is predominantly squarish or rectangular.

As described in the Methods section there were evaluated a total of four different time periods. The land use during the time periods underwent dramatically changes. It can be demonstrated on the percentage of arable land in the catchment that varies between 0% in current land use arrangement till almost 80% in the period till 1990.

After constructing of individual input scenarios the simulation of these scenarios impact on the water runoff from the area have been taken. Although, as mentioned in the Methods section, SWAT model based on the calibration and validation was not in a completely ideal form, for the purpose of obtaining image of the flood hazard in each period, it is entirely satisfactory.

Summary of the results achieved by reusing the model with each scenario is summarized in Figure 1.

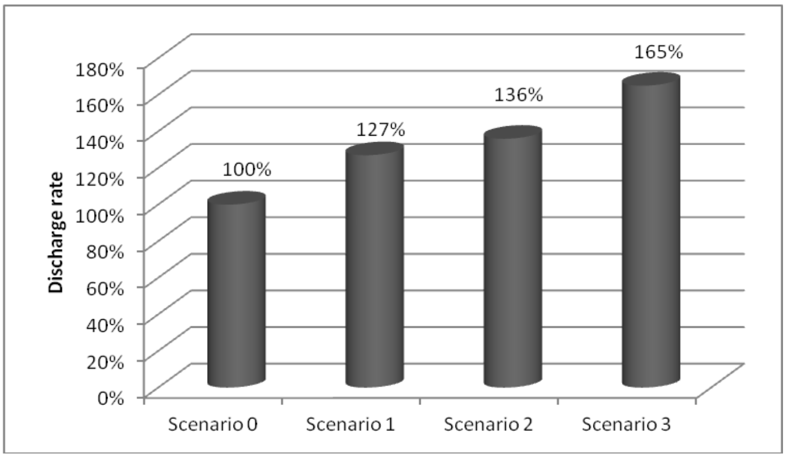

Figure 1. The results of discharge simulation for all scenarios

The results reveal several important findings. Scenario 0, which describes the current configuration of the catchment are indeed the best in terms of water retention and reducing peak flows, but the difference compared to next two scenarios is relatively small. This scenario represents the significant turnover and a partial return to the arrangement of the Scenario 2, the catchment area was completely converted to grassland, where there is extensive grazing of cattle. The reason for these changes has not been an outflow of labour or lack of technology, but the disintegration of agricultural cooperatives, their transformation into modern agricultural societies, and especially awareness of the needs of the country. High yields and intensive production has been in recent times especially in the foothill country on expenses of high and expensive inputs of fertilizers and protective substances such as pesticides and herbicides. The regulation of water regime is actually the worst problem of the locality. It is probably the reason of the unsatisfactory flood protection of the catchment. The drainage systems were constructed in 1980th and the service life of the constructions was planned for 20 – 40 years. Now many of the constructions are broken or completely damaged. The restoration process is very expensive and the land owners or land users have no possibility to gain financial subsidies for such actions. It leads to revitalisation of the previous water conditions in landscape and turning of the pastures and meadows into the wetlands with shrubs.

As a second-best scenario in terms of reduction of flood risk was paradoxically scenario 1, which describes the use of a traditional agricultural areas with very diverse representation of arable land, grassland and pasture with a mosaic of small and large forests, wetlands and water bodies. In this first evaluated period (mid 19th century) the percentage of arable land was 68.5 %. This value is relatively high, but more than the actual percentage, there is the importance of the land arrangement. Plots for crop production were separated by grassed borders or communal pastures. This arrangement was fully operational for livelihood of the population in terms of location and it also served as a stabilizing part in terms of flood protection. The size of particular plots was approximately one tenth of the actual land.

The third best variant form the flood protection point of view is the Scenario 2, where the substantial parts of the landscape originally used as arable land were converted to grazing areas after the Second World War. The reason for higher outflow from the catchment is probably a great water consumption of agricultural crops than on the extensive grasslands and also thanks to the smaller water amount kept in the catchment by the retention capacity of the stabilized part of the landscape.

The arrangement of land in the second scenario (after World War II) is very similar to the first one; the difference between these two is mainly in the percentage of arable land. The reason is primarily the period of the Second World War and especially the legislative procedures of the President of the Republic after the Second World War. The most shifts in property relations were the result of a series of so-called Benes Decrees. With these legal measures large areas of agricultural and forest land was confiscated by the state. However in border areas many lands were not redistributed or even allocated land was subsequently abandoned. Arable land was reduced mainly due to the establishment of pastoral cooperatives in the area instead of confiscated farms or abandoned land. These lands could not be maintained in the same arable land. This was mainly due the lack of permanent residents who would have been eligible to work in the fields and also due to the lack of adequate technology. The increasing of the flood risk is also highly likely contributed by the lack of personal approach of farmers.

As a wholly worst case scenario in terms of flood risk for residents in the affected area and for protection of their assets Scenario 3 was clearly demonstrated; this describes the period of most intensive agricultural production. This is mainly due to the accelerated runoff from the landscape by reducing its retention capacity. The retention capacity of the landscape was weakened mainly due to the removal of stabilizing parts of the landscape and the almost complete absence of another kind of the land than arable land. The result was due to the systematic drainage of sloping land in the area. Although the percentage of arable land is very close to scenario 1, the arrangement of the landscape is completely different. Unlike distributed small plots with embedded boundaries and pastures from the period before the Second World War, the area was consolidated into larger blocks and the separating stabilizing elements have been removed. The reason for this fact was especially adaptation of land management to intensive farming with significantly improved agricultural technology and also to increase the production of agricultural commodities. This fact contributed to the significantly lower stability. At the same time mass production efforts resulted in a change of water regime in the locality through systematic draining of the land. All these have led to a deterioration of the water regime and increase of flood risk mainly during snow melting period or summer storm events as also evidenced by entries in the annals of adjacent communities affected by the floods and damage during this period. According to theses records the annual flooding of the municipality caused many damages to the houses that led to abandonment and demolition of several houses mainly along the stream and in the riparian zone.

CONCLUSIONS

The aim of this study was to compare by using the hydrological model the discharge rate (in a precise sense flood risk) in the small sub-mountainous catchment under different types of land use and land arrangement based on historical maps. Before processing the study quite clear assumption according to the literature review was that the current use of Jenínský stream is the best scenario for flood protection of the catchment. Based on the results learned through the simulation of SWAT model, however, this assumption was only partly confirmed.

Based on the simulations, it was found that in terms of flood protection the best scenario really is the current configuration and use of the catchment, notwithstanding this land arrangement is not ideal. We suppose that in future the situation will be better thanks to spontaneous succession of the catchment area. Surprisingly the flood risk is not significantly better in comparison with the historical data than was previously assumed. The second best scenario for flood protection of the locality was the traditional way of agricultural management, which has been applied to the area for generations till the year 1945. The key to the success of this scenario is not the representation or percentage of different land use types, but rather the arrangement of plots and relationship between land and the landlords and their meticulous care of their plots.

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VALUES OF MANOR PARKS ON PROTECTED AREAS ON SOUTH PART OF POLAND

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ABSTRACT

Manor parks are important and very common elements in rural landscape in Poland. These objects were established in different centuries. More of them are designed in landscape historical style in XVIII/XIX c. The paper are presented different values of selected manor parks located on south part of Poland.

KEY WORDS

manor parks, values, Poland

INTRODUCTION

Manor parks are an essential part of the Polish countryside. Because of their origins, they are perceived as objects that possess significant architectural, ecological and landscape value. In the history of Polish culture, marked by a significant phenomenon, ie owning a home of high artistic value is often intertwined with the love of greenery, particularly trees. Palaces and castles, as generally outstanding works of architecture and art, and next to them, more or less modest offices at court surrounded by beautiful luminaries greenery - a garden or park. Sometimes these objects were older than castles and mansions. Over the centuries, parks blend in permanently in the landscape of our country, and are inseparable from its history and tradition (Drzał, Leszczynski, 1974). They represent various architectural and landscape units, or adopted from natural habitats, or secondarily by design these habitats formed by creating an intermediate shell between decorative garden and surroundings, sprawling around. It was relationship of contrast and harmony between the interior of assumptions, and landscapes like extending outward. Parks has always been a place of storage disappearing environments and landscapes.

Mostly manor parks were established in XVIII-XIX centuries on *Tilio-Carpinetum* habitat. Sometimes these objects were older than castles and mansions. It was relationship of contrast and harmony between the interior of assumptions, and landscapes like extending outward. Parks has always been a place of storage disappearing environments and landscapes.

Purpose of the study is presented values of manor parks located on Ciezkowicki-Roznowski Landscape Park. Ciezkowice-Roznow Landscape Park is a protected areas in southern Poland. It was established in 1995, covering an area of 176.34 square kilometers.

METHODOLOGY

The methodology are included indoor and field studies. It was analysis 25 manor parks located on Ciezkowicki-Roznowski Landscape Park area. The whole objects are established in XVIII/XIX centauries on the same oak-hornbeam habitat. The researches was focused on analysis of composition of objects, the biotic and abiotic elements and their conditions. It was done also phytosociological records in every parks. Plant species were grouped in phytosociological aspects. The last stages of work was prepared results and formulated conclusions.

RESULTS

Manor house is as dominant element in park. Nowadays, numerous manor parks are destroyed or abounded on Polish territory so architectonical values were "disappeared", but ecological ones are still exist. These objects are seen as a relict phenomenon, but the need and fully useful. The other component of manor parks is vegetation, created or adapted by man and is the resultant of the forces of nature and anthropogenic impacts. The developed manor parks have a different state of preservation of parks in Poland, ie 23% - destroyed parks, 46% - neglected parks, 13% - devastated the state parks, 18% - well-maintained parks (according by Drzał and Leszczynski (1974). They are represented by significant architectural, ecological and landscape values. The values of manor parks depends on many aspects as environment, historical and political conditions in Poland.

In the manor parks we can observe a big variety of plant species formed under the influence of human activities and nature. The manor parks are characteristic of the Polish countryside**.** Vegetation is the other important element in manor parks. Native and alien plant species are characteristic for these objects. Flora of manor parks are represented by natural, seminatural and synantropical plant communities. It was observed diversity of plants there as the ornamental, forests, grasses, water, rushes and synantropical plants. Plant species are represented by eutrophic forest community (*Querco-Fagetea*), coniferous forest communities (*Vaccinio-Piceetea*), riparian forest and brush of river valley (*Salicetea purpureae*), cut-over communities (*Epilobietea angustifolii*), water communities (*Potametea, Lemnetea*), rushes communities (*Phragmitetea*), bushes communities (*Rhamno-Prunetea*), meadow and pasture communities (*Molinio-Arrhenatheretea*), margin communities (*Trifolio-Geranietea sanguinei*), pionier xerothermic communities (*Agropyretea*), segetal communities (*Stellarietea mediae*), ruderal communities (*Artemisietea vulgaris*) and companion plant species. Most of the species were represented by the community from eutrophic forest community (*Querco-Fagetea*) in herb layer. Plants of eutrophic forest community like: *Carpinus betulus*, *Tilia cordata*, *Fraxinus excelsior*, *Anemone nemerosa*, *Aegopodium podagraria*, *Gagea lutea*, *Galeobdelon luteum*, *Corydalis cava*, *Milium effusum*, *Vinca minor* were dominated in herbaceous layer. Plant species from *Artemisietea* class are represented by: *Chelidonium majus*, *Impatiens parviflora* and *Urtica dioica*. It was distinguished different localization of manor parks in agricultural landscape. Some of them are closed to the forest, fields or village. Vegetation of manor parks has got aestetic values mostly during blooming periods. Because of dominated oak-hornbeam habitats, spring time is very effective. During this time plants are started blooming in herb layer. Trees are still without the leaves. Yellow and white flowers of plants were typical on spring time in herb layer. *Anemone nemerosa* with white flowers, *Gagea lutea, Galeobdolon luteum, Fragaria vesca, Anemone ranunculoides* with yellow flowers are dominated on this period. The next visual aspect is beautiful dense trees conopies. The others plants as *Ajuga reptans, Viola mirabilis* and *Vinca minor* with violet flowers are blooming during summer time. Plants with white color of flowers were represented by *Polygonatum multiflorum*, *Aegopodium podagraria.* During the summer time *Chelidonium majus*, *Impatiens parviflora*, *Hieracium murorum* are blooming with yellow flowers. Different color as yellow, brown, red, orange are typical for autumn time, when leaves are changing.

Figure 1 Manor house and view on rural landscape

Figure 2 Manor house with surroundings vegetation.

Figure 3 View on pond and groups of trees.

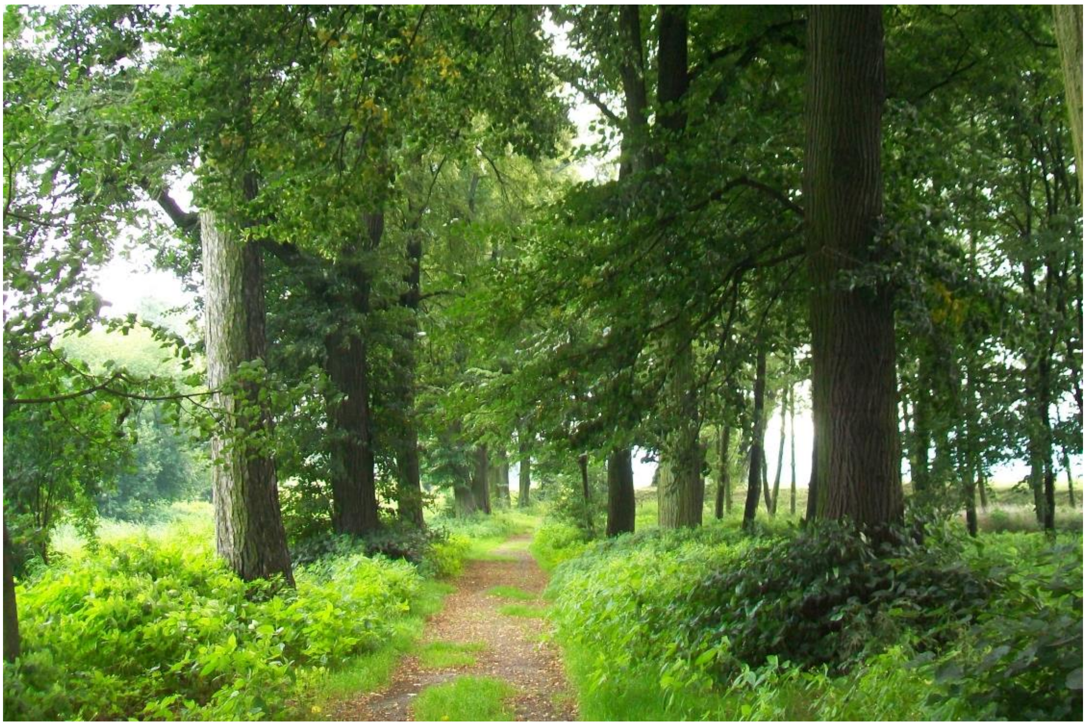

Figure 4 Avenue in historical park

Figure 5 Blooming *Hepatica nobilis* in herb layer

CONCLUSIONS

Natural values and aesthetic values of manor parks are mostly represented by vegetation. Manor parks are as "green islands" (natural refuges) in ecological network on protected area as Cięzkowice-Roznowski Landscape Park.

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FOREST PLANT SPECIES IN URBAN GREEN AREAS

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ABSTRACT

The main aim of the article was characteristic of woody plant species in parks in Tarnów. The field studies were carried out in years 2014 – 2015. In every year 100 phytosociological records were made on the all parks (20 per object), each on the area of 100 m^2 according to the Braun–Blanquet's method. Plant species were grouped by phytosociological system following Matuszkiewicz. Analysis of plant life–forms was made according to Raunkiaer. It was observed 16 native, woody plant species in public parks in Tarnów. In all of the stands a majority of native plants was observed. Among the life-form classes hemicryptophytes and geophytes prevailed in historical parks where habitat is not so changed by man.

Key words
plant species, green areas, Poland

INTRODUCTION

Urban landscape are still modificated by human but most of ancient, woody plant species tolerant stress, so they could occur on habitat with antropic pressure Wulf (2003. Green spaces have many functions biological, recreation, ecological in urban landscape. Parks as the main elements of ecological structure are very important to keep biodiversity of plant species and animals in urban landscape [(Liro & Szacki, 1993), (Saunders & Hobbs, 1991), Żarska (2005)]. Many of these objects were established on oak-hornbeam habitat. During this time the plant species were planted by man or were groining spontaneous. Mostly forest plant species, typical for natural habitat are dominated on these objects (Fornal-Pieniak et.al 2014). The aim of article is presented diversity of forest plant species in selected urban green areas in Tarnów.

STUDY AREA

Tarnow is a city in southeastern Poland. The city has been situated in the Lesser Poland Vivodeship since 1999, but from 1975 to 1998 it was the capital of the Tarnów Vivodeship. It is a major rail junction, located on the strategic east-west connection from Lwów to Kraków. Also, from Tarnów two additional lines stem - a southwards main line to the Slovakian border. It was distinguished three types of green areas: squares, parks and urban forest. Five parks as Strzelecki Park, Sanguszki Park, Piaskówka Park, St. Mischel Hill Park and Kwiatkowski Parks were established on natural, fresh forest habitats (*Tilio-Carpinetum* and *Dentario glandulosae-Fagetum*) (Tab. 1).

Table 1 Characteristic of parks in Tarnow

Park's name	Area in ha	Date of park establisment	Localization in Tarnów
Strzelecki Park	8,13	1866 year	between streets: Słowacki, Piłsudski – Romanowicza, Nowy Świat
Sanguszki Park	10,25 ha	XIX centaury	between streets: Braci Saków, Sanguszków
Piaskówka Park	20,82	no information	Piaskowka Str.
St. Mischel Hill Park	40,32	no information	South part of Tarnow, closed to *Dentario glandulosae-Fagetum* forest on St. Mischel Hill
Kwiatkowski Park	8,34	XX centaury	between streets: Czerwonych Klonów, Jarzębinowa, Topolowa, Zbylitowska

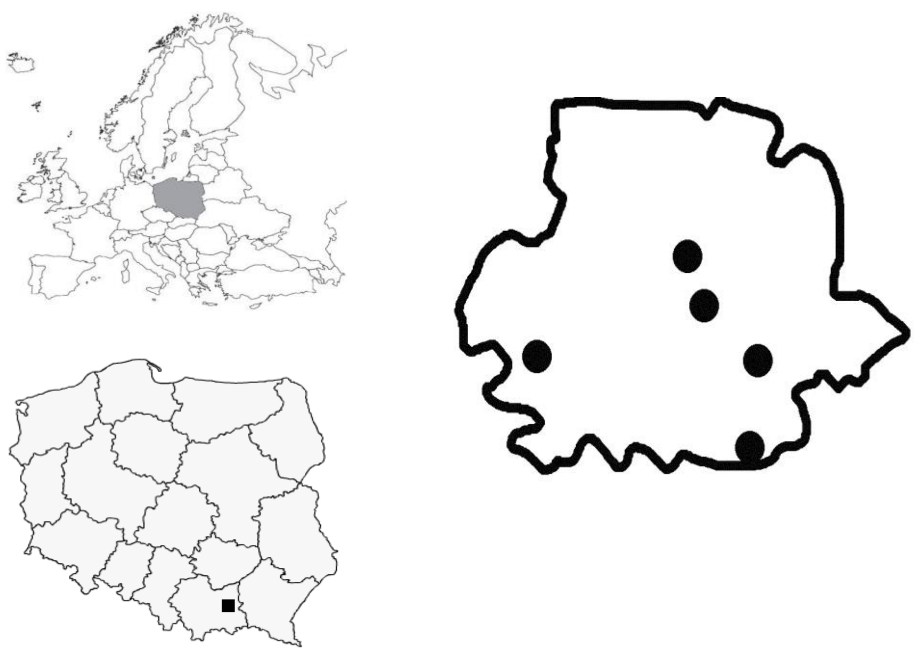

Figure 1 Localization of public parks in Tarnow (Poland)

MATERIAL AND METHODS

The field studies were carried out in years 2009 – 2012. In every year 100 phytosociological records were made on the all parks (20 per object), each on the area of 100 m^2 according to the Braun–Blanquet's method (1951). Plant species were grouped by phytosociological system following Matuszkiewicz (2001). Analysis of plant life–forms was made according to Raunkiaer (1934).

RESULTS AND DISCUSSION

It was observed 16 native, forest plant species in public parks in Tarnów. According to Matuszkiewicz (2001) these plants belong to *Querco-Fagetea* class. Only *Convallaria majalis* is characteristic for *Vaccinio-Piceetea* class. The highest number of forest species (14) was in Sanguszki Park and Strzelecki Park (10 species) (Tab.2). Mostly forest species were represented by *Anemone nemorosa, Gagea lutea, Viola mirabilis, Ulmus laevis, Tilia cordata* in study objects.

Table 2 Forest species in public parks in Tarnow

Forest plants	Strzelecki Park	Sanguszki Park	Piaskówka Park	St. Mischel Park	Kwiatkowski Park
Acer campestre			x		
Anemone nemorosa	x	x	x	x	x
Anemone ranunculoides		x			
Convallaria majalis	x	x			
Corydalis cava	x				
Dactylis polygama		x			
Gagea lutea	x	x	x	x	x
Galeobdolon luteum	x	x			
Lathyrus vernus	x	x			
Oxalis acetosella	x	x			
Ranunculus lanuginosus		x			
Stachys sylvatica		x			
Stellaria holostea		x	x	x	
Tilia cordata	x	x	x	x	x
Ulmus laevis	x	x	x	x	x
Viola mirabilis	x	x	x	x	x

X – plants which occure in parks

Forest plant species were represented by 4 living forms classification: hemicryptophytes, geophytes, phanerophytes, chamaephytes.

Hemicryptophytes were represented by *Stachys sylvatica*, *Convallaria majalis*, *Viola mirabilis*. These species were occurring mostly in all study objects (Tab. 2). The highest percentage of hemicryptophytes (32%) was in Sanguszki Park (Fig. 2).

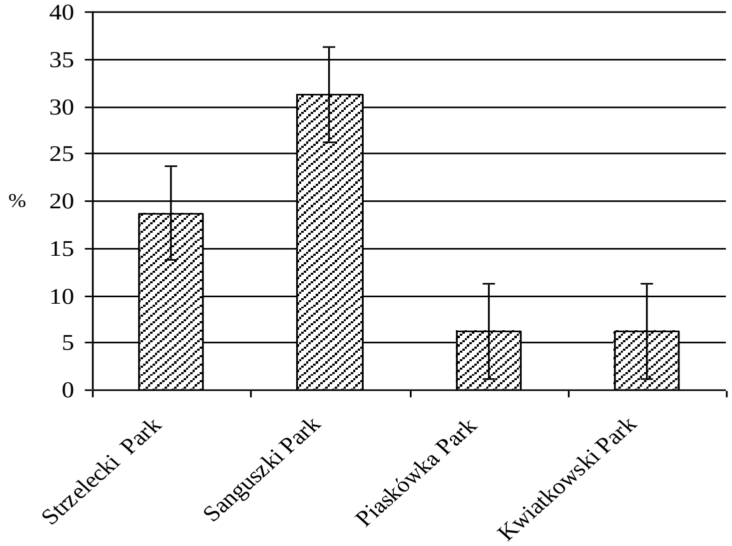

Figure 2 Percentage of hemicryptophytes on each park. Bars represent the standard deviation.

Moreover geophytes for example *Anemone nemerosa*, *Corydalis cava*, *Gagea lutea* and phanerophytes: *Acer campestre*, *Tilia cordata*, *Ulmus laevis* were occurring in study parks (Tab. 2). The highest percentage of geophytes was recognized in Sanguszki Park (Fig.3) but phanerophytes were dominated in St. Mischel Hill Park (Fig. 4).

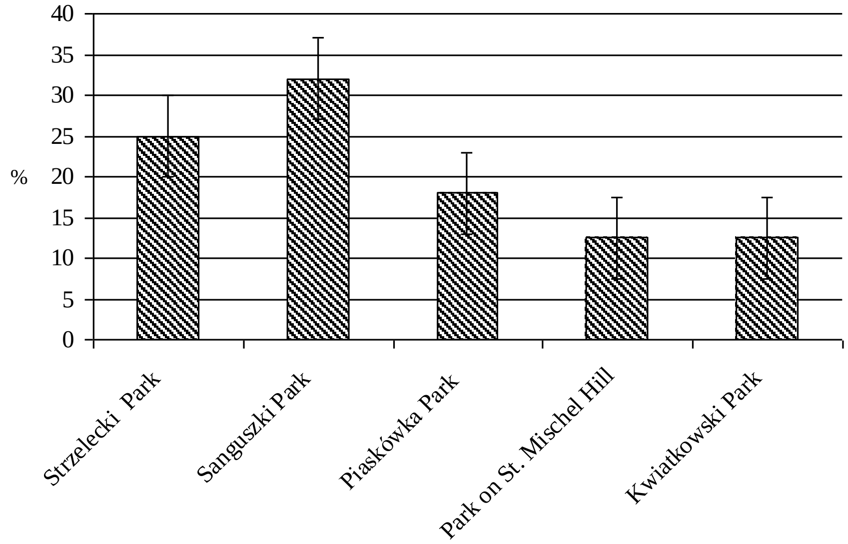

Figure 3 Percentage of geophytes on each park. Bars represent the standard deviation.

Only two chamephytes (*Galeobdolon luteum* and *Stellaria holostea*) were occurring in parks. The percentage of chamephytes was low in all study objects (Fig. 5).

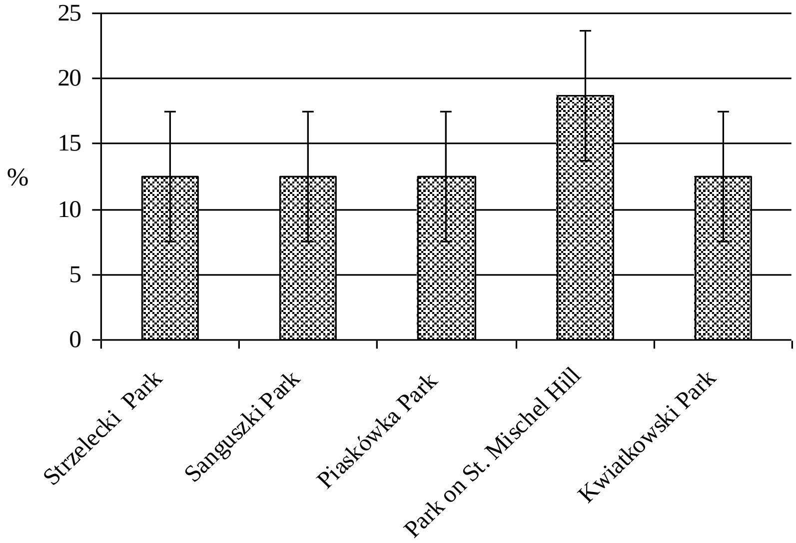

Figure 4 Percentage of phanerophytes on each park. Bars represent the standard deviation.

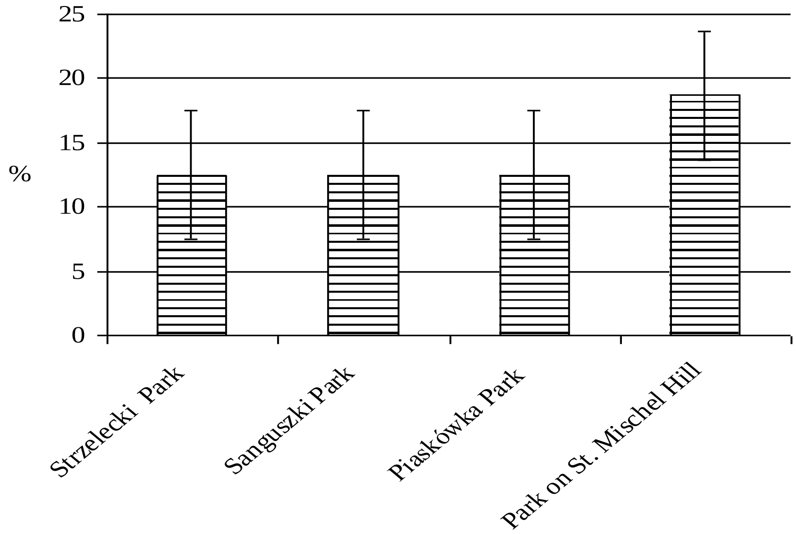

Figure 5 Percentage of chamephytes on each park. Bars represent the standard deviation. Kwiatkowski Park was without of chamephytes.

According to Forman (1995) size of patches has got influence for biodiversity of species. Higher number of ancient, forest plant species were adopted in old parks for example Sanguszki Park and Strzelecki Park in Tarnow. The number of forest plants in Tarnow parks (16 species) is lower than in country parks (30 species) (Fornal-Pieniak & Wysocki, 2009). Ancient forest plant species were represented by 4 living forms classification in parks in Tarnow and 5 living forms classification in country parks in Sandomierska Valley (Poland). Hemicryptophytes and geophytes were dominated in all country parks. Hemicryptophytes were represented by *Asarum europaeum, Milium effusum, Pulmonaria obscura, Stachys sylvatica, Circaea lutetiana.* The highest frequently of hemicryptophytes were in big country parks (14 species). Moreover geophytes for example *Anemone nemerosa, Corydalis cava, Mercurialis perennis, Gagea lutea* and phanerophytes: *Acer campestre, Corylus avellana, Tilia cordata, Ulmus laevis* were dominated in big objects (area above 6 ha), too. In all of the stands the chamaephytes were represented by *Galeobdolon luteum* and *Stellaria holostea.* Herbaceous species, as the therophytes were observed only in few country parks (Fornal-Pieniak & Wysocki, 2009). Forest plants colonization process mostly depended on time, typeuse of land and history [(Peterken & Grame, 1984), (Flinn & Vellend, 2005), Honnay et al., (2005)] and influence by human (Fornal-Pieniak & Wysocki, 2009).

CONCLUSIONS

Parks with ancient, forest plants are a sort of "green island" in Tarnow urban landscape. In all of the stands a majority of native plants was observed. Among the life-form classes hemicryptophytes and geophytes prevailed in historical parks where habitat is not so changed by man. Forest plants colonization process mostly depended on type of habitat.

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SPONTANEOUS FLORA OF INDUSTRIAL BUILDINGS IN TARNÓW, POLAND

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ABSTRACT

Urbanization process has got important impact for biotic and abiotic environment elements as soil, vegetation. Many plant species could not have big potential for growing on disturbed habitats in urban areas. During the last years it was observed plant species which founded "new habitats". These plants are called spontaneous species, which accepted urban environment. The purpose of research was presented spontaneous flora occurring on industrial building in Tarnów. Occurring plant species were grouped to phytosociological classes. It was done historical–geographical classification and life-forms, too. The last stage of research was formulated directions how it is possible to use these plant species for shaping urban landscape.

Key WORDS

spontaneous flora, industrial buildings, urban area

INTRODUCTION

Vegetation is one of the basic elements of the urban landscape. The urban landscape is still modificated and has been transformed by deliberate or unconscious human activity (Aey, 1990).In cities with spatial relationships between plant communities decide absolutely anthropogenic factors. The spatial structure of urban vegetation generally reflects the urban layout of the city (Witosławski 1990 Florgård 2000).

The urbanization process mainly causes damage to the original and natural ecosystems, which are replaced by different types of buildings and structures. Existing between the two ecosystems are educated man like. Large grassy areas, areas used for recreation or gardening, which are subjected to intensive care. For this type of disturbed areas is environmental sustainability, is dominated by introduced species, plant succession is prevented, in addition incurred high financial outlays (Turner, Lefler et al. 2005).

The basic factors that have a detrimental effect on urban vegetation include: the destruction of native vegetation and natural soil, strong nitrificatio n certain habitats, fixed mechanical effects on plants and soil salinity. It is also important urban pollution dust, soot, fumes and car exhaust (Prinz 1981; Sukopp, Henke 1989; Czerwinski 1990; Janecki, Sawczuk 1990; Czekalski, Wyrzykiewicz-Raszewska, 1992).

Urban conditions conducive to the development of synanthropic vegetation, especially ruderal vegetation. An important phenomenon readable positively associated with vegetation and synantropization in the city, is complex aesthetic effect, and in fact the direct impact of the vegetation on the sphere of human sensory (Janecki 1983).

Ruderal vegetation in cities is a popular topic developed by a number of authors of scientific works, eg. Kornaś (1977), Anioł- Kwiatkowska (1974), Kępczyńska-Rijken (1977), Janecki

(1983), Janecki, Sawczuk (1990), Witosławski (1990), Florgård (2000) Wysocki Sikorski (2002), Zimny (2005).

Despite so many scientific publications in the field of synanthropic vegetation survey cities do not include characteristics of the vegetation educated on the roofs of industrial buildings or residential areas.

The purpose of research was analysis of "spontaneous" plant species growing on roofs of old industrial buildings. The buildings are located in Azoty Company area in Tarnów (Poland) on south part of Poland.

METHODOLOGY

The field studies were carried out in years 2013 – 2015. It was distinguished 50 research plots on 5 roofs of industrial old buildings. In every year 50 phytosociological records were made on the roofs of the old industrial buildings, each on the area of 25 m^2 according to the Braun-Blanquet's method (1951). Plant species were grouped by phytosociological system following Matuszkiewicz (2001). Analysis of plant life–forms was made according to Raunkiaer (1934) and the historical–geographical classification of the species was performed following Richardson et al. (2000).

RESULTS

During the research it was recognized 20 plant species on study areas. Plant species belong to natural, seminatural and synantropical plant species as *Querco-Fagetea, Salicetea purpureae, Molinio-Arrhenatheretea, Koelerio glaucae-Corynephoretea canescentis, Thlaspietea rotundifolii, Agropyretea intermedio-repentis Stellarietea mediae, Epilobietea angustifolii, Artemisietea vulgaris* and companion species (Tab. 1).

Table. 1 Phytosociological and historical-geographical classifications of plant species.

Name of plant species	Phytosociological classification	Historical-geographical classification	Light-loving plants
Solidago canadensis	companion specie	anthropophyt	x
Betula pendula	All. Sambuco-Salicion	apophyt	x
Populus alba	Ass. Populetum albae	apophyt	
Agrostis gigantea	Cl. Molinio-Arrhrnatheretea	apophyt	x
Bromus inermis	Cl. Agropyretea intermedio-repentis	apophyt	
Erigerion canadensis	Ass. Erigeronto-Bryetum	anthropophyt	
Calamagrostis epigejos	Cl. Epilobietea angustifolii	apophyt	x
Populus nigra	Ass. Populetum albae	apophyt	
Solidago virgaaurea	Ass. Sorbus aucuparia-Solidaga virgaarea	apophyt	
Taraxacum officinale	O. Arrhenatheretalia	apophyt	
Thlapsi arvense	Cl. Stellarietea mediae	apophyt	

Acer negundo	companion specie	anthropophyt	
Artemisia vulgaris	Cl. Artemisietea vulgaris	apophyt	
Oenothera biennis	O. Onopordetalia	anthropophyt	
Sambucus nigra	Ass. Sambucetum nigrae	apophyt	
Tussilago farfara	Ass. Senecioni-Tussilaginetum	apophyt	x
Acer platanoides	Cl. Querco-Fagetea	apophyt	
Melilotus alba	Ass. Echio-Melilotetum	apophyt	
Poa pratensis	Cl. Molinio-Arrhenatheretea	apophyt	
Sedum acre	Cl. Kolerio-Corynephoretea	apophyt	x

x - light-loving plants 7, 8 – index value, according to Ellenberg

It was compared phytosociological stability of plant species in thee years: 2013, 2014, 2015. *Solidago canadensis*, *Betula pendula*, *Populus alba*, *Agrostis gigantea* had the highest frequently on researched areas. The others plant species were characterized by medium phytosociological stability without two species as *Poa pratensis* and *Sedum acre* which had the lowest occurring on roofs (Tab. 2).

Table 2 Plants species and their phytosociological stability

Name of plant species	150 phytosociological records during 3 study years 10 records for one roof															
	2013					2014					2015					Phytosociological stability
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Solidago canadensis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	V
Betula pendula	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	V
Populus alba	x	x		x	x	x	x	x	x	x	x	x	x	x	x	IV
Agrostis gigantea	x		x	x		x		x	x	x	x	x	x	x	x	IV
Bromus inermis			x	x	x			x	x	x			x	x	x	III
Erigerion canadensis		x		x	x		x	x		x	x	x	x	x	x	III
Calamagrostis epigejos	x			x		x	x		x	x	x	x	x	x	x	III
Populus nigra	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	III
Solidago virgaaurea			x	x	x			x	x	x			x	x	x	III
Taraxacum officinale	x	x	x			x	x	x			x	x	x	x	x	III
Thlapsi arvense	x		x		x	x		x		x	x	x	x	x	x	III
Acer negundo	x				x				x	x	x	x	x	x	x	II

Artemisia vulgaris				x	x				x	x			x	x	x	II
Oenothera biennis			x	x	x			x	x	x			x	x	x	II
Sambucus nigra					x			x	x	x			x	x	x	II
Tussilago farfara			x	x	x			x	x	x			x	x	x	II
Acer platanoides			x					x					x			I
Melilotus alba			x					x					x			I
Poa pratensis		x					x			x		x			x	I
Sedum acre					x					x					x	I

The system proposed by Raunkiaer (1934) as plant life-forms has been widely applied to classify plant species in life-forms (Flores et al. 2004). The plant cover which grew on the studded roofs was represented by phanerophytes, hemicryptophytes and therophytes. Hemicryptophytes were dominated in the study and were represented by: *Agrostis gigantea, Artemisia vulgaris*, *Bromus inermis*, *Calamagrostis epigejos*, *Oenothera biennis*, *Poa pratensis*, *Taraxacum officinale Sedum acre*, *Solidago canadensis*, *Solidago virgaurea* and *Tussilago farfara*. Phanerophytes were presented by *Betula pendula, Populus alba, Populus nigra, Acer negundo, Sambucus nigra, Acer platanoides*. *Thlaspi arvense* and *Erigeron candensis* belong to therophytes group.
According to the historical-geographical classification of plant species suggested by Richardson et al. (2000) both anthropophytes and apophytes occurred on studied areas.
Apophyteas were dominated on roofs. It was distinguished only four anthropophytes plants as *Acer negundo, Erigeron canadensis*, *Solidago canadensis* and *Oenothera biennis*. These plant species have got northern American origin (Tab.1).

SUMMARY

- Sponatenous plan species are belong to mostly synantropical and grasses vegetation. Only single plan species are represented by forest communities
- Apohytes and hemicryptophytes are dominated on study areas
- These plant species should be use to design green areas in cities, mostly on roofs of buildings. It is really good option for economic and biological aspects.

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THE REVIEW OF THEORIES REGARDING DESIGNING OF GREENERY IN HOUSING ESTATES

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ABSTRACT

The paper are presented different theories designing of greenery in housing estates. It was presented role of greenery and direction for proper design the space in housing estates. The last part of paper is focus on polish and foreign housing estates and also problems with directions greenery on these objects.

KEY WORDS

greenery, housing estates, design

INTRODUCTION

While creating designs of greenery in a city or projecting a modernization of already existing spaces, special attention should be paid to specificity of urban conditions, that introduce many designing limits, and also require taking in consideration factors that do not appear in designing outside urban areas. Well designed urban space should provide the "sense of place", that is the sum of features such as the meaning of place, affection to place and its identity. As proved by Ozgun Arin, the influence on them and on the user of space, have elements of spatial design (Arin, 2012).The architecture of buildings and spatial arrangement around them have indirect influence on the possibility and intensity of contacts between people – says architect Jan Gehl in his book "Life between buildings" (2009). In effect, then, in the process of designing, it is possible to create urban spaces full of life or deprived of life. For the valuation of attractiveness of space can be used three types of human's activity and degree of their intensity in specific place. Necessary activities in minimal extend depend on the quality of the environment, because for the majority of users are mandatory. Optional activities however, require already willingness from users and also proper conditions, at least minimal, to performing them. Social behavior in order to appear need the presence of other people in the space, and are therefore connected to quantity and quality of optional activities. It follows that the quality of environment and interpersonal contacts are connected between them and that with improvement of quality of space there can reveal previously ignored people's needs (Gehl, 2009). Gehl (2009) indicates a lot of factors that should be taken in consideration while designing urban public spaces. Firstly notes that the possibility of gradual move from private to public spaces gives to users bigger sense of security and allows further usage of public spaces. The next condition for creating proper space is respecting human senses functioning – mainly sight and hearing. Equally, dimensions of designed spaces should be adjusted to human body's dimensions:

the spaces of modest dimensions are perceived by users as warm and personal. Summarizing the analysis of connections between human's perception and quality of urban spaces, the author specifies five means that influence degree of isolation or contact: presence of walls, length of sections, speed, levels and orientation. As a form of special attention paid to speed, there is described positive tendency for creating streets with car traffic subordinated to walk traffic, so called places in the type of *Woonerf* – slow traffic causes that more can happen in a determined space (Gehl, 2009). About the same tendency, described as creating of zones of calmed traffic and allowing to reduce nuisances from car traffic inside a housing estate, write also Chmielewski and Mirecka. Moreover, they recommend encouraging to move on foot and by bicycle through creating a system of walking (e.g. shortcuts) and bicycle paths and through providing easily accessible and safe places to park and store bicycles (Chmielewski, Mirecka, 2002). Gehl underlines meanwhile that the system of walking paths should ensure the shortest possible connections between destination points and in the second place, be attractive for users (Gehl, 2009). Similar observations has Grant, that writes how important aspect is car traffic in housing estates: intensity of traffic influences sense of security and also making new friendships (it was proved by research of Donald Appleyard), so it is important that in places where car traffic is necessary, were introduced zones in which pedestrians and cyclists could be more privileged than car drivers. For creating such zones more important than prohibitions and barriers, that in reality do not have influence on level of security, are designs in pavements, lack of curbs and providing places for sitting (Grant, 2012).

Apart from the possibility of communication, well organized public space must meet the conditions for longer staying and sitting. The main importance has an effect of so called soft edges, or friendly areas of contact between private and public zones. These spaces, equipped in seats of major type, e.g. benches, posted in the most advantageous places and in complementary seats, like stairs, posts are appropriate for all groups of users. It is good, if seats are posted in a way that allows contact, but not forces it – e.g. at an angle. Intermediate zones make easier going out and using space for users, unlike the empty, open areas (Gehl, 2009).

Even bigger value represent areas that allow taking activities by users – as an example can be given small gardens in front of buildings – because there is observed tendency of joining other people in such activities, that causes increasing of level of activity in a space between buildings. It can be compared to a *living room* in home: everybody can at the same time be occupied by different activity or all can act together (Gehl, 2009).

Housing estates for whom..

Housing estate's space should response to needs of different groups of users – special attention must be paid to elderly people, that in getting older, European societies are becoming more numerous group which uses backyard greenery. Active spending free time by them may bring not only improvement of their health and mental comfort, but also social and economic benefits (e.g. reduction of costs of medical treatment). Usually, the improvement of area's attractiveness for older people does not involve a lot of funds, but rather involves proper designing – simple providing additional handrails on benches or comfortable access for people that are moving in a wheelchair influences area a lot. Elderly people particularly willingly use tables, e.g. for games and open-air gyms. It is desirable to arrange space in a way that grandparents could spend time actively on backyard together with their grandchildren, of whom they frequently take care (Chybalska, 2010).

While implementing recommendations of which above, as a substantial help can serve planting material. Modeling of a space by greenery, allows the change of perception of it without necessity of expensive interferences in the architectural layout. By composition of greenery, scale of architectural objects can be optically increased or decreased, and thereby feeling of degree of user's isolation. To this aim can be exploited the size of flora used, their colors and color contrast of combinations. The greenery is also perfect for diversifying a road. If there is a possibility of observing an object from above, e.g. through windows in high buildings, it is worth to take care also of a clear plan of composition. Generally, the greenery in city softens geometrics of architecture and usually there are desirable its free arrangements, but of studied and selected to the architecture form. The selection of species should be done in base of potential and existing vegetation in the specific area – it influences an optimal growth of plants and fitting to the surrounding environment (Orzeszek-Gajewska, 1982).

Functions of greenery in housing estates

Housing estate's greenery has also specific functions. They are described among others by Alicja Lipińska in publication "Role of greenery in housing estate” (1977). The author marks out five functions of greenery in housing estates. These are, by importance: biologically-sanitary, recreational, isolatingly-protective, spatially-artistic and didactically-educational functions.

Biologically-sanitary function is fulfilled by greenery mostly by releasing of oxygen, absorbing gas pollutants from the atmosphere and isolating of pollution by dust, but also by air ionization, releasing essential oils, mitigation of thermic conditions, increasing of air humidity and positive influence on eyes and psyche of inhabitants (green color).

The author pays special attention to releasing oxygen in the process of photosynthesis by urban greenery. On the basis of research made in six housing estates in Warsaw (Anin, Batorego-Zachód, Ludna, Muranów-Północ, Wierzbno and Kasprzaka) she determined the production of oxygen by trees, bushes, lawns and total amount of production. The production of oxygen by trees and bushes is from 12,4 to 64,3 kg per year on 1 inhabitant for area gross. Lipińska notices also the connection between volume of trees and bushes and the quantity of oxygen produced, that constitutes an argument for planting big trees in housing estate's greenery as well as caution in taking decisions about cutting down older trees that have the biggest contribution in production of oxygen.

Recreational function is performed by greenery thanks to fulfilling of biologically-sanitary and isolatingly-protective functions, that ensure the possibility of comfortable rest. Function isolatingly-protective consists then in suppressing of noise, allowance of zones of special usage, like playgrounds or car parks and isolating of onerous equipment (e.g. garbage places). In housing estates analyzed by Lipińska the surface of isolating greenery was from 12,8% to 58,3% of total surface of greenery (on the basis of designated isolating lines). At the same time, the bigger is the percentage of protective greenery, the smaller is the one of recreational greenery, that should have the biggest surface possible for providing the possibility of good conditions for rest, safety, ease of foot traffic and comfort in apartments.

The spatially-artistic function is performed thanks to the influence of form, structure and color of flora, "softening" of buildings, underlining of architectural value, creating of interesting views. Didactically-educational character reveals in the possibility of knowing plants, their protection, contact with nature and influence on formation of human's personality (Lipińska, 1977).

Green areas in Polish housing estates

Unfortunately many of green areas in Polish housing estates have numerous defects, that result mainly from the lack of clear division of public zones, those for groups and private, bad equipment, lack of clear ownership situation and a person responsible for their maintenance, and also from not enough money investments for organizing and maintenance of areas that accompany residential buildings. Another problem is caused also by dedicating too much space for infrastructure and communication, including car parks (Chmielewski, Mirecka, 2002).

This problem in housing estate spaces is noticed also by Grant: existing parking lots (it is valued that they occupy about 10% of area of American cities), on the one hand are indispensable and on the other, they cause negative landscape and environmental effects (e.g. contribution to creation of urban heat island). Many cities in countries like Canada, United States and Australia introduced guidelines, providing that more attention will be paid to needs of walking and cycling people: wherever it is possible, the greenery should be maintained, instead of dedicating areas for parking lots and paving of parking lots should be permeable and equipped with installations that allow infiltration of rainwater (Grant, 2012).

In places where occurs necessity of setting up a car park, it should be localized in well ventilated position, from which pollution can be easily removed, shouldn't be then located in depressions of ground, in areas too wet or between barriers posted crosswise to wind direction. Greenery that surrounds car park filters air from pollutants, gives shadow and protection from strong winds, however there should be chosen short species, posted across to the wind direction and, apart from that, of narrow crowns, in order to minimize contamination of cars by plants' secretions and by excrements of sitting on them birds (Orzeszek-Gajewska, 1982).

These major factors that bring down the quality of green areas, listed by Chmielewski and Mirecka, cause also phenomenon such as presence of neglected lawns and accidental plantings, wrongly arranged entrance zones to buildings, lack of separated areas of passive and active recreation and neglect of existing equipment (Chmielewski, Mirecka, 2002).

The solution of mentioned problems should be found in modernization of housing estate's greenery including making use of cooperation with inhabitants, creating small gardens in front of buildings and zones of calmed traffic, improvement of possibility of walking communication, changes in landform and, where it is possible, replacement of paving for permeable and creating of intimacy by division in interiors, proper arrangement of benches, lighting and usage of openwork constructions with climbing plants (Chmielewski, Mirecka, 2002).

It is worth to notice that well arranged space in housing estate increases the value of real estate, that was proved by Senetra and Szczepańska (2010) on the example of housing estates of Olsztyn. Not only then the vicinity of a park, but also the quality of the nearest surrounding of building determines the value of real estate and brings also another economic benefits (effect of cooling buildings, protection from wind in winter reduces costs of heating etc.) – the effect is an expression of human needs in relation to place of living (Senetra, Szczepańska, 2010).

How to improve it..

Apart from that, as a motto that should accompany every work over modernization can be considered the sentence: "Housing estates after modernization works must represent new social values, their inhabitants should assume for the next decades that humanized, revitalized and renovated housing estates can be decent environment to living for modern human." (Chmielewski, Mirecka, 2002).

Modern cities are also in front of specific challenges that result from population growth, pollution and results of climate changes. The present standards of sustainable development provide b.e. the usage of rain water for creating urban landscape, but in Polish cities still the major part of rainfalls goes directly to the sewer systems. The sealing of urbanized areas brings the effects in form of intensification of urban heat island, lowering of groundwater level and deterioration of vegetation conditions caused by limitation of infiltration into the soil, big changes of flow dynamics in small watercourses, excessive water pollution resulting from direct flow of rainwaters from strongly polluted areas, degradation of water ecosystems and frequent overloading of sewer systems. Long lasting effects are however: pollution of environment, deterioration of conditions of living in city, increase of flood risk and increase of operating costs of the city (Januchta-Szostak, 2011).

The method for reduction of these problems is creation of public spaces with usage of storm water retention systems, that apart from ecological advantages help make housing estate's courtyards more attractive and increase ecological awareness of society (Januchta-Szostak, 2011). The base action, possible generally in every space, is usage of permeable paving. Traditional ones, like e.g. made of gravel, are not functional on routes with higher traffic volume because of small durability, but today exist numerous types of durable and stable permeable paving, made in modern technologies. Quite frequent are paving based on system of pores in concrete or plastic material and with usage of paving blocks with connections filled with permeable material. The most modern solutions are: mixture of resin binder and aggregate of natural look and available in a variety of colors and, patented under the name of FilterPave, mixture of recycled glass with granite bound by elastomeric glue (Ratajszczak, 2014).

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VÝVOJ DISPONIBILNÝCH ZDROJOV VODY PRE ZÁVLAHY V DÔSLEDKU KLIMATICKEJ ZMENY

IMPACTS OF CLIMATE CHANGE ON IRRIGATION WATER RESOURCES

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ABSTRACT

According to climate scenarios and outputs of models of general circulation of atmosphere there is expected extraordinary increase of high precipitation totals as well as increase of number of days without precipitation. These facts will impacts the stability of agricultural production, especially in lowland areas. The area of land with water deficit increased and the moisture demand of crops also increased. However, the disposable resources of irrigation water decrease. This will limit the development of irrigation. The areas with water deficit were determined according to the ratio of actual and potential evapotranspiration ET_a/ET_0. The irrigation demand of crops was calculated with the help of model Daisy. Disposable resources of irrigation water were evaluated with the help of hydrological balance according to scenarios CCCM for time horizons 2010, 2030 a 2075.

KEY WORDS

Actual evapotranspiration, potential evapotranspiration, irrigation water resources, moisture demand of crops, water deficit , disposable water resources in hydrological river basin

ABSTRAKT

Na základe klimatických scenárov a výstupov modelov všeobecnej cirkulácie atmosféry sa reálne predpokladá mimoriadny nárast vysokých zrážkových úhrnov a nárast počtu dní bez zrážok. Tieto skutočnosti budú vplývať na stabilitu poľnohospodárskej výroby prednostne v nížinných oblastiach. Zvýšila sa výmera oblastí s deficitom vody a došlo k nárastu vlahovej potreby plodín. Zároveň sa však znižujú disponibilné zdroje vody pre závlahy, čo bude limitovať ich rozvoj. Oblasti s deficitom vody, respektíve s potrebou závlah, boli vyčlenené na základe pomeru aktuálnej evapotranspirácie a potenciálnej evapotranspirácie ET_a/ET_0. Vlahová potreba plodín bola vypočítaná s využitím modelu Daisy. Disponibilné zdroje závlahovej vody boli vyhodnotené s využitím hydrologickej bilancie podľa scenárov CCCM pre časové horizonty 2010, 2030 a 2075.

KĽÚČOVÉ SLOVÁ

Aktuálna evapotranspirácia, potenciálna evapotranspirácia, zdroje závlahovej vody, vlahová potreba plodín, vodný deficit, disponibilné zdroje vody v hydrologickom povodí

MATERIÁL A METÓDY

Po roku 1987 sa priemery teploty vzduchu výrazne zvýšili aj v strednej Európe a rekordy najvyššej teploty od začiatku pozorovaní na jednotlivých staniciach sa vyskytujú asi 5-krát častejšie ako rekordy najnižšej teploty (Lapin et al, 2003, 2012).

Ak aplikujeme na prípravu scenárov mimoriadnych epizód počasia výstupy modelov všeobecnej cirkulácie atmosféry, tak môžeme reálne predpokladať rast mimoriadne vysokých úhrnov zrážok a rast počtu dní so suchom do roku 2100 až o 50 % v porovnaní s podobnými mimoriadnymi epizódami v minulosti. Je zrejmé, že problémy so suchom budú významnejšie na juhu Slovenska (Hrvoľ et al., 2001).

Vysoká intenzita poľnohospodárskej výroby v nížinných oblastiach, ktorá je tu podmienená vysokým slnečným žiarením, prirodzenou úrodnosťou pôdy, však vyžaduje aj tomu zodpovedajúcu úroveň vstupov a ďalších produkčných faktorov (hnojív, pesticídov, vysoko výkonných osív). V nížinných oblastiach, z dôvodu predpokladu opakovania suchých vegetačných období s trvalým charakterom, sa pestovanie hlavných plodín nezaobíde bez závlah, ktoré spolu s inými opatreniami a závlahovou vodou zaručia optimálny produkčný efekt.

Voda je významným faktorom produkčného procesu, ktorý dokážeme v poľnohospodárskej sústave efektívne regulovať vo výrobných oblastiach, ktoré sú vlhkostne deficitné počas celého vegetačného obdobia. Voda ako bezalternatívny produkčný faktor výrazne ovplyvňuje stabilitu a produkciu agroekosystémov v poľnohospodársky výrobných oblastiach (PVO).

Oblasti s deficitom pôdnej vody v rizosfére počas vegetačného obdobia sú tzv. ***hlavné závlahové oblasti Slovenska***, v ktorých je potrebné dnes, alebo v blízkej budúcnosti regulovať obsah vody v pôde, pokiaľ chceme zachovať v týchto oblastiach poľnohospodársku výrobu. Hlavné závlahové oblasti sú v priamom vzťahu s poľnohospodárskymi výrobnými oblasťami v rámci povodí Slovenska. Konfrontáciou nárokov plodín na prírodné podmienky s údajmi uloženými v bonitačnom informačnom systéme (BIS), boli prírodné podmienky SR podľa kódu BPEJ rozčlenené do poľnohospodárskych výrobných oblastí (PVO) (Buday, Vilček, 2013).

Vyčlenenie závlahových oblastí bolo vykonané na základe klimatických regiónov a pôdnych parametrov poľnohospodárskych výrobných oblastí, avšak ako determinujúce kritérium bola zvolená evapotranspirácia, resp. pomer aktuálnej a potenciálnej evapotranspirácie za reprezentatívne obdobie, tzv. relatívna evapotranspirácia (ETa/ETp).

Rozloženie relatívnej evapotranspirácie na území Slovenska

Efektívnosť atmosférických zrážok, ktoré sú prirodzeným zdrojom zásob vody v pôde, závisí od ich množstva a rozloženia počas roka ako aj podmienok evapotranspirácie. Viacerí odborníci ukázali, že pri optimálnych podmienkach rastu poľných plodín sa úhrny aktuálnej evapotranspirácie len málo líšia od potenciálnej evapotranspirácie, t. j. maximálne možnej evapotranspirácie v daných klimatických podmienkach, ak povrchová koreňová vrstva pôdy obsahuje dostatok vody pre normálny rast poľných plodín (Rehák 1994; Šútor et al. 2010).

V súlade s metódou, ktorú navrhli M. I. Budyko a L. I. Zubenokova (1961), aktuálna evapotranspirácia E je daná vzťahom:

$$E = E_0 \cdot \frac{W}{W_0} \qquad (1)$$

kde E_0 je potenciálna evapotranspirácia, W je vlhkosť pôdy za uvažovaný časový interval a W_0 je optimálna vlhkosť pôdy zabezpečujúca normálny rast poľných plodín.

Vychádzajúc z rovnice turbulentného prenosu vodnej pary od vyparujúceho povrchu do atmosféry, pre stanovenie úhrnov potenciálnej evapotranspirácie bol použitý vzťah:

$$E_o = \rho D (q_s - q_2), \qquad (2)$$

kde ρ je hustota vzduchu, D – integrálny koeficient vonkajšej difúzie (v zime D = 0,30 cm.s^{-1} a v lete D = 0,6 – 0,7 cm.s^{-1}), q_s je merná vlhkosť vzduchu nasýteného vodnou parou pri teplote vyparujúceho sa povrchu a q_2 je merná vlhkosť vzduchu vo výške 2 m nad povrchom (v meteorologickej búdke).

Ak údaje o teplote vyparujúceho povrchu chýbajú, potom q_s sa určuje metódou matematického modelovania z rovnice energetickej bilancie povrchu. Priemernú vlhkosť pôdy:

$$W = \frac{W_1 + W_2}{2} \qquad (3)$$

určujeme z rovnice vodnej bilancie metódou postupných priblížení (W_1 je vlhkosť pôdy na začiatku a W_2 na konci zvoleného časového intervalu, za ktorý počítame W).

Hodnoty optimálnej vlhkosti pôdy (W_o) pre najvyššiu jeden meter hrubú vrstvu pôdy sa menia od 100 do 200 mm v závislosti od klimatických pomerov a ročného obdobia. V ročnom chode pozorujeme pokles W_o od jari k letu a jej rast na jeseň, čo súvisí s vývojom koreňového systému počas roka, ktorým plodiny čerpajú vodu z väčších hĺbok pôdy (Budyko 1974; Budyko, Zubenok 1961).

Z rovnice (1) je zrejmé, že $W < W_o$ pomer

$$\frac{E}{E_0} = \frac{W}{W_0}$$

t.j. $\frac{E}{E_0}$ je funkciou vlhkosti pôdy (4)

Relatívna evapotranspirácia $\frac{E}{E_0}$ a tiež evapotranspiračný deficit (E_o– E) umožňujú kvantifikovať nedostatok vody v pôde pre optimálny rast plodín, t. j. dovoľujú stanoviť množstvo vody potrebnej na závlahy.

Podkladom pre vyhodnotenie relatívnej evapotranspirácie na území Slovenska bol modelový výpočet mesačných úhrnov potenciálnej a aktuálnej evapotranspirácie za vegetačné obdobie na 32 meteorologických staniciach za obdobie 1981 až 2010. Ako doplňujúce údaje boli použité ročné hodnoty E/E_o za obdobie 1951 až 1980 na 54 staniciach.

Výpočet mesačných úhrnov E a E_o bol robený aplikáciou metódy založenej na spoločnom riešení rovníc energetickej a vodnej bilancie povrchu. Matematický model bol rozpracovaný na Katedre meteorológie a klimatológie Matematicko-fyzikálnej fakulty UK v Bratislave.

V priemere najmenšie ročné hodnoty E/E_o za obdobie 1981 až 2010 boli zaznamenané na Podunajskej nížine (E/E_o < 60 %), t. j. v našej najteplejšej a na atmosférické zrážky najchudobnejšej oblasti. Západná časť Záhorskej nížiny, južné Slovensko a južná časť Východoslovenskej nížiny sú v priemere za rok charakterizované relatívnou evapotranspiráciou menšou ako 65 %. V južnej časti Košickej kotliny, na juhozápadnom Slovensku, na východnej časti Záhorskej nížiny, na Považí južne od Trenčína, na strednom Ponitrí, v strednej časti Východoslovenskej nížiny na juh od Michaloviec a v juhovýchodnej časti Zvolenskej kotliny je priemerná ročná hodnota E/E_0 menšia ako 70 %. Na severe Slovenska a hlavne v horských oblastiach pozorujeme dostatok zrážok počas celého roka, a preto ročné hodnoty relatívnej evapotranspirácie sú tu väčšie ako 90 % .

Tabuľka 1 Závlahové oblasti Slovenska s reprezentatívnymi meteorologickými stanicami (Alena et al. 2005; Rehák et al. in press)

Oblasť	Názov	Stanica
I.	Podunajská nížina – Juh	Hurbanovo, Žihárec
II.	Podunajská nížina – Sever Časť Hornonitrianskej kotliny	Bratislava – letisko, Jaslovské Bohunice, Piešťany , Nitra, Prievidza
III.	Záhorská nížina	Malacky, Myjava
IV.	Juhoslovenské kotliny	Boľkovce, Rimavská Sobota,
V.	Východoslovenská nížina	Michalovce, Somotor, Čaklov
VI.	Košická kotlina	Košice, Moldava n. Bodvou

Tabuľka 2 Výmery vlahovo deficitných oblastí – závlahových oblastí (Alena et al. 2005; Rehák et al. in press)

P. č.	Názov oblasti	Plocha oblasti (ha)	% podiel na celkovej ploche PPF v SR
1.	Podunajská nížina - juh	527 362,59	21,87
2.	Podunajská nížina - sever a časť Hornonitrianskej kotliny	485 987,64	20,16
3.	Záhorská nížina a Myjavská pahorkatina	191 979,26	7,96
4.	Juhoslovenské kotliny	192 598,86	7,99
5.	Východoslovenská nížina	246 108,42	10,21
6.	Košická kotlina	122 767,98	5,09
SPOLU		1 766 804,75	73,29
Celková výmera PPF v SR		2 410 812	

Oblasť I. Podunajská nížina – Juh je ohraničená ***izočiarou relatívnej evapotranspirácie 0,6***. Je to najsuchšia oblasť na Slovensku s najväčšou intenzitou poľnohospodárskej výroby.

Oblasť II. Podunajská nížina – Sever sa rozprestiera medzi Bratislavou a Šahami na území medzi ***izočiarami relatívnej evapotranspirácie 0,6 až 0,7.*** Je to mierne suchá oblasť, v ktorej by mali v budúcnosti prevládať v štruktúre plodín husto siate obilniny.

Oblasť III. Záhorská nížina predstavuje mierne suchú oblasť ohraničenú ***izočiarou relatívnej evapotranspirácie 0,7*** a hraničnou riekou Morava.

Oblasť IV. Juhoslovenskej kotliny je mierne suchá oblasť ohraničená ***izočiarou relatívnej evapotranspirácie 0,7,*** od Šiah po Lenártovce a hranicou s Maďarskom.

Oblasť V. Východoslovenská nížina zaberá mierne suchú oblasť ohraničenú ***izočiarou relatívnej evapotranspirácie 0,7*** a hranicami s Maďarskom a Ukrajinou.

Oblasť VI. Košická kotlina tvorí významnú oblasť pre pestovanie ovocia a zeleniny pre mestské obyvateľstvo, preto v tejto oblasti je potenciál pre rozvoj závlah – mikrozávlah.

Uvedené nížinné oblasti Slovenska sú charakteristické ročnými zrážkovými úhrnmi nižšími ako sú ročné úhrny potenciálnej evapotranspirácie (ETc).

Zvyšovanie rozdielov medzi zrážkovými úhrnmi a úhrnmi potenciálnej evapotranspirácie zvyšuje citlivosť územia na sucho. Pri zložitých pôdnych podmienkach to znamená značnú závislosť zložiek vodnej bilancie územia od prejavov klimatickej zmeny. Tvorba sucha je doménou bez zrážkového obdobia. Jeho parametrizácia, t. j. frekvencia výskytu a dĺžka trvania, je kľúčom ku kvantifikácii pôdneho sucha počas hydrologického roka vo výrobných oblastiach. Ak sa časový interval medzi zrážkami zvýši na čas, počas ktorého zásoba vody v zóne aerácie pôdy klesne vplyvom evapotraspirácie porastu až na hodnotu odpovedajúcu bodu vädnutia, začína pôdne sucho. Podľa spracovaných výsledkov najviac BZO celkovo sa vyskytlo v rokoch 1990 a 1996, najviac BZO nad 20 dní v rokoch 1989 a 1991. Taktiež možno konštatovať, že najväčšia bola suma dní bez zrážkových periód v rokoch 1991 (180 dní) a 1990, najvyššia suma 20 a viac dňových periód bez zrážok sa vyskytla v rokoch 1991 (127 dní) a 1989. Dve najdlhšie periódy bez zrážok sa vyskytli v rokoch 1989 a 1991. Prvá v trvaní 40 dní (od 9.1. do 17.2.), druhá 44-dňová (11.2. - 22.3).

Na základe predložených výsledkov (Šútor a kol., 2007) možno konštatovať, že v procese retrospektívneho sledovania a hodnotenia BZO má počas vegetačného obdobia na vznik pôdneho sucha v poľnohospodárskych výrobných oblastiach dominantný vplyv výskyt extrémnych bez zrážkových časových periód. ***BZO sú významným fenoménom klimatickej zmeny***. Z výsledkov vidieť, že nie je možné nájsť nejaký pravidelný výskyt BZO. Majú stochastický charakter.

V Európe, s ohľadom na klimaticky vývoj, sa závlahy prestávajú posudzovať a navrhovať ako intenzifikačný faktor poľnohospodárskej produkcie, ale ako jej stabilizačný faktor udržateľného rozvoja poľnohospodárstva.

Podľa predpokladov, rozšírenie závlahových sústav v hlavných závlahových oblastiach bude jedným z hlavných adaptačných opatrení na zmiernenie negatívnych dôsledkov meniacej sa klímy.

Tabuľka 3 Súčasný stav a predpokladaný rozvoj závlah na území Slovenska do roku 2075

Závlahová oblasť	Výmera závlah (tis. ha)			
	2005	2010	2030	2075
I.	177	160	255	325
II.	76	60	70	75
III.	22	15	25	35
IV.	18	8	25	35
V.	27	7	25	30
VI.	1	0	0	0
Spolu	321	250	400	500

Rozšírenie závlah na takmer 500 tis. ha bude vytvárať veľký tlak na vhodné vodné zdroje. Do časového horizontu roku 2075 sa predpokladá nárast celkovej potreby vody pre závlahy o 115 % a jej spotreba na úroveň cca 75 %.

Prognóza potreby závlahovej vody podľa scenárov klimatickej zmeny pre časové obdobie rokov 2010, 2030 a 2075

Prognóza potreby závlahovej vody je spracovaná pre jednotlivé oblasti hlavných závlahových oblastí Slovenska, priemerných simulovaných množstiev potreby závlahovej vody, prognózových stavov výmer závlah pre tieto oblasti a časové horizonty rokov 2010, 2030 a 2075.

Tabuľka 4 Prognóza potreby závlahovej vody podľa scenára CCCM (Takáč in Alena et al. 2005)

Oblasť	Horizont 2010			Horizont 2030			Horizont 2075		
	$m^3.ha^{-1}$	tis. ha	mil. m^3	$m^3.ha^{-1}$	tis. ha	mil. m^3	$m^3.ha^{-1}$	tis. ha	mil. m^3
I.	1 380	160	220,8	1 400	255	357,0	1 480	325	481,0
II.	1 000	60	60,0	990	70	69,3	1 050	75	78,75
III.	900	15	13,5	950	25	23,75	1 030	35	25,75
IV.	1 090	8	8,75	1 130	25	28,25	1 320	35	46,2
V.	1 020	7	7,15	1 040	25	26,0	1 210	30	36,3
VI.	400	0	0	430	0	0	430	0	0
Spolu	Ø 1 240	250	310,2	Ø 1 240	400	504,3	Ø 1 336	500	668,0

Tabuľka 5 Prognóza potreby závlahovej vody podľa scenára GISS (Takáč in Alena et al. 2005)

Oblasť	Horizont 2010			Horizont 2030			Horizont 2075		
	$m^3.ha^{-1}$	tis. ha	mil. m^3	$m^3.ha^{-1}$	tis. ha	mil. m^3	$m^3.ha^{-1}$	tis. ha	mil. m^3
I.	1 390	160	222,4	1 420	255	362,1	1 450	325	481,0
II.	1 000	60	60,0	1 050	70	73,5	1 050	75	78,75
III.	870	15	13,0	890	25	22,25	1 030	35	25,75

IV.	1 100	8	8,8	1 120	25	28,0	1 320	35	46,2
V.	990	7	6,9	1 000	25	20,0	1 210	30	36,3
VI.	390	0	0	390	0	0	430	0	0
Spolu	Ø 1 245	250	311,1	Ø 1 265	400	505,85	Ø 1 325	500	662,5

Ako je z uvedených tabuliek zrejmé, medzi scenármi CCCM a GISS nie sú výrazné rozdiely v celkovej potrebe závlahovej vody v jednotlivých oblastiach a časových horizontoch. V priebehu cca 60 rokov by mala celková potreba závlahovej vody vzrásť o cca 115 %, čo bude spôsobené nárastom deficitu potenciálnej a aktuálnej evapotranspirácie a výmery potrebných závlah, ktorá by sa mala zvýšiť o cca 100 % v porovnaní k súčasnému stavu, resp. roku 2010.

Nárast celkovej potreby vody pre závlahy bude možné riešiť zavádzaním nových spôsobov zavlažovania, s dôrazom na efektívnosť zavlažovania a šetrenia vody. Avšak aj napriek technickému pokroku v závlahách je pravdepodobné, že potreby vody poľných plodín budú uspokojené len čiastočne.

Vodné zdroje pre závlahy

Povrchové vodné zdroje

Jediným zdrojom vody našich autochtónnych tokov (t. j. tokov prameniacich a tečúcich na našom území) sú zrážky. Priemerný ročný zrážkový úhrn za obdobie 1931 – 1980 bol 753 mm, čo na ploche územia Slovenska 49 034,55 km^2 predstavuje 36,924 km^3 vody. Z uvedeného priemeru pripadá na zimný polrok (október až marec) 306 mm a na letný polrok (apríl – september) 447 mm. Časť zrážok, ktorá sa v dlhodobom priemere dostáva do odtoku vodnými tokmi predstavuje na Slovensku 35 %.

Potenciálne možnosti využitia povrchových vodných zdrojov pre závlahy najlepšie vystihuje dlhodobý priemerný ročný prietok. Z územia Slovenska priemerne odteká 405 $m^3.s^{-1}$, čo v ročnom objeme činí 12,781 km^3. V prepočte na odtokovú výšku je to 261 mm a špecifický odtok 8,26 $l.s^{-1}.km^{-2}$. Kapacita povrchových vodných zdrojov v suchom období predstavuje 90,3 $m^3.s^{-1}$. Po odčítaní prietokov vody, ktoré sa musia ponechať v koryte z ekologického hľadiska, zostáva (bez Dunaja, Moravy a Tisy) na využívanie 36,4 $m^3.s^{-1}$.

Najväčším zdrojom povrchovej vody Slovenska sú alochtónne rieky, pritekajúce na naše územie z okolitých krajín. Najvýznamnejšou z nich je Dunaj. Pri započítaní všetkých povrchových vodných zdrojov dostaneme priemerný prietok 2 963 $m^3.s^{-1}$, to znamená že samotné územie Slovenska sa na celom odtoku podieľa len 13,7 %. Podstatná časť priteká zo susedných štátov (hlavne Dunajom, Moravou, Uhom, Latoricou, Tisou, prítokmi Ipľa). Maximálne prietoky sa vyskytujú pravidelne v mesiacoch marec, apríl (na Dunaji, Poprade a Dunajci je ich výskyt o 2 – 3 mesiace neskôr), minimálne prietoky sú koncom leta, na jeseň a v zime. Najvyrovnanejší prietokový režim má Dunaj, mohutný a pohotový vodný zdroj, ktorého dlhodobý priemerný prietok vo výustnom profile z nášho územia je 2 348 $m^3.s^{-1}$. Z vodohospodárskeho hľadiska je veľmi nepriaznivá veľká rozkolísanosť prietokov väčšiny ostatných našich tokov (Kalúz, Rehák 2007, 2010).

Pod povrchové vodné zdroje

Termín „pod povrchová voda" sa používa na súborné označenie pre pôdnu vodu a podzemnú vodu podľa STN 73 6511.

Pri posudzovaní využiteľných zdrojov podzemných vôd pre závlahy je základným problémom kvalitatívne zhodnotenie prírodných podzemných vôd, z ktorého sa vychádza pri stanovení využiteľných zásob. V kvartérnych a v mezozoických štruktúrach je dokumentovaných až vyše 80 % všetkých využiteľných zásob Slovenska.

Celkové využiteľné množstvo podzemných vôd Slovenska predstavuje sumár zdrojov schválených Komisiou pre klasifikáciu využiteľných množstiev podzemných vôd (KKMPzV) a množstiev neschválených KKMPzV, stanovených na základe dokumentovaných množstiev z hydrogeologických výskumov a prieskumov.

Základnou hodnotenou jednotkou vodohospodárskej bilancie podzemných vôd Slovenska je hydrogeologický rajón s jeho následným detailným členením na subrajóny a čiastkové rajóny. Hydrogeologický rajón je hydrogeologicky jednotné územie s podrobnými hydrogeologickými vlastnosťami, typom zvodnenia a obehom podzemnej vody. Podľa súčasnej hydrogeologickej rajonizácie je územie Slovenska rozdelené na 141 hydrogeologických rajónov (1995). V r. 2004 bolo v rámci Slovenska vyčlenených 101 útvarov podzemných vôd.

Celková kapacita podzemných vodných zdrojov (2004) bola ocenená na 146,7 $m^3.s^{-1}$. Využiteľné zásoby tvorí 76,541 $m^3.s^{-1}$.

Malé podzemné vodné zdroje

Za malé podzemné vodné zdroje sa považujú podzemné zdroje vôd, pramene a vrty s výdatnosťou od 0,2 do 2 $l.s^{-1}$, môžu byť zaujímavým zdrojom pre vodárenské využitie. Na území Slovenska je viac ako 6 641 malých vodných zdrojov (MVZ), ktoré predstavujú celkove 29 286 $l.s^{-1}$ využiteľného množstva podzemných vôd na rôznej úrovni preskúmanosti.

Štrkoviská predstavujú odkrytú podzemnú vodu v dôsledku ťažby štrkov a pieskov, predovšetkým na stavebné účely.

Tieto vodné plochy sa zvyčajne nedostatočne rekultivujú a preto nie vždy prispievajú k celkovému vzhľadu okolia. Poskytujú možnosti ich využitia pre rekreačné, estetické, poľnohospodárske a iné účely a pritom vytvárajú ekostabilizačné prvky širšieho okolitého prostredia. Kvantitatívne (hydrologické a hydraulické) parametre režimu týchto vôd podporujú ich zaradenie medzi podzemné vodné zdroje, avšak ich špecifické podmienky môžu viesť k tomu, že chemický a hydrobiologický režim ich môže radiť k vodám charakteru povrchových vôd, využiteľných ako zdroje vody pre závlahy.

Malé vodné nádrže

Malé vodné nádrže (MVN) sú súčasťou poľnohospodárskej krajiny. Na území Slovenska evidujeme 200 malých vodných nádrží, ktoré boli vybudované pre účely závlah.

Zachytávajú a akumulujú vodu, čím slúžia predovšetkým pre zásobné účely. Existujúce nádrže sa navrhovali kvôli zabezpečeniu zdroja vody pre závlahy v oblastiach, v ktorých je riedka hydrografická sieť a zásoby podzemnej vody nie sú dostatočné. V období, kedy priame odbery vody z vodného toku by s ohľadom na vodnosť toku neboli uskutočniteľné, môžu poskytnúť akumulovaný objem z vodnejších častí roka. Pri hospodárení s vodou v rámci jedného roku hovoríme o nádržiach s jednoročným vyrovnaním prietokov. Táto tzv. zásobná funkcia slúži zachovaniu životného prostredia – biologicky potrebných prietokov v tokoch a tiež poľnohospodárstvu (najmä rastlinná produkcia) (Čistý 2003, Šálek et al., 1989, Cablík 1960).

Hydroekologické limity

Vo vodohospodárskych bilanciách sa za prvoradú považuje požiadavka udržateľného rozvoja spoločnosti, pretože zdroje vody je možné využívať len dovtedy, pokiaľ sa nenaruší funkcia vody v ekosystéme. Stanovenie hydroekologických limitov, resp. hodnoty minimálneho prietoku, ktorý je nevyhnutný pre zachovanie bioty toku, patrí k veľmi zložitým problémom vodného hospodárstva u nás i v cudzine a problém nie je možné považovať za doriešený.
Hydroekologické limity súvisia s povoľovaním odberov z povrchových a podzemných vôd takto:
Orgán štátnej vodnej správy je viazaný pri povoľovaní odberu:

- z vodného toku prietokom vody vo vodnom toku, ktorý ešte umožňuje všeobecné užívanie povrchových vôd a zabezpečuje funkcie vodného toku a zachovanie vodných ekosystémov v ňom (ďalej len "minimálny zostatkový prietok"),
- z podzemných vôd hladinou podzemnej vody, ktorá ešte umožňuje trvalo udržateľné využívanie vodných zdrojov a riadnu funkciu vodných útvarov s nimi súvisiacich (ďalej len "minimálna hladina podzemných vôd").

Vodohospodárska hydrologická bilancia

Pri výpočte miery ovplyvnenia hydrologického režimu boli použité údaje z kvantitatívnej vodohospodárskej bilancie za rok 2012:

E – ovplyvnený prietok,
C – očistený prietok (prirodzený prietok, ktorý by bol v profile bez ľudských vplyvov – odberov a manipulácii na vodných stavbách).

Výpočet bol prakticky vypočítaný podľa vzorca:

$$C - E / E \tag{5}$$

pričom:
C – E – vplyv užívania vôd, vrátane vplyvu manipulácii na vodných stavbách
E – zdroj vody ovplyvnený, čiže prietok ktorý zostal po všetkých vplyvoch!

Pri kvantitatívnej vodohospodárskej bilancii povrchových vôd sa posudzuje vzťah medzi zdrojmi vody (*Z*) a požiadavkami na vodu (*P*) v danom priestore (povodie, sieť profilov, resp. výhľadovo sieť vodných útvarov):

$$Z <=> P \tag{6}$$

kde *Z* je označenie pre zdroje a *P* je označenie pre potrebu vody.

Širší tvar základnej bilančnej rovnice používanej v SR je:

$$ZP \pm ZN \pm ZPR <=> P + MQ - V \tag{7}$$

kde je:

ZP – prirodzený zdroj vody,
ZN – zmena zdroja spôsobená vodnými nádržami,
ZPR – zmena zdroja spôsobená prevodmi vody,
P – potreba vody (odbery),
MQ – minimálny bilančný prietok,
V – vypúšťanie vody do toku.

Základné bilančné hodnotenie sa posudzuje podľa dvoch parametrov:
1. Bilančného stavu vypočítaného z pomeru hodnôt Z/P:
- ak Z/P <= 0,9 ide o pasívny (nevyhovujúci) bilančný stav,
- ak 0,9 < Z/P < 1,1 ide o napätý bilančný stav,
- ak Z/P => 1,1 ide o aktívny bilančný stav.

2. Využiteľnej kapacity zdroja vypočítanej ako rozdiel Z-P:
- ak Z-P je kladná hodnota, zdroje prevyšujú potreby vôd (možnosť ďalších odberov),
- ak Z-P je záporná hodnota, je nedostatok vôd (potreby vody možno kryť ďalšími zdrojmi).

VÝSLEDKY A DISKUSIA

Prognóza zabezpečenosti disponibilných zdrojov vody pre závlahy
Aktuálne spracovaná prognóza vodohospodárskej bilancie (Fekete 2013) uvažuje na strane potrieb vôd na závlahy zo scenára CCCM pre horizonty 2010, 2030 a 2075. Na strane zdrojov vody sú uvažované prirodzené priemerné mesačné prietoky s vysokou zabezpečenosťou a na strane minimálnych zostatkových prietokov sú použité platné hodnoty MQ (Fekete 1985, 1990). Bilancia je spracovaná hodnotením výustných profilov jednotlivých čiastkových povodí. Výsledky sú deklarované prostredníctvom kapacity zdrojov vody (prietokov). Záporné číslo znamená nedostatok zdrojov vody.

Tabuľka 6 Kapacita zdroja po mesiacoch – rok 2010

Povodie	mesiac						
	4	5	6	7	8	9	10
Bodrog	26,85	18,71	9,801	0,383	0,196	3,604	6,140
Hron	6,461	6,042	3,072	1,165	-1,554	0,961	-0,111
Ipeľ	0,763	0,110	-0,686	-0,972	-0,792	-0,053	0,311
Slaná	1,894	3,496	1,480	0,476	0,221	0,549	0,550
Nitra	2,456	0,575	-0,833	-1,018	-1,453	-0,026	0,567
Váh	47,42	17,95	13,64	4,707	-2,042	0,529	-1,365
Morava	30,99	22,93	9,396	3,022	2,013	5,314	3,219

Dunaj	888,5	828,4	824,1	890,8	437,5	276,7	13,6
Bodva	-0,005	0,339	0,306	-0,249	-0,299	-0,318	-0,178
Poprad	5,386	6,261	8,239	3,874	2,923	2,137	1,381
Hornád	2,047	3,396	2,024	1,745	1,035	0,126	0,604

Údaje sú v $m^3.s^{-1}$

Tieňované bunky znamenajú nedostatok zdrojov.

Tabuľka 7 Kapacita zdroja po mesiacoch – rok 2030

Povodie	mesiac						
	4	5	6	7	8	9	10
Bodrog	26,56	17,38	7,691	-1,166	-1,001	3,168	5,928
Hron	5,047	3,980	0,957	-0,321	-3,040	-0,103	-0,886
Ipeľ	0,206	-1,129	-2,023	-2,050	-1,655	-0,331	0,203
Slaná	1,475	2,595	0,409	-0,425	-0,590	0,223	0,415
Nitra	2,294	0,214	-1,223	-1,332	-1,720	-0,107	0,551
Váh	45,73	15,31	10,78	1,890	-4,015	-0,257	-1,722
Morava	30,51	22,21	8,566	2,218	1,363	4,997	3,143
Dunaj	881,8	815,9	811,1	880,3	428,2	272,8	11,2

Údaje sú v $m^3.s^{-1}$

Tieňované bunky znamenajú nedostatok zdrojov.

Tabuľka 8 Kapacita zdroja po mesiacoch – rok 2075

Povodie	mesiac						
	4	5	6	7	8	9	10
Bodrog	26,40	16,64	6,538	-2,012	-1,654	2,929	5,813
Hron	4,242	2,602	-0,467	-1,190	-3,909	-0,599	-1,126
Ipeľ	-0,216	-2,069	-3,036	-2,867	-2,309	-0,543	0,122
Slaná	1,075	1,735	-0,614	-1,285	-1,364	-0,088	0,286
Nitra	2,036	-0,360	-1,841	-1,831	-2,144	-0,236	0,526
Váh	43,66	12,04	7,237	-1,571	-6,459	-1,221	-2,151
Morava	29,94	21,33	7,569	1,254	0,582	4,618	3,051
Dunaj	875,5	804,0	798,4	870,0	419,4	269,4	9,3

Údaje sú v $m^3.s^{-1}$

Tieňované bunky znamenajú nedostatok zdrojov.

V súčasnosti je hlavný spôsob aplikácie závlahy naďalej postrek (cca 95 %) s postupným zavádzaním progresívnejších spôsobov zavlažovania mikrozávlahami (cca 5 %). Nové spôsoby zavlažovania a automatického riadenia závlah by mali zvýšiť efektívnosť zavlažovania, šetrenia spotreby závlahovej vody. Tento trend modernizácie závlah by mal pokračovať a v časovom horizonte roku 2075 by sa pomer postreku a mikrozávlah mal pohybovať na úrovni 70 %/30 %.

Šetrenie vodou sa dosahuje zvýšením kvality zavlažovania, t. j. zvýšením kvalitatívnych parametrov, akými sú stupeň rovnomernosti rozdelenia závlahovej vody zvýšením rovnomernosti z priemerných 50 až 60 % pri najrozšírenejšom spôsobe závlah, postrekom na 90 až 96 % pri aplikácii mikrozávlah. Úspory vo výške 40 – 50 % z objemu dodanej závlahovej vody, pri spravidla zvýšených produkčných efektoch procesu zavlažovania, sú jednoznačným príspevkom do problematiky.

Pre účely ovplyvňovania vodného režimu pôd sa veľmi perspektívne ukazujú jestvujúce odvodňovacie systémy, ktoré by pri svojej primárnej odvodňovacej funkcii vykonávali aj funkciu zavlažovaciu počas vegetačného obdobia. V územiach s vhodnými stanovištnými podmienkami, ovplyvňovaných retardáciou odtoku drenážou, resp. odvodňovacími kanálmi by bolo možné kryť 30 – 50 mm z celkovej potreby vody plodín za vegetačné obdobie.

ZÁVER

Voda ako bezalternatívny produkčný faktor výrazne ovplyvňuje stabilitu a produkciu agroekosystémov v poľnohospodársky výrobných oblastiach (PVO). Relatívna evapotranspirácia $\frac{E}{E_0}$ a tiež evapotranspiračný deficit (E_o– E) umožňujú kvantifikovať nedostatok vody v pôde pre optimálny rast plodín, t. j. dovoľujú stanoviť množstvo vody potrebnej v poľnohospodárskych výrobných oblastiach, resp. v závlahových oblastiach. Výpočet mesačných úhrnov E a E_o bol robený aplikáciou metódy založenej na spoločnom riešení rovníc energetickej a vodnej bilancie povrchu. Pre vyčlenenie závlahových oblastí bolo ako determinujúce kritérium zvolená evapotranspirácia, resp. pomer aktuálnej a potenciálnej evapotranspirácie za reprezentatívne obdobie, tzv. relatívna evapotranspirácia (ETa/ETp).

Rozšírenie závlahových sústav v hlavných závlahových oblastiach bude jedným z hlavných adaptačných opatrení na zmiernenie negatívnych dôsledkov meniacej sa klímy. Prognóza potreby závlahovej vody je spracovaná pre jednotlivé oblasti hlavných závlahových oblastí Slovenska, priemerných simulovaných množstiev potreby závlahovej vody, prognózovaných stavov výmer závlah pre tieto oblasti a časové horizonty rokov 2010, 2030 a 2075. Aktuálne spracovaná prognóza vodohospodárskej bilancie uvažuje na strane potrieb vôd na závlahy zo scenára CCCM pre horizonty 2010, 2030 a 2075. Na strane zdrojov vody sú uvažované prirodzené priemerné mesačné prietoky s vysokou zabezpečenosťou a na strane minimálnych zostatkových prietokov sú použité platné hodnoty MQ.

Nárast celkovej potreby vody pre závlahy bude možné riešiť zavádzaním nových spôsobov zavlažovania, s dôrazom na efektívnosť zavlažovania a šetrenia vody. Napriek technickému pokroku v závlahách, potreby vody poľných plodín budú uspokojené len čiastočne z dôvodu obmedzených disponibilných zdrojov vody pre závlahy v niektorých povodiach Slovenska. Už v blízkej budúcnosti sa bude uplatňovať zásada, že plodiny náročné na vodu by mali byť prednostne umiestňované na plochy s vybudovanými závlahami s dostatočnými zdrojmi závlahovej vody. To znamená, mala by byť dodržiavaná zásada, aby ***plodina išla za vodou a nie voda za plodinou***.

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IMPLEMENTATION OF THE AHP METHOD FOR DETERMINING THE WEIGHTS OF FACTORS DECISIVE FOR THE LOCATION OF THE MUNICIPAL WASTES CONVERSION PLANT, ON THE EXAMPLE OF THE CITY OF KRAKOW

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SUMMARY

The paper proposes methodology for calculating the weights of factors determining the choice of location of municipal waste incineration plant (ZTPOK). Objective and accurate determination of the weights, is offering an optimal choice of location. To achieve the planned purpose, the method of the analytical hierarchical process was applied. The study included seven potential locations for the municipal waste incineration plant, located within the area of the city of Krakow. The objective of the analysis, which is the subject of this publication, is determination of weights of factors decisive for the choice of ZTPOK location. These weights were calculated using the method of the analytical hierarchical process. The choice of method is dictated by the fact, that in the studied case we are dealing with multivariate analysis, and its components are described both in a quantitative and a qualitative way.

KEY WORDS

AHP, wastes management

INTRODUCTION

Wastes management is a global problem and it becomes increasingly important due to the population growth, industrialization, as well as lifestyle changes. Currently, the majority of generated waste is neutralized in open dumps. Dumping of wastes causes many environmental problems. Construction of incineration of municipal waste plants (ZTPOK) is the optimum solution. Poland is obliged to implement the principles of the EU Directive concerning wastes management and environmental protection. The adopted environmental policy indicates support for the implementation of cost-effective and environmentally sound technologies of recovery and disposal of wastes, as a one of the main directions of activities in the municipal sector. This also applies to technologies related to the recovery of the energy contained in wastes.

National Waste Management Plan implies, inter alia, that in the nearest future extension of the existing and construction of new lines for recovery and disposal of waste will be necessary. This applies both to the thermal and biological methods. Construction of ZTPOK will help to reduce the number of open landfills in the country.

RESEARCH METHOD

The implementation of the tasks arising from the EU Directive concerning waste management and environmental protection is related to the choice of location of ZTPOK. The location of this type of investment requires consideration of factors of legal-social, technological, economic and ecological character. These factors are discussed in detail in table 2.

Case study were carried out using the analytic hierarchy process (AHP). This method is one of the methods of solving multivariate tasks by creating a hierarchy structure in the form of a decision tree (Figure 1). The main advantage of the analytical hierarchy method is complex multi-band and multi-criteria model presented in hierarchical terms (Saaty, 1977; Piasek and Siejka, 2003).

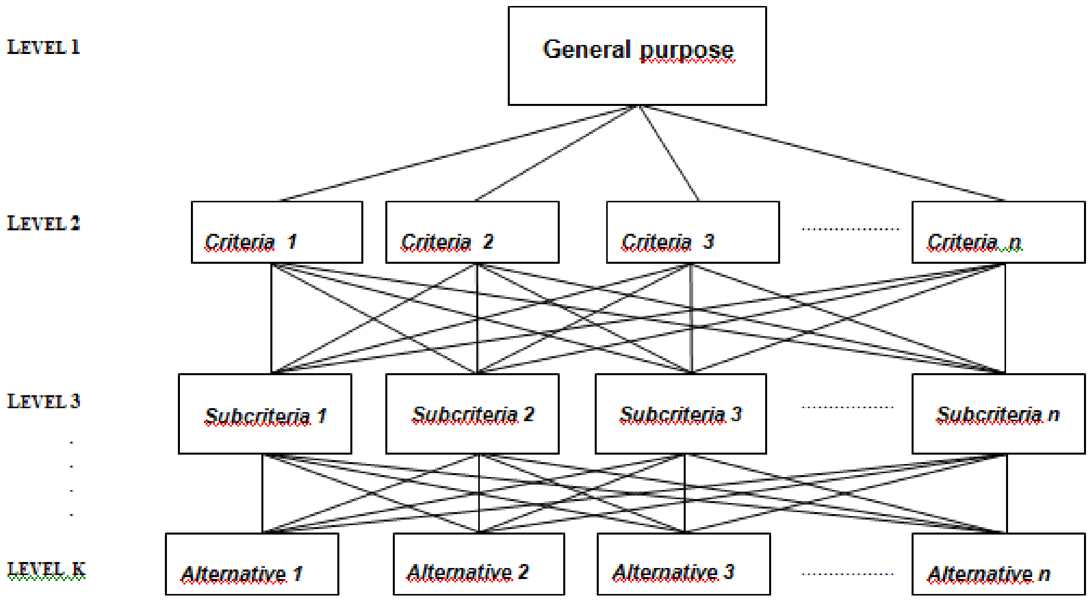

Figure 1 An example of the hierarchy decision tree.

Considering the choice of location ZTPOK as a set of features $(w_1, w_2, \dots , w_n)$, pairwise comparison matrices were constructed, in the form:

$$\boldsymbol{A} = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \boldsymbol{n} \cdot \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \tag{1}$$

After transformation it was obtained:

$$\boldsymbol{A} \cdot \boldsymbol{w} = n \cdot \boldsymbol{w} \quad \text{czyli} \quad |\boldsymbol{A} - n \cdot \boldsymbol{I}| \cdot \boldsymbol{w} = \boldsymbol{0} \tag{2}$$

where:

$\boldsymbol{A}$ – square matrix,

$\boldsymbol{w}$ – vector of weights,

n – matrix dimension,

$\boldsymbol{I}$ – identity matrix.

Matrix algebra shows, that apart from the solution, wherein $\boldsymbol{w} = 0$, the first factor, $|\boldsymbol{A} - n\cdot\boldsymbol{I}|$ is equal to zero only when the dimension of the matrix $\boldsymbol{n}$ is equal to the matrix eigenvalue, and $\boldsymbol{w}$ is the eigenvector associated with the eigenvalue (Saaty, 1980).
However, in practice, especially in the analyzed case, factor $\boldsymbol{a_{ij}}$,$=\boldsymbol{w_i/w_j}$, is associated with the evaluation and in a situation where it is not based on accurate measurements, factor $\boldsymbol{a_{ij}}$ differs from the "ideal" value $\boldsymbol{w_i/w_j}$ and therefore the equation (2) will be modified to the following form:

$$\mathbf{A}' \cdot \mathbf{w}' = \lambda_{max} \cdot \mathbf{w}' \quad \text{lub} \quad |\mathbf{A}' - \lambda_{max}\,\mathbf{I}| \cdot \mathbf{w}' \qquad (3)$$

where $\boldsymbol{\lambda_{max}}$ – is the maximum real eigenvalue of the matrix $\boldsymbol{A}'$.
It is worth noting, that the matrix $\boldsymbol{A}'$ has a specific structure:

- all elements $a_{ij} > 0$
- elements on the diagonal $a_{ii} = 1$
- elements on opposite sides of the diagonal $a_{ij} = a_{ji}^{-1}$

The matrix $\boldsymbol{A}'$ presented above always has a real and positive eigenvalue λ, which has the following features (Saaty, 1980).

1. It is a simple root of the characteristic equation of this matrix,
2. It is the largest in terms of module eigenvalue of the matrix, and eigenvector $\boldsymbol{w}$ corresponding to this eigenvalue always has all components positive (w_i>0).

In order to determine priorities (weights) after building the evaluations matrix, for each array the maximum eigenvalue $\boldsymbol{\lambda_{max}}$ and associated with that value eigenvector $\boldsymbol{w}$ were determined. In order to verify the correctness of the obtained results two indicators were introduced (Saaty, 1980):

1. consistency index– CI

$$CI = \frac{\lambda_{max} - n}{n-1} \leq 0{,}10 \qquad (4)$$

where: $\boldsymbol{n}$ – dimension of the matrix
$\boldsymbol{\lambda_{max}}$ – maximum eigenvalue of the matrix

2. consistency ratio – CR

$$CR = \frac{CI}{RI} \leq 0{,}10 \qquad (5)$$

where: RI (random index) depends on the size $\boldsymbol{n}$ of the matrix , Table 1.

Table 1 Random index RI value depending on the dimension $\boldsymbol{n}$ of the matrix

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,44	1,45	1,49	1,51	1,53	1,56	1,57	1,59

Source: Saaty, 1980.

When the consistency ratio *CR>0,1* or consistency index *CI>0,1*, evaluation of the relation of elements in the matrix must be repeated.

After determining all the partial priorities the solution of the task is the vector:

$$C[1,k]^T = \prod_{i=2}^{k} B_i = B_k \cdot B_{k-1} \ldots B_2 \qquad (6)$$

where:

C[1,k] - vector of results of priorities (weights) assigned to elements of hierarchical level ***k***, (i.e. alternatives of solutions) relative to the target, which is the first level,

$\boldsymbol{B_i}$ - level ***i*** matrix, which columns are priorities vectors of ***i*** level elements relative to the element of ***i – 1*** level.

RESULTS AND DISCUSSION

Presented method was used for achieving the goal which was to determine the weights of the factors influencing the choice of ZTPOK location. After solving pairwise the 23 comparisons matrices, the weights of features at various levels of the hierarchy were obtained. The results are summarized in Table 2.

Table 2 The factors influencing the choice of ZTPOK location and their weights

Level I Criteria	Weight [%]	Level II Subcriteria	Weight [%]	Level III Components	Weight [%]
Legal/Social	35	Compliance with the spatial development plan	5	Full	3,00
				Partial	1,50
				None	0,50
		The current usage	3	Residential areas	1,50
				Agricultural areas	0,75
				Forest areas	0,75
		Legal status / ownership	7	Areas of legal status regulated – fully	3,00
				Areas of legal status regulated – partly	2,50
				Areas of unregulated legal status	1,50
		Expected public acceptance	20	Favourable	9,00
				Average	6,00
				Adverse / None	5,00
		Sum	35		35,00
Technical	20	The size of the land	5	Favourable /optimal	3,00
				Average	1,50
				Adverse	0,50
		Access to technical	3	Favourable	1,75

		infrastructure		Average	0,75
				Adverse	0,50
				Favourable	2,50
		Communication system	4	Average	1,05
				Adverse	0,45
		Geological conditions / ground waters / flood risk	8	Favourable	4,25
				Average	2,80
				Adverse	0,95
		Sum	20		20,00
Economical	15	Land prices	4	High	0,60
				Average	1,15
				Low	2,25
		Expenditures necessary for building the infrastructure	4	High	0,95
				Average	1,30
				Low	1,75
		Costs of servicing the plant	7	High	1,75
				Average	2,20
				Low	3,05
		Sum	15		15,00
Ecological	30	Emissions / location in relation to the compass rose	5	Favourable	2,75
				Average	1,60
				Adverse	0,65
		Conditions of sewage collection	3	Favourable	1,65
				Average	0,95
				Adverse	0,40
		Distance from landfill for hazardous waste	2	Favourable	1,25
				Average	0,60
				Adverse	0,15
		Distance from residential areas / housing development ratio	7	Favourable	3,95
				Average	2,25
				Adverse	0,80
		Distance from the ecologically valuable areas	7	Favourable	4,05
				Average	2,10
				Adverse	0,85
		Possibility to use the obtained products (energy, slags) in the nearest area of location	4	Favourable	2,65
				Average	1,00
				Adverse/None	0,35
		The possibility of the use of renewable energy sources	2	Favourable	1,05
				Average	0,80
				Adverse/None	0,15
		Sum	30		30,00

In a further step of analysis, the resulting weights were used in the evaluation of the investigated objects. The calculations were used to compare the investigated objects (1-7) and to indicate the optimal location (Figure 2).
The calculation results showed that for the seven tested location point values vary in the range from 26 to 44 (Figure2). The optimal location is the object number 3.

Figure 2 The results obtained for the tested objects.

CONCLUSIONS

Presented in this paper analytical hierarchical structure is useful in many processes of analyzes related to the determination of decision-making relevancy. AHP method used in this study, proved to be a good tool for decision-making, for indication of the weights of attributes associated with a choice of ZTPOK location. Another advantage of this method is the possibility to combine quantitative and qualitative factors in the process of comparative analyzes. As a result of carried out analysis numerical notation of each factor describing a given object is obtained, which helps avoiding errors in the evaluation. Therefore, it must be stated unequivocally, that the presented method can be successfully applied in the point estimation of the features determining the choice location of an object of ZTPOK type, as well as the objects of another function.

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ESTIMATION OF SOIL SURFACE ROUGHNESS BY TERRESTRIAL LASER SCANNING

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ABSTRACT

Erosion control or flood protection measures are frequently designed according to volume or discharge of overland flow. To estimate these values, it is necessary to know characteristics of overland flow, which are functions (among others) of soil surface roughness. The roughness value is defined as rate of disturbance or irregularity of the soil surface at such a scale which is generally too small to be captured by conventional topographic maps. It is described predominately with table values as Manning, Bazin or Allmaras´s Random Roughness index, which is calculated as standard deviation from surface irregularities by micro-relief (pin) meter. Recently, this method is replaced by terrestrial laser scanning (TLS), which as a modern information technology is nowadays intensively used within surface modeling, enabling generation of 2D - and 3D digital terrain model (DTM) in the various forms like accurate wireframed or photorealistic visualized. There are various methods available for the acquisition of present surface reconstruction depending on the technology, distance and accuracy required. This paper deals with TLS as very effective and highly accurate method to obtain a digital micro-relief model of defined part of arable land, calculation the roughness value as the standard deviation of elevation and its comparison with idealized pin meter.

KEYWORDS

random roughness, terrestrial laser scanning, digital micro-relief model, standard deviation.

INTRODUCTION

Historical maps (military mapping survey) and also aerial survey photos show the rich distribution of ecostabilization elements that in many cases play also a role in the transformation of surface runoff to subsurface runoff. In the second half of the last century, it came not only to land merging but also to the removal of landscape elements that were fulfilling besides the others also ecostabilization functions. This resulted in increase of soil erosion, sedimentation of water basins and streams, but also flood damage in built-up areas. Although the current realization of various projects (land consolidation projects, water management plans, etc.) restores ecostabilization elements in a certain measure, the positive consolidation of arable land does not occur, because land remains in use of agricultural cooperatives. Except this issue, it is necessary to take into account also to the climatic change, predominately occurrence of local storm events and also extremely heavy regional rains that we are witnessing for example in spring (but also summer) months of year 2010. Solution of this kind of negative phenomenon can be possible by retaining of water in the land, in depression storage and in slowing runoff, respectively. In this way, soil surface roughness plays important role. Hitherto used roughness values according to Manning or Bazin appear to be inadequate especially in the case of arable land. On the contrary, random roughness index can describe surfaces of differently cultivated soils using micro-relief or pin meter, but measurement, and especially evaluation is time consuming. It has to be taken into account that the roughness changes almost heterogeneously at each rainfall event, but this change does not necessarily always mean only a reduction (particularly at the high rainfall amount).To eliminate this imperfection, modern technology approach – terrestrial laser scanner (TLS) – can be used as a very important and valuable tool. TLS are contactless measuring devices which can collect dense point-clouds reflected from the surface of objects. After processing each point is assigned with X, Y, Z coordinates; color and reflectance value. This technology is becoming increasingly important for surveying applications. The contribution deals with application of laser scanning technology and elevation data evaluation, illustrated by an example from research of micro-relief reconstruction, soil surface roughness determination and comparison of results with idealized pin meter.

MATERIALS AND METHODS

The term soil roughness is used to describe disturbances or regularities in the soil surface at a scale which is generally too small to be captured by a conventional topographic map or survey. Römkens and Wang (1986, cit. Govers et al., 2000) make a distinction between four types of roughness:

a) micro-relief variations, which are due to individual grains or micro-aggregates,
b) random roughness, which is related to soil cloudiness,
c) oriented roughness, which describes the systematic variations in topography due to farm implements
d) higher order roughness, representing elevation variations at the field, basin or landscape level.

Because random roughness (with oriented roughness) affects various hydrologic and erosion processes on arable land, we pay increased attention to this important issue. Random roughness was estimated using micro-relief meter (Allmaras et al., 1966). It was designed to measure surface elevations on a 2- by 2-inch grid over a 40- by 40-inch area Its improvement is pin meter (Garcia Moreno et al., 2010) with the plot size 1 m^2. (Figure 1). Pin meter consisted of a row of 35-cm high pins placed in a frame in which they could slide up or down to conform to surface irregularities. With rows containing 50 pins spaced at 2-cm intervals, each x-axis reading covered one full meter of ground. The y-axis readings were taken by sliding the instrument across the one square meter plots. The cells on the resulting grid measured 2 x 2 cm, and a total of 2500 readings was taken per square meter (in the case of micro-relief meter with 20 pins, number of readings is 400).

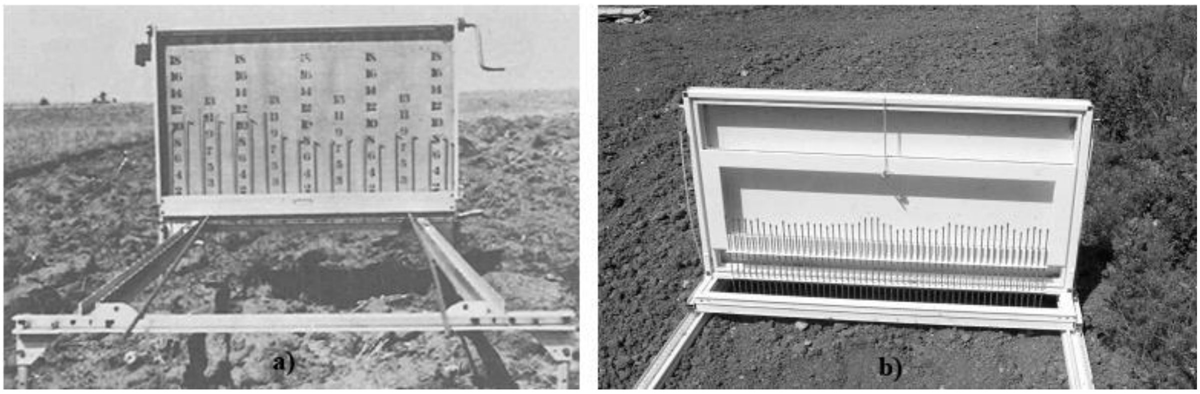

Figure 1 (a) Micro-relief meter (Allmaras et al., 1966) and (b) Pin-meter (G. Moreno et al., 2010)

This time-consuming method was replaced by **terrestrial laser scanning (TLS)**, which is an alternative to standard survey techniques. Laser scanning generates a **point cloud** as a collection of XYZ co-ordinates in a common coordinate system that portrays to the viewer an understanding of the spatial distribution of a subject (Lemmens, 2011). It may also include additional information, such as pulse amplitude or RGB values. Laser scanners could operate on one of three principles :

Triangulation

Triangulation scanners calculate 3D coordinate measurements by triangulating the position of a spot or stripe of laser light. Triangulation-based systems enable measurements at a range of up to 25m, although at this range you can expect a further degradation in accuracy.

Time of flight (pulse)

Systems based on the measurement of the time of flight of a laser pulse and appropriate to conservation activities offer an accuracy of between 3 mm and 6 mm. Such systems use the two-way travel time of a pulse of laser energy to calculate a range.

Phase comparison

This type of laser scanning achieves similar accuracies to time-of-flight systems. A phase-comparison bases its measurement of range on the differences in the signal between the emitted and returning laser pulses. As this is a continuous process, phase-comparison systems have much higher rates of data capture (hundreds of thousands of points per second), what can be very demanding on computer hardware. Time-of-flight and phase-comparison systems are typically able to scan a full 360 degrees in the horizontal and often up to 270 degrees in the vertical.

Computer software is required at all steps of the laser scanning and data postprocessing. This includes the operation of the scanner, the processing of the collected data and the visualization and utilization of the digital models and their analyses. Software is essential for controlling the scanner during surveying and to process the raw data into measurable point-clouds and 3D models. The manufacturer of the laser scanner usually provides the control software that steers the movement of the scanner, visualizes object points during scanning in 2D or 3D, and carries out onsite data cleaning. Software is also necessary to join the point-clouds gathered at the sequence of scan positions into one model, and to geo-reference the model within a desired coordinate system (Fröhlich et al, 2004).

In our research a **pulse laser scanner Leica P20,** operated with WFD (Waveform Digitizing) technology was used for the acquisition of the point surface model (figure 2).

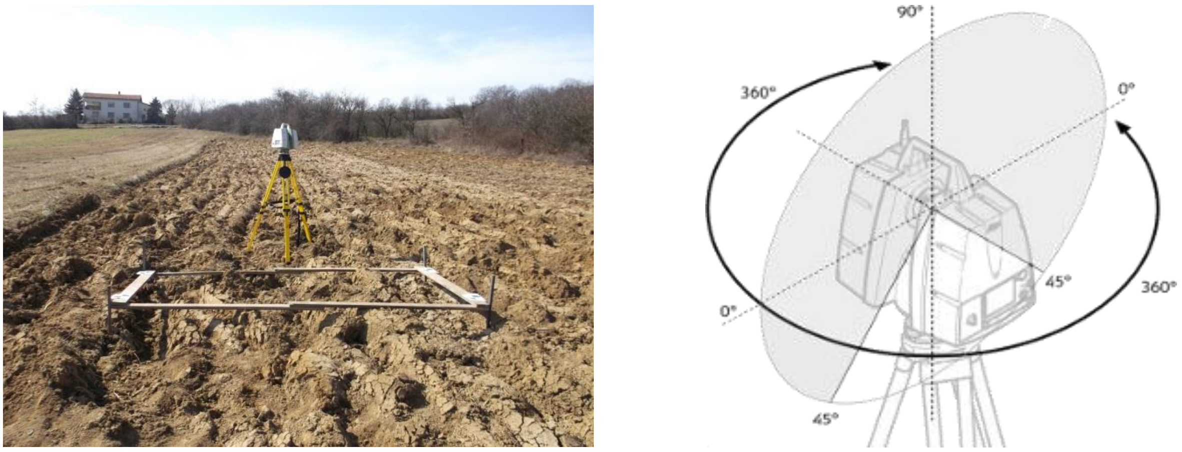

Figure 2 Research area within arable land and schematization of laser scanning process

Pulse laser scanners could achieve position up - to 100.000 points in 1 second. Scanners with measuring on phase comparison base have performance up - to 1 million points measured per second at the expense of smaller reach and precision in comparison to the pulse scanners. **Scan resolution (or point density),** which is defined by the average distance between XYZ - coordinates of the particular points within a cloud, is an important parameter given by user and limited by minimal angular increment machine (8“/8“ – horizontal/vertical in the case of Leica P20 Scanner used in our research). An important criterion for precision of the measuring is a **distance between the scanner and measured point** on reflective surface. In the state-of-the-art pulse scanner the maximal measuring distance moves at intervals up - to 200 - 300m, phase comparison scanners have the operating range in 100- 120m. Measuring precision is also dependent on texture, color, and reflectiveness of the surface, where laser beam bounces back from.

RESULTS AND DISCUSSION

The research was realized on 17 March 2015 on arable land (ploughed surface) situated in cadastral area of Jelenec (district Nitra). The research area with internal dimensions 140 cm x 200 cm is located at 90 m of slope length. The land is protected against the inflow of strange waters by drainage ditch (see figure 2). The area under interest was scanned in time-shifts from two opposite scanstation positions (the laser scanners retain only points on visible surfaces, it is necessary to change a scanner positions to provide sufficient covering of the space under investigation) and subsequently registered into resultant point cloud, whereby for constraining three 6“ reflective black&white targets were used. The maximal linear vector error of registration was 1.0 mm. The acquisition of the point clouds (figure 3) representing the terrain surface was scanned with point density of 3,1mm@10 m. Registered and cleaned resultant point clouds (of 140 cm x 200 cm research area) contained 399 116 points. The global position of the investigated area of land was measured by the means of GNSS Rover – Leica GS-08Plus RTK, with the static precision 6mm+0.

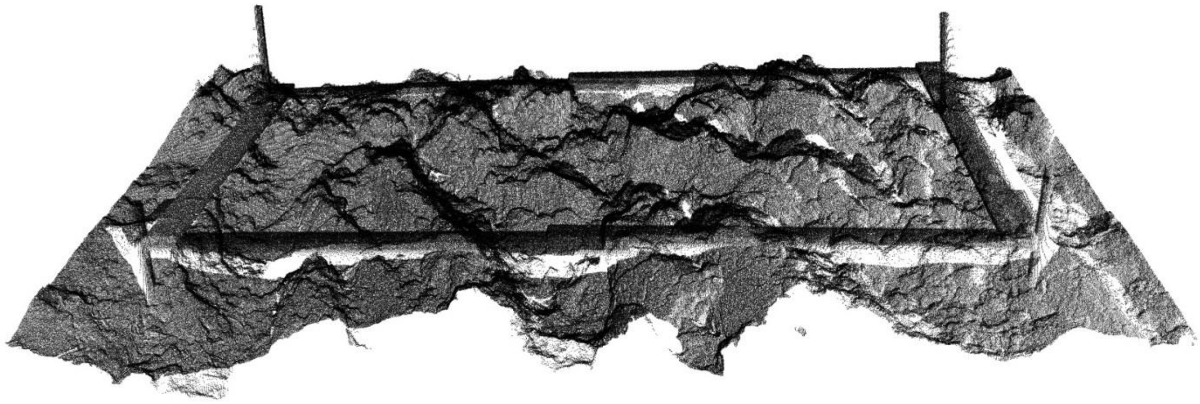

Figure 3 Point clouds of ploughed surface (analyzed only the inner area)

From mathematical point of view a point cloud is a single data structure. In order to analyze the character and shape of the scanned surfaces it is necessary to convert the irregularly distributed point data into 3D digital micro – relief model using surface reconstruction. This reconstruction should be ensured by suitable interpolation method in GIS environment, in our case Topo to Raster. This method uses an iterative finite difference interpolation technique. It is optimized to have the computational efficiency of local interpolation methods, such as inverse distance weighted (IDW) interpolation, without losing the surface continuity of global interpolation methods, such as Kriging and Spline. It is essentially a discretized thin plate spline technique (Wahba, 1990), for which the roughness penalty has been modified to allow the fitted DEM to follow abrupt changes in terrain, such as streams and ridges. Using statistical tools for areas of interest the standard deviation ± 90.6 mm was calculated, which also expresses the value of the random roughness. The reconstructed surface with calculated statistical values was subsequently visualized by the means of 3D visualization techniques of ArcScene (figure 4).

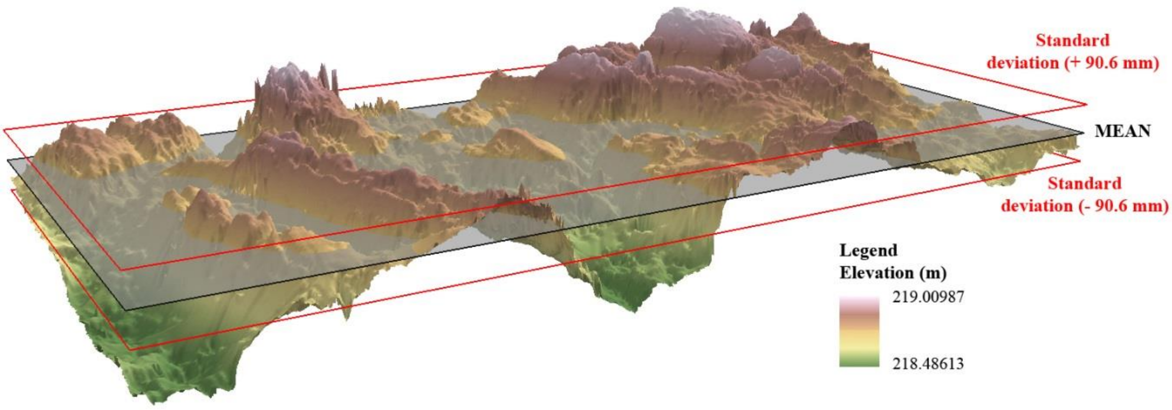

Figure 4 Digital micro-relief model and random roughness of ploughed surface

In the next step, under the research area of 140 x 300 cm have been defined 30 cross-section profiles ("rows" of pin meter) with constant spacing of 10 cm. Each profile consisted of the 140 points ("pins" of pin meter) spaced at 1-cm intervals. Height of each point was derived from digital micro–relief model. In this way we have obtained data from idealized pin meter with parameters: 140 pins and 4200 (= 140 x 30) readings of height. The resulting standard deviation, and thus the random roughness with a value of ± 91.7 mm (figure 5; for reasons of clarity we visualized only 4 profiles from 30) was very similar to the results obtained by the processing of nearly 400 000 point clouds. Whether the similarity of our results is a coincidence or rule, can be confirmed by further research. Results from the processing of 4200 points are idealized, since the pins of real pin meter in a certain measure will be counterbored below the soil surface, and this countersinking we can hardly assumed a uniform, particularly in the case of ploughed surface. Another disadvantage of pin meter is time-consuming data acquisition, but their processing may be more effective using photogrammetry.

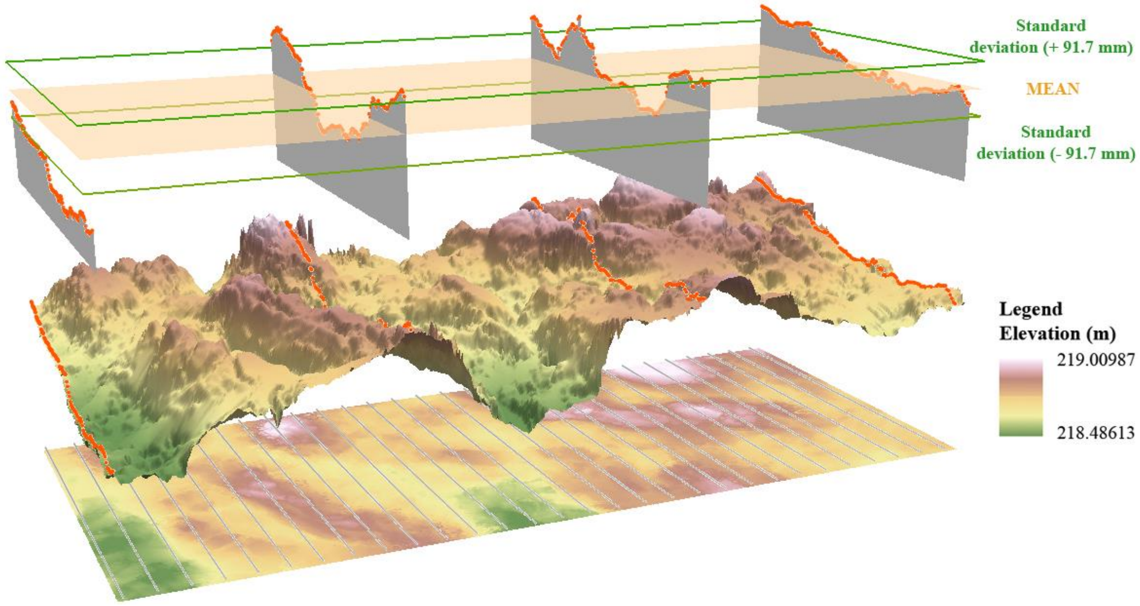

Figure 5 Random roughness of ploughed surface with application of idealized pin meter

CONCLUSIONS

The contribution deals with the application of the terrestrial laser scanning to produce a digital micro-relief model of the small ploughed surface. Standard deviation, calculated from 3D surface defines a very significant characteristic of relief, which is random roughness. Recalculating this random roughness values to Manning (or Basin) roughness coefficient, it is possible to include them into formulas of surface runoff characteristics determination (volume, discharge). Estimation of roughness has its justification also in erosion protection, because it enters into revised USLE within a C-factor. This is conditioned by reduction in erosion due to surface cover and surface roughness. Value of soil roughness is very variable during the year, it varies depending on cultivation methods as well as rainfall totals and intensity. Therefore, further measurements were realized in the 2015 year. Due to the limited scope of this paper, these could not be included.

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RESTORATIVE MEASURES OF THE POREC BROOK IN THE ABROD RESERVE

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ABSTRACT

Engineering measures for restoration of the Porec Brook are presented in this paper. In Slovakia, implementation of the river restoration projects falls behind the European standard. Restorative works in the channel of the Porec Brook are beneficial especially in the field of education, acquiring practical experiences with implementation of theoretical knowledge but also in increase of public interest in improving the landscape and nature conservation. Porec represents a hydrological axis of the Abrod National Nature Reserve, situated in the lower area of the stream. Abrod is one of the most important reservations of the Borská lowland and it is protected by the Ramsar Convention.

KEYWORDS

river restoration, wetland, river regulation, water regime

INTRODUCTION

Implementation of engineering restorative measures started intensively since the 1970s. Efforts were directed to mitigating the negative impact of the degradation of the country, especially of river regulation unilaterally oriented towards flood protection. These activities were characterized by intense involvement of civil society organizations. Even in the former Czechoslovakia there was a trend of stream restoration, but mainly in the territory of the Czech Republic. In the first phase these works were named “river regulation close to the natural conditions”. In technical terms, their implementation was in line with today's requirements of river restoration. The main difference lied in the lack of knowledgeable civic interest in the conservation and improvement of the environment, which created the driving force of similar efforts in Europe and U. S. A. In Slovakia, implementation of the river restoration falls behind the European standard. In theoretical field there are more favourable conditions, because a number of tasks based on a systematic approach to river restoration were developed. The results highlight the need to break away from the ordinary techniques and begin to validate and apply methods of restoration, which are based on the specifics of the water stream and its response to technological interventions.

Measures for restoration of the Porec Brook presented in this paper are beneficial especially in the field of education, acquiring practical experiences with implementation of theoretical knowledge but also in increase of public interest in improving the landscape and nature conservation.

The basic objective of river and floodplain restoration is improvement of its original state. Before carrying out any restoration action it is necessary to assume that the intervention in the river ecosystem, though insignificant at a first sight, may have a major impact on the populations of many protected and endangered species. It is important to assign well-elaborated project documentation from both abiotic and biotic viewpoints.

Restoration proposals of two reaches in the Porec Brook are described in following section. Porec represents a hydrological axis of the Abrod National Nature Reserve (NNR), which is situated in the lower area of the stream. The first reach is located close to the top spring area and a second reach at the bottom of the Porec Brook above the Abrod wetland system.

MATERIALS AND METHODS

The Abrod National Nature Reserve was launched in 1964 and it is one of the most important reservations of the Borská lowland. The fen meadows are preserved in this area, which are important for Slovakia in terms of biodiversity. The incidence of rare communities of *Caricion davallianae* and *Molinion* and rare fen and wetland species of flora and fauna was the reason to protect the area. These types of wetlands are threatened worldwide and are subject to protection by the Ramsar Convention (Stanová, Viceníková, 2003).

A strong decline in groundwater levels occurred as a result of regulation of the Porec Stream and drainage of wetlands, especially wet meadows throughout the river basin in the years 1962 – 1966. The restoration was implemented in two phases in which the conditions were created that are suitable for the formation of habitat of Community importance "3270 Rivers with muddy banks with *Chenopodion rubri p.p.* and *Bidention p.p.* vegetation", which corresponds to Br5 habitat according to the National Habitat Classification (Stanová, Valachovič, 2002).

Restorative measures in the upper reach of Porec

The aim of the restoration was to propose measures to increase the variability of the channel and to increase the accumulation capacity of surrounding area. These measures created favourable microhabitats in the aquatic zone of the stream and shortened the period of non-outflow (channel with no flow). A modest contribution to the improvement of minimum flows is also expected.

The area of interest is located in the upper basin, above the village of Závod and under the spring of the Porec Brook. Route of the regulated stream was located on the right bank of the former riverbed. The entire route is located outside the original channel except the area between cross section 8 and 9 (Fig. 3). The upper part of Porec was regulated by technocratic manner aimed at flood protection of agricultural land use. The flow route is straightened; bed is stabilized by concrete revetment units (Figs. 1 and 2).

Figure 1 Clogged regulated riverbed of Porec overgrown with vegetation

From the point of view of the accumulation ability of the area, as well as creation of favourable aquatic habitat such solution is inappropriate. Concrete revetment insulates the water from the surrounding area; therefore there is no accumulation of water in the basin. Straightened channel with a low degree of roughness drained the water from the basin fast, which negatively affected the accumulation process. Recessed bottom line of the regulated channel acts as a drain, which dries the surrounding area. Prismatic channel provides no cover spaces for aquatic biota, what has particularly negative effect in the period of minimum flows and the channel is even completely without the water through a certain part of the year. Regulated riverbed is currently overgrown with soft wood, which negatively affects the capacity of the channel, but on the other hand, it mitigates the negative impact of the stream regulation implemented by the "channel" type (Figs. 1 and 2).

Figure 2 Bank vegetation growing up in the concrete revetment of the riverbed

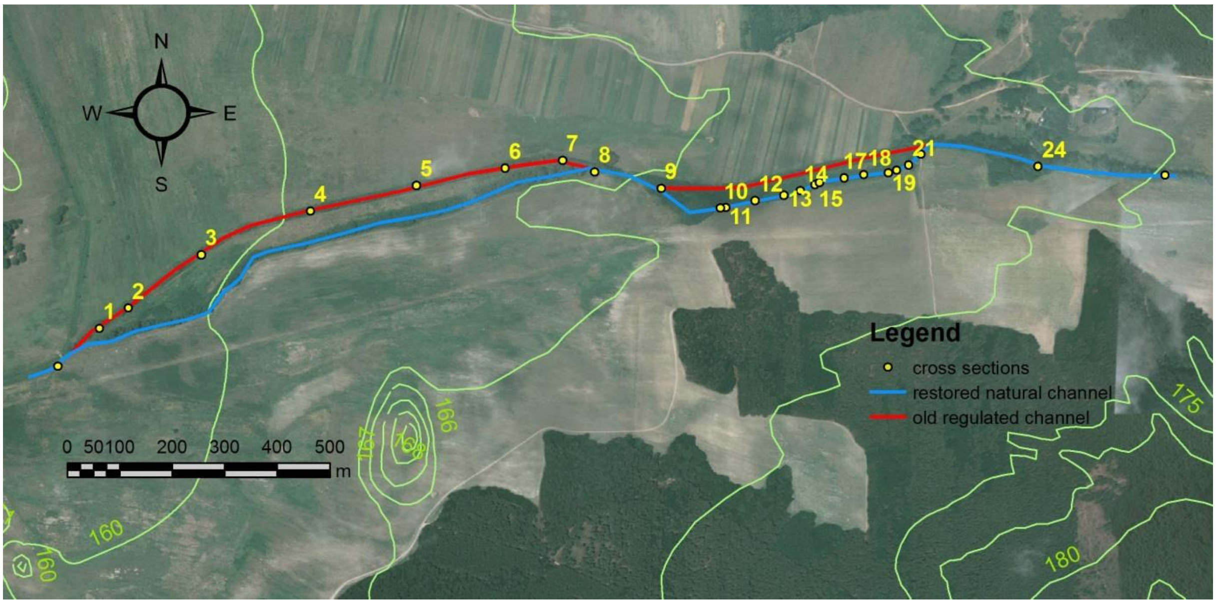

Figure 3 Situation of the upper reach with both channels of the Porec Brook. The cross sections are numbered against the flow direction.

The restoration of this reach had two contradictory requirements: 1. to maintain flood protection. 2. to increase the retention capacity of the river bed and to support channel segmentation for creation of aquatic habitats. Flood protection is provided by the original river regulation, which has been preserved and increased retention capacity and creation of favourable habitats is ensured by restoring the natural river bed.

Principle of the proposed restoration is rerouting of small discharges into restored original channel. Flow distribution between both channels provides the sill (Fig. 4) in the bed of the old regulation in cross section no. 1 (Fig. 3). The sill directs all discharges up to the water level of 30 cm into the restored original channel. After crossing this height the water spills through the sill and it is flowing in the old regulated riverbed. The philosophy of such a proposal is based on the assumption that the saturation of the area is not critically affected by the discharge, but rather saturation time and position of water level. Therefore, the bottom line in the restored original riverbed is higher than in the old regulated channel, what contributes to higher saturation of the area by water and reduces the effect of drainage by river regulation.

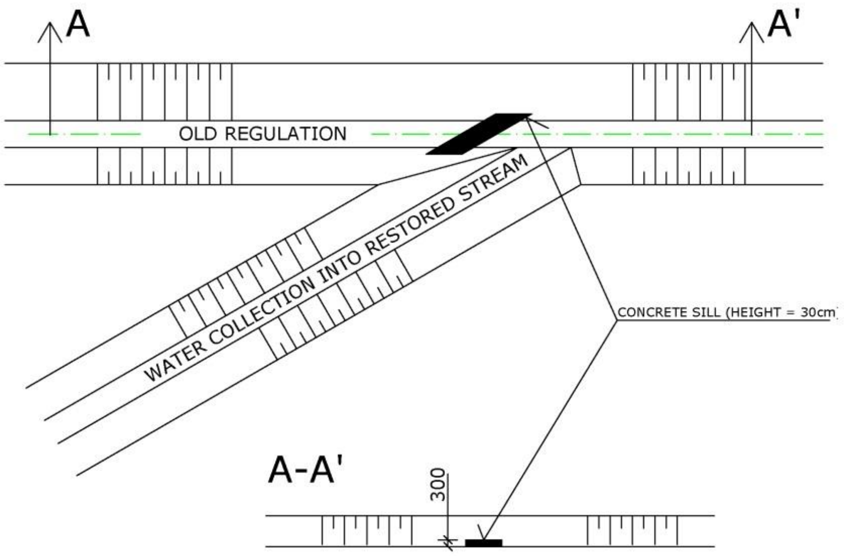

Figure 4 Design of the control structure (sill) intended for flow distribution between the old regulation and restored original river bed

Restored original riverbed slightly increased the capacity of whole channel, which implies that the restoration as a complex does not have a negative impact on flood protection of the area. Therefore, in the context of the restoration the purging of the old regulation and removing vegetation from the riverbed was not designed. Clogged regulated riverbed overgrown with vegetation has even positive impact on biota and water regime of the channel. The main positives of this solution are as follows:

1. Concrete surface of revetment units inappropriate for biota is clogged by sediment material and leaves of vegetation which grows in areas between the panels (Fig. 2)
2. Sediment material and vegetation increases the roughness of the river bed, what has a positive effect on slowing down the flow process in the channel.

Solutions in the lower reach of Porec

This reach is located between the railroad and highway D2 and it was characterized by seven cross sections. The Abrod NNR lies below the railway (Fig. 5) and the village of Závod lies above the highway. There is a small weir built by beavers in cross section 1 above the railroad culvert (Fig. 6).

Analysis of the water level regime in the channel focused on the possibility of mitigating the humidity deficit in the Abrod NNR. It has been considered that the increase in water levels in the channel will increase the groundwater supplies, which would increase the supply of water into the protected area.

Hydraulic analysis of the level regime was verified based on two measurements at different water levels during the discharges of 0.1 $m^3.s^{-1}$ and 0.3 $m^3.s^{-1}$. Discharges of 0.5 $m^3.s^{-1}$ and 1.0 $m^3.s^{-1}$ were simulated using a hydraulic model. Hydrometric measurements suggest that the discharge was reduced from 0.3 $m^3.s^{-1}$ (in cross section 7) to 0.12 $m^3.s^{-1}$ (in cross section 2) and at a discharge of 0.1 $m^3.s^{-1}$ (in cross section 7) there was even no flow in cross section 2. It was no water flow below the weir, not even due to possible leakage. It is important to recall that according to local citizens the beaver weir was built at least 30 years ago.

The design of restorative measures recently being implemented in this reach is oriented towards creation of the wide cross sections with gentle slope of the banks, which supports the spillage of the flow into the floodplain at low water levels and increased retention time of water in inundation. This solution will provide the Br5 habitat described above. Transfer of the flow route was impossible with respect to the private ownership of the surrounding lands and inability to obtain them for the design plan.

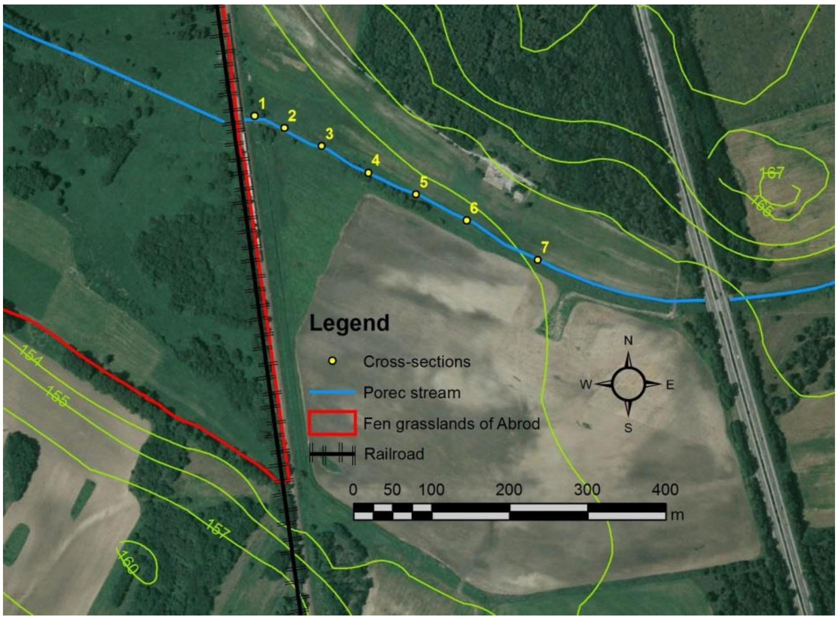

Figure 5 Situation of the lower reach of Porec Brook with the localization of Abrod NNR. The cross sections are numbered against the flow direction.

Figure 6 The small weir built by beavers above the railway culvert (in cross section 1).

DISCUSSION AND CONCLUSIONS

Implemented restoration of the Porec Brook in the upper reach above the village of Závod improved the habitat in the area of interest, as well as the water regime in the terrestrial area of the stream, which has a positive impact on the balance of flow regime of Porec.

Figure 7 Cascade of beaver weirs in the spring area of Porec

From the hydraulic analysis of a lower reach of Porec it follows that the current status affected by beaver weir ensures maximum saturation of the adjacent area. It can be stated that the beavers set the optimal moisture regime in this reach of Porec. This statement holds true also for the whole spring area of the stream located above the upper reach described in the first part of previous chapter. It is influenced by beaver constructions - a cascade of weirs to take utmost advantage of the flow potential to increase the accumulation capacity of this area. Example of beaver dams in this reach is shown in Fig. 7.

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SULFORAPHANE CONTENT AND ANTIOXIDANT CAPACITY IN BROCCOLI

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ABSTRACT

The zinc and selenium are important micronutrient in plant nutrition. In experiment, effect of following treatments were tested: C-control; Zn; Se and Zn+Se. The foliar application by both micronutrients resulted in significant changes of broccoli quality. The zinc fertilization resulted in statistically significant increase of sulforaphane content in broccoli florets. On the contrary, selenium application was expressed by statistically significant decrease of sulforaphane content. The zinc and selenium fertilization resulted in higher total antioxidant capacity (TAC) of broccoli at all fertilized treatments. The most expressive increase of TAC compared to the control treatment was shown at the combined Zn+Se treatment.

KEYWORDS

broccoli, zinc, selenium, sulforaphane, antioxidant

INTRODUCTION

The broccoli is marked as an important vegetable product because of high content of bioactive phytochemicals such as glucosinolates, phenolic compounds, vitamin C or mineral nutrients. Thus, broccoli consumption can help to prevent a human organism against serious health problems, such as various types of cancer or cardiovascular diseases (Moreno *et al*., 2006).

The anticarcinogenic activity of *Brassica* vegetable species is primarily connected with activity of isothiocyanates – iberine and glucoraphanine (precursor of sulforaphane) which are accumulated in edible parts of cole crops (Higdon *et al.*, 2007). The broccoli is one of the most important source of sulforaphane which chemoprotective function consists in ability to act as single-function stimulator of detoxification enzymes in human body (Yeh and Yen, 2009). Sulforaphane retards and kills bacteria *Helicobacter pylori* which are responsible for ulcerous disease of stomach (Fahey *et al*., 2013). Infections by *Helicobacter pylori* are very common, causing gastroduodenal inflammation including peptic ulcers, and increasing the risk of gastric neoplasia. The sulforaphane derived from edible Brassica vegetables such as broccoli is potential bactericidal agent against *Helicobacter*, including antibiotic-resistant strains (Fahey *et al*., 2013). The *Helicobacter pylori* is marked as the one of most probable reasons for gastric cancer (Øverby *et al*., 2014).

Broccoli is known as vegetable species with higher antioxidant activity. Antioxidants can scavenge free radicals and protect the human body from oxidative stress which is the main cause of many serious health problems, such as some cancer types and heart diseases (Soengas *et al*., 2011). The antioxidant activity of broccoli was ranked as the second among 10 common vegetables (Chu *et al*., 2002) or sixth from 22 vegetable species (Cao *et al*., 1996). The total antioxidant potential of broccoli may be influenced by different parameters, such as genotype (Kaur *et al.*, 2007), plant parts (Guo *et al.*, 2001), postharvest treatment (Serrano *et al.*, 2006) or cooking method (Pellegrini *et al.*, 2010).

MATERIAL AND METHODS

The small-plot field experiment with broccoli was established in the area of The Botanical garden at Slovak University of Agriculture in Nitra in 2013. In this trial, we used a middle-late broccoli variety COVINA F1.

Broccoli seedlings were planted out at the experimental area on 2nd July 2013. All variants had four repeatings. In each repeating, nine seedlings were planted into the plating space 0,5 x 0,5 m. The basic fertilization was realized on the basis of agrochemical soil analysis to the supply level N : P : K : S = 200 : 40 : 160 : 80 kg.ha^{-1} (tab. 1). Phosphorus and potassium were not applied because its content in soil exceeded the necessary level for broccoli cultivation. The calculated dose of nitrogen and sulphur were applied in the form of fertilizer LAD27 (27 % of N, 4,1% of MgO) and DASA 26/13 (26 % of N, 13% of S). The DASA 26/13 fertilizer was applied three weeks before planting. The LAD 27 fertilizer was applied in two terms - three (50 % of calculated dose) and six weeks (50%) after planting.

Table 1 Agrochemical analyses of soil before the experiment establishment in 2013

pH/KCl	Content of nutrients in mg.kg^{-1}						Humus (%)
	N_{min}*	P	K	S	Ca	Mg	
6,36	13,3	232,5	285	45	5630	364	4,01
slightly acid	medium	very high	good	good	high	very high	high

N_{min} – N-mineral (N-inorganic)

In this experiment, we tested different treatments of foliar application of zinc and selenium to the sulforaphane content and total antioxidant activity of broccoli (tab. 2). The zinc and selenium were applied by foliar spraying four weeks after planting. The zinc was applied in the form of ZINKURAN SC fertilizer (Zn = 36 %). The selenium was applied in the form of sodium selenate solution.

Table 2 Treatments tested in the field experiment with broccoli

Treatment No.	Description	Treatment code
1	control = basic fertilisation (BF)	C
2	BF + Zn (0,75 l of Zinkuran SC.ha^{-1}	Zn
3	BF + Se = 300 g.ha^{-1}	Se
4	BF + Zn + Se	Zn+Se

The harvest of broccoli florets, including stump with length of 10 cm), was realized from 16th September to 26th September 2013. Broccoli florets were harvested including stumps long 10 cm. The content of monitored qualitative compounds was evaluated from broccoli harvested on 20th September 2013. The average sample for determination was prepared from 4-5 broccoli florets. The sample was taken from different points of all broccoli florets, including stump. The sulforaphane content was determined chromatographically (HPLC) according to

Sivakumar *et al*. (2007). Total antioxidant capacity was measured by the Brand-Williams *et al*. (1995) method-using a compound DPPH (2.2-diphenyl-1-pikrylhydrazyl)).
The analysis of variance (ANOVA), the multifactor analysis of variance (MANOVA) and the multiple Range test were done using the Statgraphic Centurion XV (StatPoint Inc. USA).

RESULTS AND DISCUSSION

The zinc and selenium application had different impact from aspect of sulforaphane (SF) content in broccoli florets. The SF content varied in the range from 58.56 $mg.kg^{-1}$ (Se) to 80.95 $mg.kg^{-1}$ (Zn) of fresh weight (tab. 3).
The analysis of variance for experimental results showed statistically significant increase of SF content at Zn and Zn+Se treatments compared to the control treatment. The more expressive increase of SF content compared to the control was determined at the Zn treatment. Difference between mentioned treatments presented value of 13.80 $mg.kg^{-1}$ (20.6%). On the contrary, the selenium application had negative effect on the SF content in broccoli florets. The statistically significant decrease of SF content was detected at the Se treatment compared to the control treatment. Difference between mentioned treatments presented value of 8.59 $mg.kg^{-1}$ (12.8%).
Zinc and selenium are notable micronutrients which plays an important role in plants metabolism. The zinc appears as an important micronutrient in the term of SF content in *Brassica* species. Liang *et al*. (2006) examined the effect of six micronutrients on the broccoli quality from which Zn application was only expressed in the form of higher SF content. Coolong and Randle (2004) found the direct correlation Zn application to the content of glucoraphanin, SF precursor, in the hydroponic culture of *Brassica rapa*. Its value was gradually increased in dependency on the increasing Zn dose in the nutrient solution.
Adhikari (2012) indicates that broccoli is vegetable species with high ability to accumulate selenium in edible parts of florets. However, the effect of higher selenium intake to the SF content is not clear and well-proved. Ramos *et al*. (2011) showed that selenium application had minimal impact to the content of total glucosinolate content in broccoli. Robbins *et al*. (2004) stated significant increase of SF content in edible parts of broccoli in dependency on the selenium dose. On the contrary, it is inconsistent with results which was found at our experiment.

Table 3 Sulforaphane content and total antioxidant capacity (TAC) of broccoli in dependency of foliar zinc and selenium application

Variant	Sulforaphane ($mg.kg^{-1}$)*	Relatively (%)	TAC (%)*	Relatively (%)
C	67.15^{b}	100	34.17^{a}	100
Zn	80.95^{d}	120.6	40.94^{c}	119.8
Se	58.56^{a}	87.2	38.80^{b}	113.6
Zn+Se	76.26^{c}	113.6	42.79^{d}	125.2

* **Sulforaphane** content ($mg.kg^{-1}$ of fresh weight) **TAC** - total antioxidant capacity (%)
Different letters in the same column (a, b) show statistically significant differences at $p<0.05$.

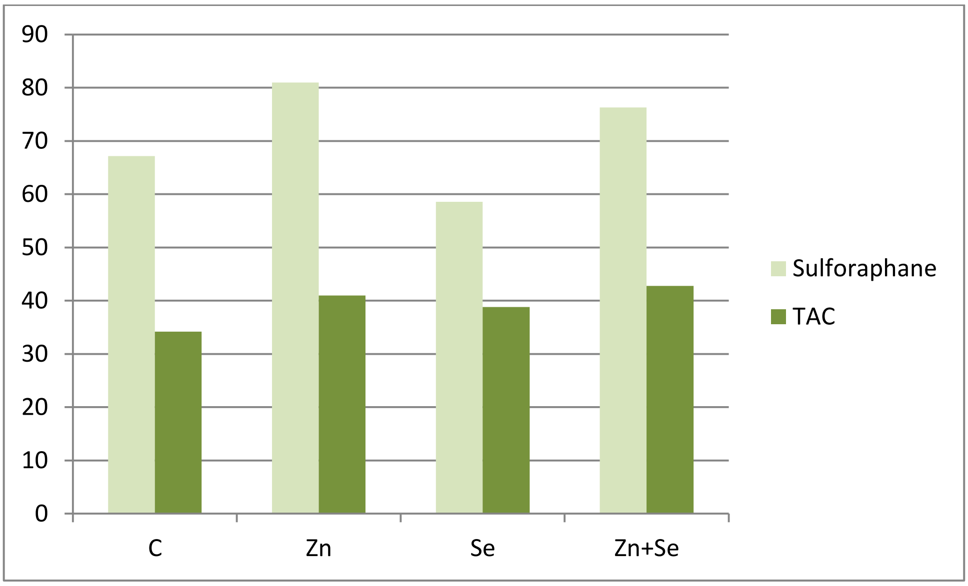

Figure 1 The effect of zinc and selenium fertilization to the sulforaphane content (mg.kg^{-1} fresh weight) and TAC - total antioxidant capacity (%) of broccoli

The foliar application of Zn and Se had also marked influence on the total antioxidant capacity (TAC) of broccoli. The TAC of broccoli was ranged from 34.17% (control) to 42.79% (Zn+Se). At all fertilized treatments, the statistically significant increase of TAC value was shown compared to the control treatment. The zinc application resulted in more expressive increase of TAC compared to the Se treatment. The most expressive increase of TAC in comparison with control was detected at the combined Zn+Se treatment. The increase of TAC between mentioned treatments presented value of 25.2%.

At our experiment, selenium application tended to the significant increase of broccoli TAC. Similar results were also presented by Zielinska *et al*. (2011) found that cultivation of broccoli under higher doses of selenate provided broccoli heads of higher antioxidant capacity. On the contrary, Adhikari (2012) stated minimal, statistically non-significant, impact of selenium application on the TAC of broccoli and onion. The positive effect of zinc fertilization to the antioxidant activity, as it was presented in our experiment with broccoli, was shown in experiment with canola (Bybordi, Mamedov, 2010).

CONCLUSION

The zinc and selenium appears as important micronutrients significantly influencing on the important qualitative parameters of broccoli, such as sulforaphane content and total antioxidant activity. The application of both mentioned micronutrients resulted in higher total antioxidant capacity of broccoli. The zinc fertilization had expressive positive effect on the sulforaphane content in broccoli florets. On the contrary, selenium application tended to the lower content of sulforaphane in broccoli.

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HODNOTENIE EKOLOGICKÝCH FUNKCIÍ POĽNOHOSPODÁRSKEJ PÔDY V SLOVENSKEJ REPUBLIKE

THE ECOLOGICAL FUNCTIONS OF AGRICULTURAL LAND ASSESSMENT IN SLOVAK REPUBLIC

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ABSTRACT

Recently a growing interest of the scientific community and professional public in new research on meeting the ecological and socio-economic functions of soil has emerged. Those functions are commonly named environmental functions. While the soil importance is reflected in its various functions, its conversion into money evaluation is still the subject of research. It follows an innovative aspect of the problem how to fairly evaluate all the features in (production and non-production) including assessment, mapping and categorization (ecosystem services). This paper focuses on methods of scoring and economic valuation of ecological functions of soil in Slovakia. The aim of this paper is specifying and spatial expression of score and financial value of selected ecological functions of agricultural land in the cadastral territory Žirany.

Key words

ecological soil functions, assessment, ecosystem services

ÚVOD

V súvislosti s uznaním multifunkčného pôsobenia pôdy v prírodnom prostredí (geoekosystéme) a konceptu celospoločenských ekosystémových služieb odvíjajúcich sa od pôdnych funkcií, akcelerujú v posledných desaťročiach názorové zmeny na problém, ako merať a hodnotiť kvalitu pôdy. Historicky si ľudstvo cení predovšetkým úžitkovú funkciu pôdy, t.j. schopnosť poskytovať produkciu biomasy a socio-ekonomickú funkciu pôdy, teda poskytovať priestor na ktorom žijeme a niektoré suroviny (Novák a kol., 2008; Streďanský, 2010). Pôda má však výraznú skupinu ďalších ekologických (mimoprodukčných) funkcií, ktoré formujú stabilitu zemských ekosystémov a následne kvalitu ľudského života. Preto je potrebné kvalitu pôdy hodnotiť v širších ekologických, resp. environmentálnych súvislostiach (Bujnovský, Juráni, 1999; Bujnovský a kol., 2009).

Funkcia pôdy je jej schopnosť zabezpečovať, alebo sa podieľať na niektorých ekologických, environmentálnych a socio-ekonomických javoch a činnostiach v prírode (Bedrna, 2002). Pôdne funkcie podľa Bluma (1990) predstavujú celkový potenciál pôdy, ktorý je dôležitý pre poľnohospodárstvo, životné prostredie, ochranu prírody, krajinnú architektúru a urbanizmus. Pôdne funkcie sú z rôznych hľadísk definované mnohými autormi. Rámcová smernica EÚ pre ochranu pôdy (European Commision, 2006) uvažuje s ekologickými, socio-ekonomickými a kultúrnymi funkciami pôdy, medzi ktoré zaraďuje produkciu biomasy, akumuláciu, filtráciu a transformáciu živín, látok a vody, rezervoár uhlíka, rezervoár biodiverzity, fyzické a kultúrne prostredie pre ľudí a ľudské aktivity, zdroj surovín, uchovávanie geologického a archeologického dedičstva. Sobocká a Saksa (2011) zjednodušene rozdeľujú funkcie pôdy na: ekologické a environmentálne funkcie spojené s ľudskými aktivitami.

a) Ekologické funkcie:

- Produkcia biomasy, ako základná podmienka života človeka a iných organizmov;
- Filtrácia, neutralizácia (pufrovanie), premena a akumulácia látok v prírode ako súčasť funkčných a regulačných mechanizmov v prírode;
- Udržiavanie ekologického a genetického potenciálu živých organizmov v prírode (biodiverzita druhov a ekosystémov) a asanácia odumretých organizmov.

b) Environmentálne funkcie spojené s ľudskými aktivitami:

- Súčasť priestorovej základne pre socio-ekonomické aktivity (poľnohospodárstvo, lesníctvo, priemysel, doprava, stavebníctvo, turistika a i.) a sociálne istoty obyvateľstva (zamestnanosť, výživa, príjmy);
- Zdroj surovinových materiálov (ako íl, hlina, štrk, piesok, minerály, voda a pod.);
- Kultúrne a prírodne dedičstvo krajiny vrátane paleontologických a archeologických artefaktov.

Ekosystémy v poľnohospodárskej krajine (vrátane pôdy) plnia mnohé funkcie, čo prináša úžitky pre celú spoločnosť. Ak tieto funkcie priamo ovplyvňujú ľudské zdravie alebo ekonomický blahobyt sú považované za služby (Makovníková a kol., 2013). Ekosystémové služby (ES) sú definované ako kapacita ekosystémov (vrátane pôdy) poskytovať tovary a služby uspokojujúce potreby človeka (Sobocká, 2015). Otázka mapovania, posúdenia stavu a finančného oceňovania hodnôt ekosystémov a ich služieb je jedným z cieľov stratégie EÚ v oblasti biodiverzity do roku 2020 (KOM 2011/244). Preto výskum ES je veľmi aktuálnou témou, čo potvrdzuje narastajúci počet vedeckých prác a projektov riešených na medzinárodnej ale aj národnej úrovni.

Hodnota potenciálu environmentálnych funkcií pôdy sa môže prejaviť vtedy, keď sa ich využívanie vyjadrí v ekonomických kategóriách a ocení ako nemateriálne i materiálne statky (Vološčuk, 2013). Ide o novú úroveň hodnotenia pôd, ktorá umožní vypočítať a poznať skutočnú hodnotu pôd. Treba však zdôrazniť, že hodnota nie je ekvivalentná peniazom, no finančné ocenenie môže indikovať význam hodnoty (Dawes, 1988). Podľa Bujnovského a Vilčeka (2008) väčšinu služieb ekosystému, a platí to aj pre ekologické funkcie pôdy, nie je jednoduché priamo premietnuť do trhovej ekonomiky, pretože metódy ekonomického hodnotenia nemôžu zachytiť normatívne a etické aspekty hodnotenia ekologických funkcií pôdy. Základom pre ekonomické hodnotenie funkcií resp. vlastností pôdy je oceňovanie prínosov priamo vyplývajúcich zo zabezpečovania konkrétnych funkcií pôdy alebo kompenzačných nákladov súvisiacich s nápravou následkov vyplývajúcich zo zníženia kvality pôdy a zabezpečovania danej funkcie pôdy (metóda nákladov a výnosov).

Ako uvádza celý rad našich autorov (Bujnovský, Juráni, 1999; Bujnovský, Vilček, 2008; Bujnovský a kol., 2009; Vilček a kol., 2010; Torma a kol., 2015; a iní), jednotlivé ekologické funkcie pôdy je možné hodnotiť osobitne, ale keďže v ekosystéme pôsobia vo vzájomnej súčinnosti, je potrebné ich posudzovať ako celkovú schopnosť pôdy plniť ekologické funkcie, čo platí aj pri snahe o jej finančné vyjadrenie.

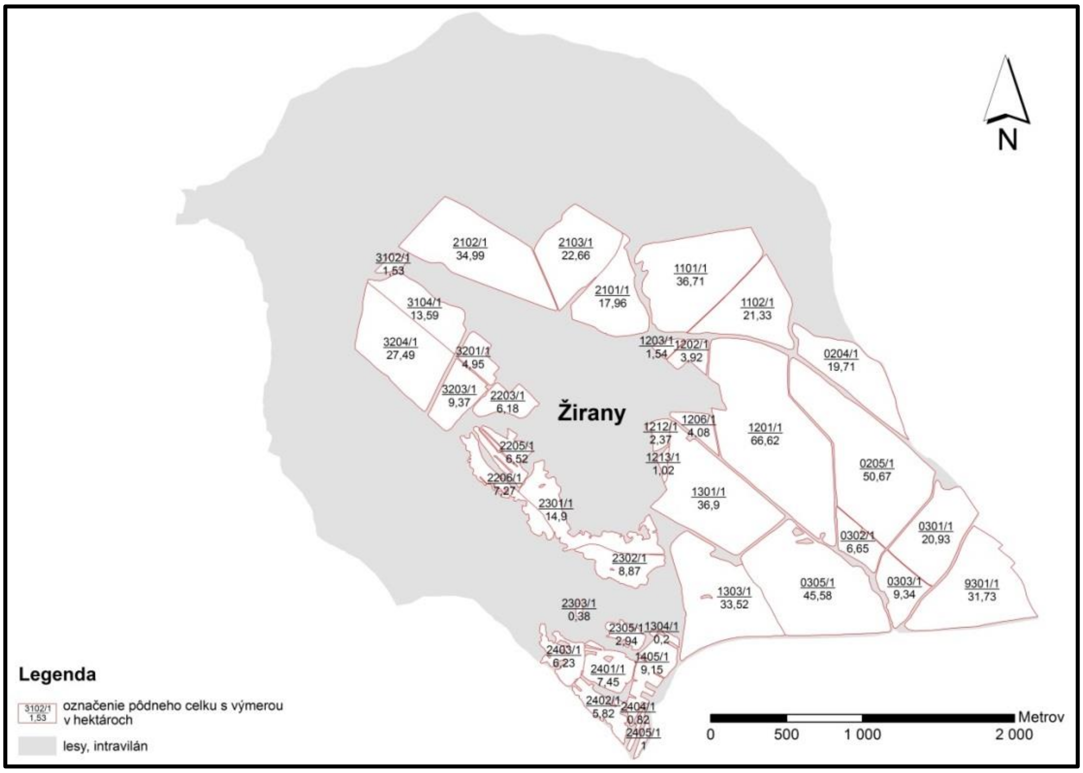
Hodnotenie funkcií pôdy vychádza z výberu indikátorov kvality pôdy – parciálne vlastnosti pôdy, ktoré sú analyticky stanoviteľné a podľa ktorých je možné stanoviť mieru ich vplyvu na funkcie pôdy (Barančíková a kol., 2010). Môžu byť vyjadrené rôznymi spôsobmi, najčastejšie sa však využíva ratingový prístup (indikátor hodnotený bodovým rozsahom), alebo tzv. indexový prístup (hodnotenie celého súboru indikátorov vypočítaním jediného indexu).

Pracovníci Výskumného ústavu pôdoznalectva a ochrany pôdy na základe systému tzv. indexov environmentálneho potenciálu pôd (IEPP) vypracovali bodové i finančné ohodnotenie poľnohospodárskych pôd Slovenska zabezpečovať vybrané environmentálne funkcie (ekosystémové služby). Indexy pozostávajú z číselného vyjadrenia miery schopnosti pôdy zabezpečovať akumuláciu vody, imobilizáciu rizikových prvkov, imobilizáciu organických polutantov a transformáciu organických polutantov. Tieto funkcie pôdy boli vyhodnotené stupnicou ballovej škály 1 – 5 s príslušným rozsahom bodov pre každý stupeň škály. Kombináciou vyjadrenia hodnotených funkcií vznikol 4-miestny kód – index, ktorý vyjadruje potenciál konkrétnej pôdnej jednotky plniť uvedené ekologické funkcie. Pre územie Slovenska bolo zaevidovaných 493 kombinácií relevantných IEPP (Vilček a kol., 2010).

Bodová hodnota IEPP sa pre územie Slovenska pohybuje v škále rozsahu bodov od 20 bodov po 100 bodov. Priemerná bodová hodnota vyjadrujúca schopnosť poľnohospodárskych pôd Slovenska zabezpečovať environmentálne funkcie je 55,3 bodov. Hodnota schopnosti poľnohospodárskych pôd Slovenska plniť ekologické funkcie má vo finančnom vyjadrení hodnotu 35,946 miliárd €. Znamená to teda, že priemerná hodnota 1 m^2 je asi 1,42 € (Vilček a kol., 2010; Vilček, 2011;Vilček, 2014).

MATERIÁL A METÓDY

Príspevok je zameraný na stanovenie a priestorové vyjadrenie bodovej a finančnej hodnoty vybraných ekologických funkcií poľnohospodárskej pôdy v časti katastrálneho územia obce Žirany. Obec leží 10 km severovýchodne od krajského mesta Nitra, na rozhraní úpätia pohoria Tríbeč a Žitavskej pahorkatiny. Minimálna nadmorská výška v obci je 210 m n.m, maximálna nadmorská výška je 470 m n.m. Územie Žirian spadá do povodia rieky Žitava, hlavným recipientom pre odvádzanie povrchových vôd z územia obce je tok Bocegaj. Z hľadiska klimatických pomerov je územie charakterizované priemernou ročnou teplotou 9,9^{o}C a ročným úhrnom zrážok 539 mm. Záujmové územie, ktoré má výmeru 602,86 ha poľnohospodárskej pôdy, obhospodaruje Vysokoškolský poľnohospodársky podnik Slovenskej poľnohospodárskej univerzity s.r.o. Kolíňany. Z toho je výmera trvalých trávnych porastov 71,53 ha a 531,33 ha sú plochy ornej pôdy. Poľnohospodárska pôda je sústredená do 39 pôdnych celkov (obr.1).



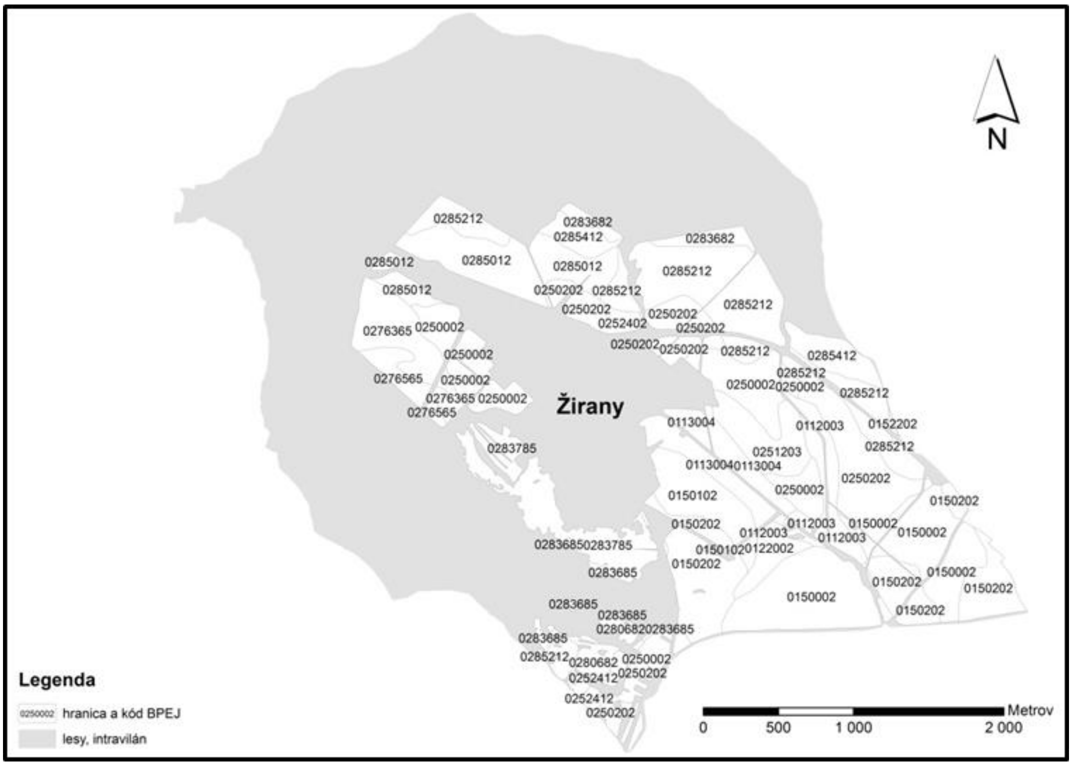
Obrázok 1 Usporiadanie pôdnych celkov poľnohospodárskej pôdy v riešenom území

Základom riešení prezentovaných v príspevku je zastúpenie BPEJ na jednotlivých pozemkoch poľnohospodárskej pôdy riešeného územia. Pôdno-ekologické jednotky boli vyčlenené a mapované podľa hodnotenia základných vlastností pôdy: vlastnosti klímy (T), genetických vlastností pôd (P), pôdotvorných substrátov (G), zrnitosti pôdy (Z), obsahu skeletu (K), hĺbky pôdy (H), svahovitosti (S) a expozície územia (E) (Džatko a kol., 1976).

Podľa plošného zastúpenia BPEJ na pozemkoch poľnohospodárskej pôdy (obr.2) a dešifrovaním kódov ich jednotlivých vlastností môžeme stručne charakterizovať základné pôdne vlastnosti záujmového územia nasledovne: Najrozšírenejším pôdnym typom sú hnedozeme (50,5%) v subtypoch kultizemné pseudoglejové a kultizemné erodované. Luvizeme kultizemné pseudoglejové zaberajú výmeru 149,53 ha (24,8%). Kambizeme modálne, zo zvetranín kryštalických hornín sa na výmere poľnohospodárskej pôdy podieľajú výmerou 93,82 ha (15,56%). Fluvizeme kultizemné, glejové zaberajú plochu 45,9 ha (7,61%) a najkvalitnejšie - čiernice kultizemné iba plochu 9,15 ha (1,52%). Z hľadiska svahovitosti je najviac pôd – 45% lokalizovaných na svahu 3-7°, 39% sa nachádza na rovine resp. na svahu do 3^{o}, 10% poľnohospodárskej pôdy je na výraznom svahu 12-17°. Vyše 84% pôd je hlbokých, plytké sú len kambizeme, so zvýšeným podielom skeletu. Podľa zrnitostného zloženia v území prevládajú pôdy stredne ťažké (piesočnatohlinité a hlinité) – 537,34 ha (89,13 %). Zrnitostne ťažké, ílovitohlinité pôdy sú na výmere 37,74 ha (6,26%) a veľmi ťažké (ílovité a íly) na výmere 27,78 ha (4,61%). Obsah humusu v ornici sa pohybuje od 1,65 po 2,25 % - nízky až stredný.

Výhodou sústavy BPEJ je, že bola vytvorená podrobná vektorová digitalizovaná databáza priestorovo orientovaných údajov o pôde a sprístupnená prostredníctvom webových GIS aplikácií na Pôdnom portáli VÚPOP. Aktuálny stav priebehu hraníc BPEJ a ich číselné

sedemmiestne kódy v jednotlivých katastroch je možné konkretizovať až na úroveň tzv. produkčných blokov, resp. parciel (LPIS) na ortofotomapách (www.pôdnemapy.sk).
Pre hodnotenie mimoprodukčných vlastností pôd je často možné z celej schémy BPEJ použiť len časť charakteristík ako parametre (indikátory) kvality pôdy a je potrebné ich doplniť aj inými detailnejšími údajmi, resp. databázami (Sobocká, Saksa, 2011).



Obrázok 2 Mapa bonitovaných pôdno-ekologických jednotiek v riešenom území

Pre hodnotenie ekologických funkcií (bodové a ekonomické) v príspevku sme vybrali:
1. vyjadrenie hodnoty produkčnej funkcie,
2. vyjadrenie hodnoty vybraných mimoprodukčných funkcií a to:
   - schopnosť pôdy akumulovať vodu (akumulačná funkcia),
   - schopnosť pôdy inaktivovať organické kontaminanty,
   - schopnosť pôdy transportovať organické polutanty.

Pre hodnotenie produkčného potenciálu pôd, ktorý v podstate vyjadruje úroveň produkcie biomasy pestovaných plodín, sme použili systém bonitovaných pôdno-ekologických jednotiek (BPEJ). Každá BPEJ má stanovenú bodovú hodnotu (BH) produkčnej schopnosti, pričom hodnotu 100 bodov má pôda (BPEJ) s najvyšším produkčným potenciálom (Džatko, 2002). Váženým aritmetický priemerom zastúpených BPEJ na pozemkoch riešeného územia sme vypočítali bodovú hodnotu jednotlivých pôdnych celkov a podľa rozsahu bodovej hodnoty zatriedili do tried (1 až 9) produkčnej schopnosti (Němeček a kol, 1985; Vilček a kol., 2000). Ekonomické hodnotenie produkčnej funkcie pôdy (bonita) vyjadruje legislatívne stanovená cena pôdy (Vyhláška MP SR č. 38/2005 Z.z.) ktorá vychádza z produkčného ocenenia BPEJ prostredníctvom parametrizovaných naturálnych výnosov 10 hlavných poľnohospodárskych plodín a normatívnych nákladov na ich dosiahnutie (výnosovosť pôdy) (Streďanská, Buday, 2006; Buday, Bradáčová, 2009; Buday, 2012; Buday, Vilček, 2013). Na základe znalostí o výmere, bodovej a finančnej hodnote každej BPEJ na jednotlivých pôdnych celkoch riešeného územia, sme vypočítali bodovú hodnotu produkčnej schopnosti ako aj celkovú cenu jednotlivých pôdnych celkov a následne, celej výmery hodnotenej poľnohospodárskej pôdy. Podľa výnosovosti pôdy - hrubého ročného rentového efektu (HRRE) a bodovej hodnoty produkčného potenciálu (BH PP) sú bonitované pôdno-ekologické jednotky zoradené do skupín kvality (1 až 9) pre účely stanovenia odvodov za záber pôdy podľa Nariadenia vlády SR č.58/2013 Z.z. (Streďanská a kol., 2013).

Aplikovaný metodický postup hodnotenia schopnosti pôdy akumulovať vodu (akumulačná funkcia) využíva databázu BPEJ a ich kategorizáciu do hydrologických skupín, ďalej údaje z dátovej banky o hĺbke pôdy, skeletovitosti a zrnitostnom zložení. Konečné vyhodnotenie retenčnej vodnej kapacity (RVK) sa vzťahuje na vyhodnotenie objemu vody, ktorý môže byť zadržaný pôdou s určitou textúrou a hĺbkou v rámci hlavnej pôdnej jednotky (HPJ – tretie a štvrté číslo v 7-miestnom kóde BPEJ), publikovanej Houškovou (2011). Na základe rozpätia dosiahnutých hodnôt RVK ($m^3.ha^{-1}$) bola poľnohospodárska pôda riešeného územia kategorizovaná do 5 skupín schopnosti akumulovať vodu (veľmi vysoká, vysoká, stredná, nižšia stredná, veľmi nízka). Finančné ohodnotenie vyplynulo z analýz nákladov na budovanie vodných diel na zadržanie 1 m^3 vody (2 €), premietnutého do jednotlivých kategórií schopnosti pôd akumulovať vodu (Bujnovský a kol., 2009; Vilček a kol., 2010).

Kvantitatívne vyjadrenie inaktivácie (zadržania, imobilizácie) organických polutantov sa považuje ten podiel polutantov, ktorý sa zachytí v pôdnom profile a neprenikne z pôdy do podložia alebo potravinového reťazca (filtračná funkcia). Pre hodnotenie schopnosti pôdy imobilizovať organické kontaminanty bol zvolený minimálny súbor indikátorov: množstvo a kvalita pôdnej organickej hmoty, hrúbka humusového horizontu, obsah ílu, hĺbka pôdy (indikátory pôdnej kvality) a množstvo zrážok (environmentálny faktor). Na základe vzájomných vzťahov medzi uvedenými indikátormi a ich vplyvu na hodnotenú funkciu (indexový prístup) bolo vytvorených 5 kategórií imobilizácie organických kontaminantov, od veľmi nízkej až po veľmi vysokú schopnosť pôdy imobilizovať organické kontaminanty. Podľa tejto kategorizácie bola vytvorená pôdna databáza, v ktorej pre každú BPEJ bola priradená vypočítaná hodnota indexu imobilizácie organických kontaminantov a vytvorená účelová mapa, dostupná pre verejnosť na www.podnemapy.sk. Ocenenie tejto funkcie pôdy vychádza z predpokladu, že veľmi vysoká schopnosť pôd zachytávať organické kontaminanty sa rovná nákladom na očistenie vody v čistiarňach odpadových vôd (cena stočného, t.j. 0,80 $€.m^{-3}$). Nakoľko pôda zachytáva tak organické, ako aj anorganické kontaminanty (ktoré v príspevku nehodnotíme), cenová hodnota zadržiavania organických polutantov je upravená v rovnakom 50% podiele, teda 0,4 $€.m^{-3}$ (Bujnovský a kol., 2009). V tomto zmysle pre uvádzaných 5 kategórií pôd bolo stanovené cenové rozpätie v $€.ha^{-1}$ (Bujnovský a kol., 2009; Vilček a kol., 2010).

Transportná funkcia je opakom inaktivácie, pretože ide o schopnosť pôd premiestňovať látky v rámci pôdneho profilu a z pôdneho profilu do podložia. Preto je možné po vypočítaní indexu inaktivácie len zmeniť poradie kategórií (napr. veľmi vysoká inaktivácia = veľmi nízky transport). Tak, ako pri imobilizácii organických látok, tak aj pri ich transporte je najdôležitejším mechanizmom ich sorpcia k pôdnym fázam ako kvalitatívny faktor a množstvo zrážok ako kvantitatívny faktor Barančíková a kol. (2010). Pri transporte organických kontaminantov sa okrem zrážok zohľadňuje ďalší parameter lokality, a to svahovitosť pôdy, ktorý zohráva dôležitú úlohu pri horizontálnom transporte eróziou. Schopnosť pôd transportovať organické kontaminanty je tiež jednou z účelových máp v informačnom systéme o pôde Slovenska a dostupná na stránke Výskumného ústavu pôdoznalectva a ochrany pôdy (VÚPOP) www.podnemapy.sk.

Ekonomické ohodnotenie tejto funkcie je v intenciách hodnotenia predchádzajúcej funkcie.

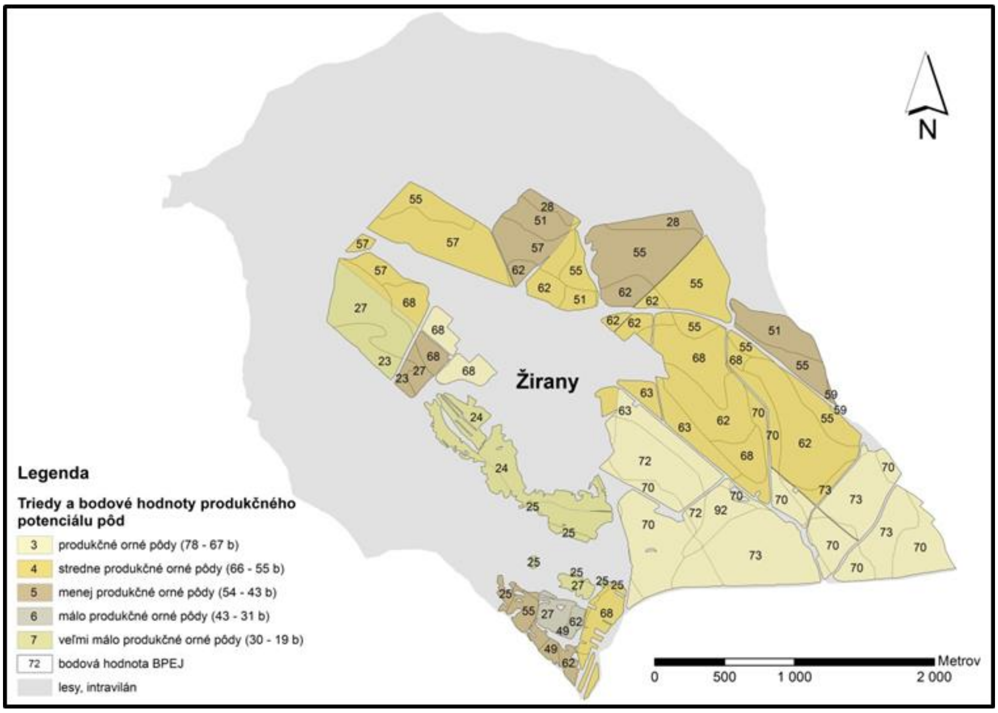
Uvádzané hodnotenia boli tabuľkovo spracované a pre záujmové územia priestorovo vyjadrené na prezentovaných účelových mapách konštruovaných prostredníctvom GIS.

VÝSLEDKY A DISKUSIA

Hodnotenie produkčnej funkcie pôdy

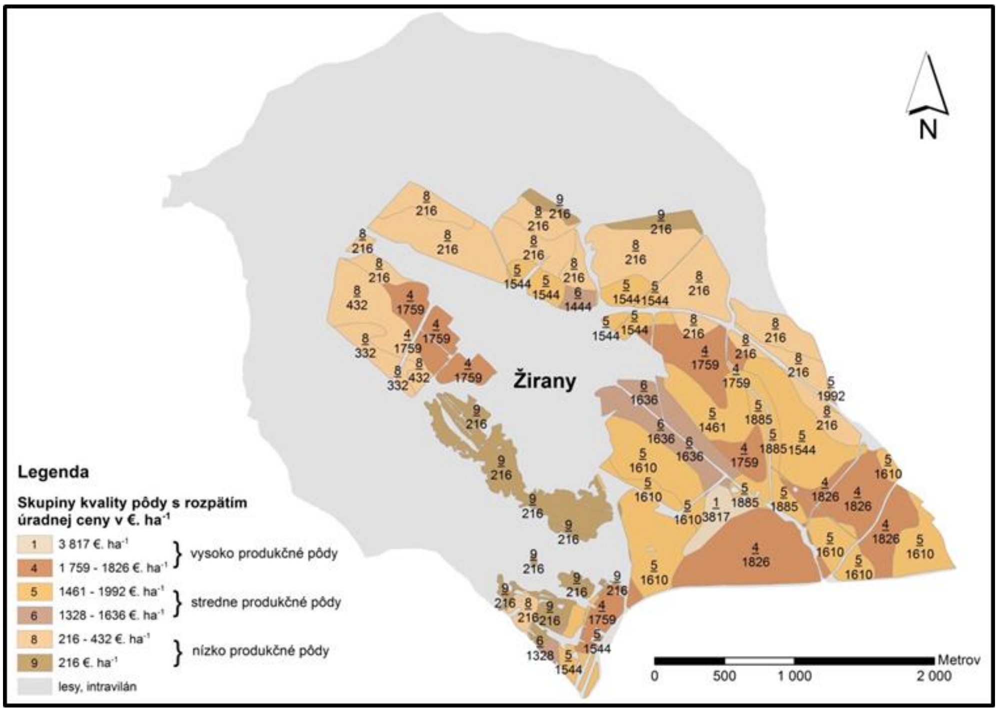
Bodové hodnotenie produkčného potenciálu BPEJ (obr.3) vyjadrujú a kvantifikujú reálne rozdiely potenciálu územných celkov pre pestovanie plodín. V záujmovom území sa táto hodnota v rámci 100 bodového rozpätia pohybuje od 23 (BPEJ 0276565) po 92 bodov (BPEJ 0122002). Po vypočítaní produkčnej schopnosti jednotlivých pôdnych celkov poľnohospodárskej pôdy v Kolíňanoch bola následne zistená priemerná bodová hodnota produkčnej schopnosti (PS) poľnohospodárskej pôdy v hodnote 54,12 bodov. Týmto postupom je možné vypočítať hodnoty produkčnej schopnosti v rámci poľnohospodárskych podnikov, okresov, regiónov až do úrovne republiky. Podľa Vilčeka a kol. (2000) takto stanovený priemerný produkčný potenciál poľnohospodárskych pôd za Slovensko predstavuje 44,4 bodov. V záujme rýchlych informácií o produkčnej schopnosti pôd bola bodová hodnota BPEJ sumarizovaná do deviatich tried PS: 1. vysoko produkčné pôdy (100-91 bodov); 2. veľmi produkčné pôdy (90-79 b); 3. produkčné pôdy (78-67 b); 4. stredne produkčné pôdy (66-55 b); 5. menej produkčné pôdy (54-43 b); 6. málo produkčné pôdy (42-31 b); 7. veľmi málo produkčné pôdy (30-19 b); 8. menej vhodné pôdy pre poľnohospodársku výrobu (18-16 b); 9. nevhodné pôdy pre poľnohospodársku výrobu (5-1 b). V hodnotenom území sa podľa vypočítanej produkčnej schopnosti jednotlivých pôdnych celkov vyskytujú produkčné triedy 3-7 (s najväčšou výmerou trieda 4 – 38,08%). Ich plošné rozmiestnenie vidieť na obr.3. Podľa priemernej hodnoty bodovej hodnoty produkčnej schopnosti (54,12 b) môžeme poľnohospodársku pôdu Kolíňany hodnotiť tak, ako aj produkčnú schopnosť Slovenska (44,4 b) len ako menej produkčnú.

Ekonomické hodnotenie produkčnej funkcie pôdy vyjadrené úradnou cenou pôdy zobrazuje obrázok 4. Každá BPEJ má uvedenú cenu pôdy v €.ha^{-1} a zároveň jej zaradenie do skupín kvality pre účely stanovenia odvodu pri zábere na nepoľnohospodárske účely. Cena BPEJ v riešenom území sa pohybuje od 216 do 3 817 €.ha^{-1}. Počítali sme cenu jednotlivých pozemkov poľnohospodárskej pôdy a ich spočítaním sme určili finančné ohodnotenie celej výmery poľnohospodárskej pôdy (PP) v sledovanom území na 685 433,69 €. Priemerná cena PP je 1 136,97 €.ha^{-1}. V porovnaní s priemernou cenou poľnohospodárskej pôdy Slovenska - 1 256,42 €.ha^{-1} ktorú uvádzajú Buday a Vilček (2013), je o 119,45 € nižšia. Ešte výraznejší je rozdiel v porovnaní s okresom Nitra (v rámci ktorého sa záujmové územie nachádza), kde priemerná cena PP je 2 239,20 €.ha^{-1}.



Obrázok 3 Mapa bodovej hodnoty produkčného potenciálu BPEJ a triedy produkčnej schopnosti pôdnych celkov riešeného územia

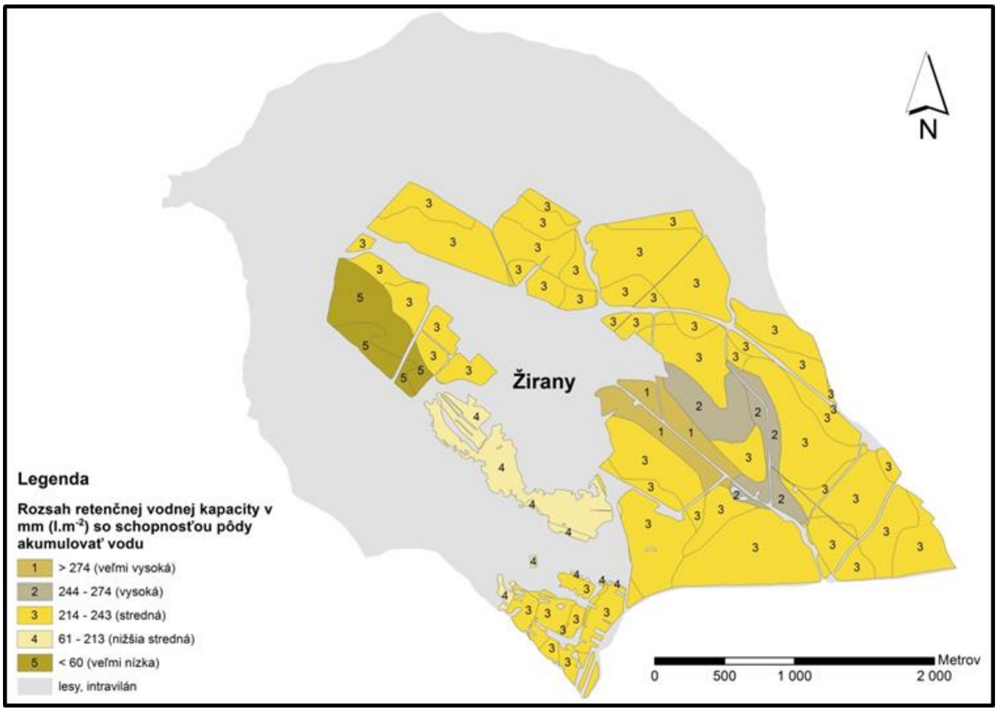
Z deviatich skupín kvality pôdy, z ktorých 1 až 4 predstavujú vysoko produkčné pôdy, skupina 5 až 7 stredne produkčné pôdy a skupina 8 až 9 nízko produkčné pôdy (Bielek, 2008) sa v riešenom území vyskytuje šesť. Do skupiny 1 patrí v území len jedna BPEJ (0122002) s výmerou 9,15 ha. Celkovo do skupiny vysoko produkčných pôd patrí 146,51 ha (4,30%), do skupiny stredne produkčných pôd patrí výmera 212,99 ha (35,33%), do skupiny nízko produkčných pôd patrí najviac – 243,36 ha (40,37%).



Obrázok 4 Úradná cena poľnohospodárskej pôdy a skupiny kvality pôdy v riešenom území

Hodnotenie schopnosti pôdy akumulovať vodu (akumulačná funkcia)

Retenčná vodná kapacita pôd určená na základe pedotransferových pravidiel a vyjadrená piatimi skupinami schopnosti akumulovať vodu v záujmovom území je zrejmá z obrázku 5. Veľmi vysokou schopnosťou akumulácie vody disponuje najmenšia výmera, t.j. 27,78 ha poľnohospodárskej pôdy. Vysokú schopnosť vykazuje plocha 37,74 ha PP. Najvyššiu výmeru zaberá poľnohospodárska pôda v skupine strednej schopnosti akumulácie vody, t.j. 463,01 ha (76,80%) poľnohospodárskej pôdy.



Obrázok 5 Skupiny schopnosti poľnohospodárskej pôdy akumulovať vodu

Množstvo potenciálne zadržanej vody poľnohospodárskou pôdou riešeného územia je 1 288 895,40 m^3. Podľa Houškovej (2011) toto množstvo v poľnohospodárskych pôdach Slovenska predstavuje hodnotu v rozpätí od 2,27 až po 4,89 mld. m^3 vody.

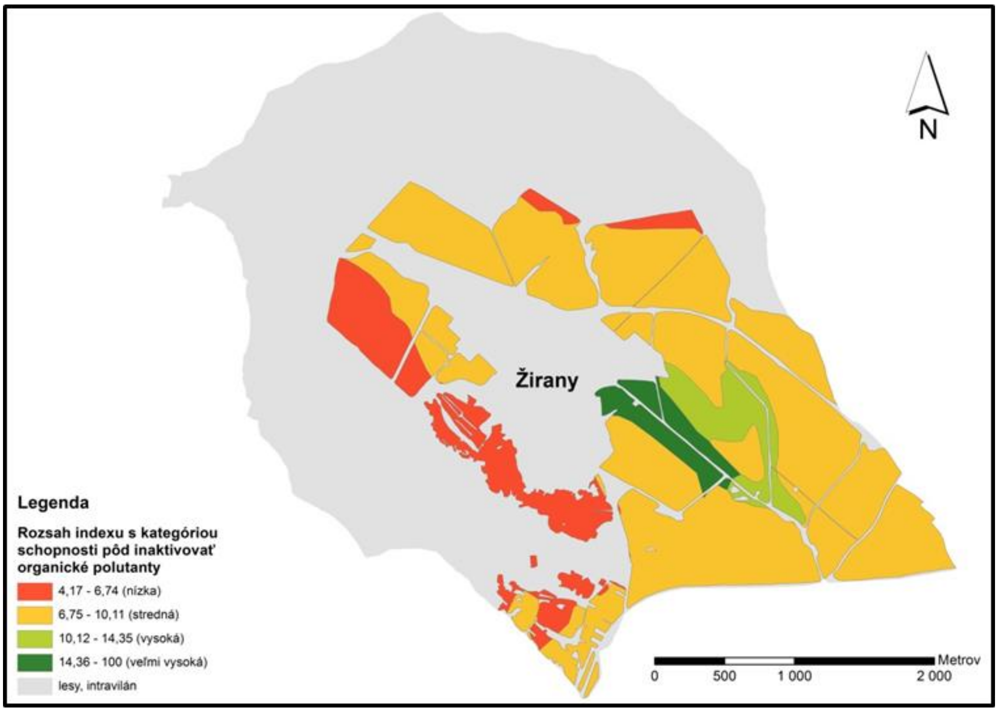
Ocenenie uvádzanej akumulačnej funkcie poľnohospodárskej pôdy na území Kolíňany sme sumárne ohodnotili na 2 577 790,80 €, čo na 1 ha predstavuje hodnotu 4 275,94 €.

Podľa prác Bujnovského a kol. (2009) ako aj Vilčeka a kol. (2010), celková hodnota poľnohospodárskych pôd Slovenska z hľadiska akumulácie vody je zhruba 12,5 mld. €. Priemerná hodnota pre akumuláciu vody tak na 1 ha poľnohospodárskych pôd Slovenska predstavuje 5 300 € .

Mapa RVK môže slúžiť na rýchlu informáciu o potenciálne rizikovej oblasti z hľadiska možných záplav, resp. na voľbu vhodných opatrení na elimináciu tohto rizika pri využívaní poľnohospodárskej pôdy (Houšková, 2011).

Hodnotenie schopnosti pôdy inaktivovať organické kontaminanty (filtračná funkcia)

Priestorové vyjadrenie schopnosti pôdy imobilizovať organické kontaminanty v riešenom území predstavuje obrázok 6. Z piatich skupín vymedzených pre hodnotenie tejto funkcie sa v území vyskytujú len štyri; pôdy s veľmi nízkou inaktiváciou organických polutantov sa tu nevyskytujú. Najväčšiu výmeru (436,76 ha, t.j. 72,45%) zaberajú poľnohospodárske pôdy so strednou schopnosťou, najmenšiu výmeru (27,77 ha, t.j. 4,61%) zasa pôdy s veľmi vysokou schopnosťou inaktivácie organických polutantov. Nízku úroveň tejto schopnosti vykazujú pôdy na výmere 93,85 ha (15,57%) a vysokú na výmere 44,48 ha (7,38%).



Obrázok 6 Mapa schopnosti pôdy imobilizovať organické kontaminanty

Ekonomické ohodnotenie pre vyskytujúce sa štyri skupiny schopnosti poľnohospodárskej pôdy imobilizovať organické kontaminanty v záujmovom území bolo vypočítané a sumarizované na celkovú hodnotu 1 691 681,10 €, čo predstavuje na 1 ha hodnotu 2 806,09 €. Keďže schopnosť pôdy inaktivovať organické a anorganické kontaminanty je v pomere 1:1 (Bujnovský a kol., 2009) odhadujeme, že výsledná hodnota imobilizácie oboch typov polutantov v sledovanom území by bola 3 383 362,21 € celkom, to znamená 5 612,19 €.ha^{-1} a 0,56 €.m^{-2}.

Vilček a kol. (2010) uvádzajú celkovú hodnotu poľnohospodárskej pôdy Slovenska imobilizovať organické a anorganické polutanty na úrovni 10,9 mld. €, čo predstavuje asi 0,43 €.m^{-2}.

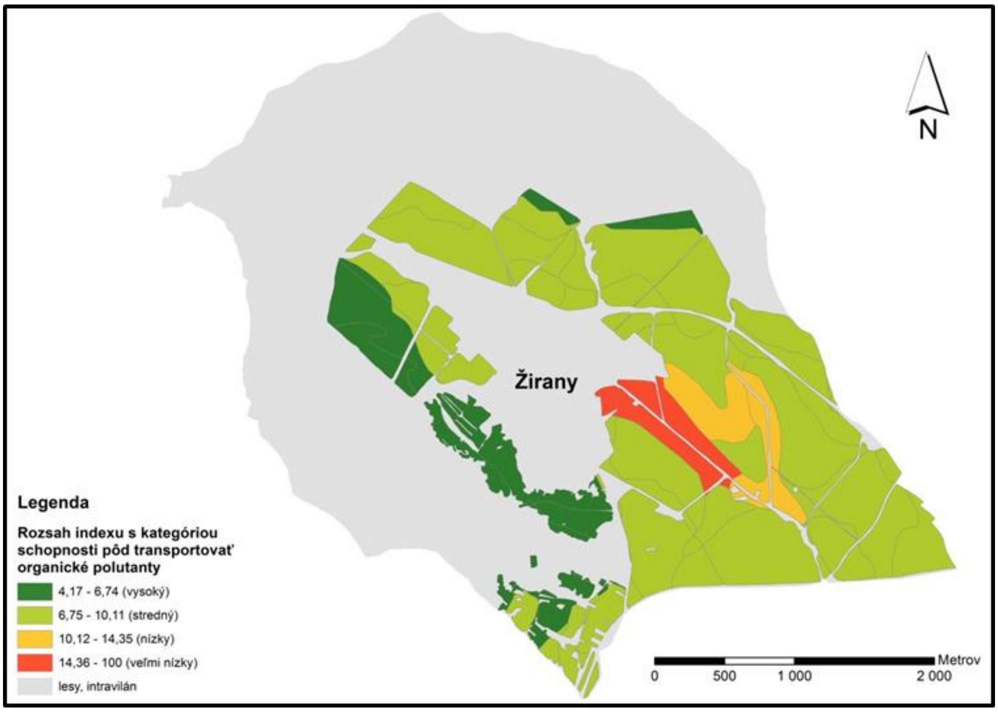
Z uvedeného môžeme konštatovať, že filtračná funkcia poľnohospodárskej pôdy v riešenom území je v priemere vyššia ako poľnohospodárskej pôdy Slovenska.

Hodnotenie schopnosti pôdy transportovať organické polutanty (transportná funkcia)

Transportná funkcia pôdy je opakom filtračnej funkcie, potenciálna schopnosť vertikálneho i horizontálneho transportu bude tým vyššia, čím nižšia bude intenzita sorpcie na jednej strane a čím vyššia bude intenzita zrážok a sklon svahu na strane druhej (Barančíková a kol.,2010).

Podľa obrázku 7 vidieť, že v území Kolíňany plošne prevláda kategória poľnohospodárskych pôd so strednou schopnosťou transportu organických kontaminantov, nasleduje kategória s vysokou schopnosťou a po nej kategórie s nízkou a veľmi nízkou schopnosťou transportu. Kategória s veľmi vysokou schopnosťou transportu organických kontaminantov sa v území nevyskytuje. V kategórii s vysokým potenciálnym rizikom transportu organických polutantov sú najviac zastúpené kambizeme plytké a kambizeme na svahoch. Tieto pôdne typy majú nízky sorpčný komplex spôsobený plytkým humusovým horizontom s nízkym obsahom humusu ako aj s nebezpečenstvom odplavenia kontaminantov vodnou eróziou.

Celkové ekonomické ohodnotenie schopnosti transportu organických polutantov na poľnohospodárskej pôde Kolíňany sme odhadli na 1 719 731,51 €, t.j. 2 852,63 $€.ha^{-1}$, resp. 0,2852 $€.m^{-2}$.



Obrázok 7 Mapa schopnosti pôdy transportovať organické kontaminanty

Zhrnutie výsledkov zo stanovenia finančnej hodnoty vybraných ekologických funkcií pôdy v časti katastrálneho územia Kolíňany uvádzame v tabuľke 1.

Tabuľka 1 Ocenenie vybraných ekologických funkcií v záujmovom území

Vybrané ekologické funkcie	Hodnota	
	celkom €	na 1 ha $€.ha^{-1}$
Produkčná funkcia	685 433,69	1 136,97
Schopnosť pôdy akumulovať vodu (akumulačná funkcia)	2 577 790,80	4 275,94
Schopnosť pôdy inaktivovať organické kontaminanty (filtračná funkcia)	1 691 681,10	2 806,09
Schopnosť pôdy transportovať organické polutanty (transportná funkcia)	1 719 731,51	2 852,63

Výsledky prezentované v príspevku potvrdili, že.:

- čím je vyšší produkčný potenciál pôd, tým je vyšší aj potenciál pôdy zabezpečovať vybrané ekologické funkcie,
- aj menej produkčné pôdy môžu mať v ekosystéme vysokú environmentálnu hodnotu,
- mapové vyjadrenie produkčných a hodnotených ekologických funkcií pôd na lokálnej úrovni prístupnou formou umožňuje identifikáciu problémových častí územia pre optimalizáciu ich využitia a voľbu opatrení na ochranu zložiek životného prostredia,
- jednotliví autori volia pri hodnotení mimoprodukčných funkcií pôd a najmä ich ekonomického hodnotenia rôzne východiská a prístupy, preto aj výsledky týchto hodnotení sa odlišujú.

ZÁVER

Príspevok prezentuje výsledky hodnotenia a priestorové vyjadrenie bodovej a finančnej hodnoty vybraných ekologických funkcií pôd na miestnej úrovni – v časti katastrálneho územia obce Žirany. Produkčná funkcia poľnohospodárskej pôdy vyjadrená úradnou cenou pôdy podľa BPEJ je 685 433,69 €. Ocenenie obmedzeného počtu vybraných mimoprodukčných (ekologických) funkcií predstavuje spolu hodnotu 5 989 203,41 €. Táto suma predstavuje takmer 9-násobok produkčnej funkcie. Uvedené poukazuje na to, že komplexné hodnotenie schopnosti pôdy plniť ekologické funkcie by sa malo premietnuť do finančného ohodnotenia pôdy, čo by podporilo uvedomenie si skutočnej hodnoty pôdy širokou verejnosťou. Integrácia verejnoprospešných funkcií pôdy do trhového mechanizmu môže zlepšiť docenenie významu pôdy ako najvýznamnejšieho fyzikálneho a chemického reaktora v podmienkach globálnych a regionálnych zmien (biodiverzita, klimatické zmeny). Analýza potenciálu a priestorovej diferenciácie ekologických funkcií pôdy, naviazané na prírodný kapitál (agroekosystémové služby), môže byť významným vodítkom pri usmerňovaní nevyhnutnej ochrany pôdy, najmä pred jej degradáciou, neodôvodneným trvalým záberom a antropickými zásahmi do krajinného prostredia, v rámci uplatňovania udržateľného manažmentu pôdnych zdrojov. Preto uplatňovanie konceptu prírodného kapitálu a ekosystémových služieb v plánovacích a rozhodovacích procesoch sú jedným z hlavných pojmov súčasnej ekológie, ochrany životného prostredia a koncepcie udržateľného rozvoja.

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MEDZISEKTOROVÉ HODNOTENIE ZRANITEĽNOSTI NITRIANSKEHO SAMOSPRÁVNEHO KRAJA NA KLIMATICKÉ ZMENY (Prípadová štúdia)

CROSS – SECTORIAL CLIMATE CHANGE VULNERABILITY ASSESSMENT ON NITRA SELF – GOVERNING REGION (Case study)

Ivan ŠEMBERA, Tomáš ŠEMBERA, Jana HRABOVSKÁ, Tibor TÓTH

EKOJET, s.r.o.

SUMMARY

CROSS – SECTORIAL CLIMAT CHANGE VULNERABILITY ASSESSMENT ON NITRA SELF – GOVERNING REGION is a first attempt of a pan Nitra region. Case study uses a conceptual framework ESPON Climate project, provide in-depth regional analyses of climate change vulnerability (exposure to climatic stimuli, sensivtivity to climatic stimuli, adaptive capacity, impacts of climate change, vulnerability to climate change). The results of the Case study shows that the following sectors are directly affected the primary sectors agriculture, water management and forestry.

KEY WORDS

climate change, adaptability, vulnerability assessment, ESPON Climate,

SÚHRN

Medzisektorové hodnotenie zraniteľnosti Nitrianskeho samosprávneho kraja na klimatické zmeny je prvým pokusom medzisektorového hodnotenia zraniteľnosti na klimatické zmeny regiónu. Prípadová štúdia má koncepčný rámec projektu ESPON Climate. Poskytuje regionálne analýzy klimatických zmien (expozícia, citlivosť, dopad, adaptácia). Výsledky projektu ukazujú, že priamo ovplyvnené sú sektory poľnohospodárstva, vodného hospodárstva a lesníctva.

KLÚČOVÉ SLOVÁ

klimatické zmeny, adaptabilita, zraniteľnosť, ESPON Climate

ÚVOD

V súčasnej dobe sa venuje vysoká pozornosť klimatickej zmene. Jedna z príčin globálnej zmeny klimatu je rastúca koncentrácia tzv. skleníkových plynov v atmosfére, spôsobená činnosťou človeka. Znečistenie ovzdušia spôsobujú oxid uhličitý (CO_2) a ďalej emisie oxidu dusného, amoniaku a metánu. Za najzávažnejší dôsledok tohto vývoja sa považuje globálne oteplenie o 2,0° C, zmena cirkulácie atmosféry s posunom frontálnych zón a klimatických pásiem (*IPCC, 2007*)

Miesta najviac zasiahnuté zmenami klimatu v Európe sú južná Európa, Stredomorie a Arktída. Neobvyklým problémom čelí horské oblasti Álp, ostrovy, pobrežné a mestské oblasti a husto osídlené záplavové oblasti Belgicka, Holandska a Talianska *(EEA 2008*). Očakávaná klimatická zmena má vážne dôsledky aj pre Slovensko z dlhodobého hľadiska: rastúca frekvencia extrémnych prejavov počasia, lejaky a prudké povodne, dlhotrvajúce sucho, riziká požiarov, zosuvy *(Šiesta národná správa o klimatických zmenách v SR, MŽP SR, 2013).*

MATERIÁL A METÓDA

Nitriansky región je najvýznamnejším poľnohospodárskym producentom a druhým najvýznamnejším producentom energií v Slovenskej republike. Počtom 706 158 osôb k 31.12.2007 sa región zaraďuje na 3. miesto v medzikrajovom porovnaní s podielom 13,09% na úhrne SR. V hustote obyvateľstva dosahuje 109 obyvateľov na km^2. V kraji sa nachádza 354 obcí. Rozloha územia kraja dosahuje 643 375 ha. Reliéf kraja má prevažne rovinný a nížinný charakter, prerušovaný nížinou pahorkatinou v severnej časti. V území prevládajú akumulačné a akumulačno-erózne reliéfy nad erózno-denudačnými *(AUREX, 2013*).

Podľa našej klimatickej rajonizácie nížinatú časť územia zaberá klimatická oblasť teplá, ktorá má 50 a viac letných dní. Táto je zastúpená najmä jej okrskom T1, ktorý je teplý, veľmi suchý s miernou zimou a rozprestiera sa v rovinatých častiach územia. Naň v pahorkatinovom teréne nadväzuje okrsok T2, ktorý je suchý a má miernu zimu. Ďalej na úpätiach hôr do výšky cca 400 m oblasť teplú zastupujú okrsky T4 (mierne suchý) a T6 (mierne vlhký). Nad teplou oblasťou sa nachádza oblasť mierne teplá, charakterizovaná počtom letných dní nižším ako 50 a júlovým priemerom teplotou vzduchu 16°C a viac, ktorý je tu zastúpený okrskom M4 (vlhký s miernou zimou) (*Lapin,M.,Tomlain,J.,2001).*

K riešeniu úlohy bol zvolený koncepčný a metodický princíp programu *ESPON Climate project, www.espon.com)* ktorý definuje možné dopady zmien klimatu na vybrané prírodné riziká, zvlášť tie, ktoré sa prejaví v priestorovom plánovaní a v jednotlivých sektoroch hospodárskej činnosti.

Metodika obsahuje nasledujúce komponenty:

Expozícia (*Exposure*) – vyjadruje povahu a stupeň, ktorými je určitý systém vystavený významným klimatickým variáciám. Analýza expozície využila existujúce projekcie klimatických zmien a klimatickej premenlivosti z modelu CCS 2000, ktorého výsledky boli použité k vytvoreniu scenára klimatickej zmeny a scenára hydrologického cyklu Nitrianskeho región pre obdobie do roku 2050.

Citlivosť (*Sensitivity*) – vyjadruje stupeň, ktorým je systém ovplyvnený buď negatívne alebo kladne a klímou súvisiacimi stimuly. Pre každý rozmer citlivosti (fyzikálny, environmentálny, sociálny, ekonomický a kultúrny) boli vypracované viaceré indikátory citlivosti.

Expozícia a citlivosť boli kombinované na určeniu *potenciálnych vplyvov* klimatických zmien a na určenie celkovej zraniteľnosti Nitrianskeho regiónu.

Dopad (*Impact*) - vyjadruje dôsledky klimatickej zmeny na prírodné a humánne systémy. V závislosti na úvahe prispôsobenia, môžeme rozlišovať medzi potenciálnym i a zvyškovými vplyvmi.

Zraniteľnosť(*Vulnerability*) - vyjadruje stupeň, v ktorom je systém zraniteľný, alebo neschopný sa vyrovnať sa so zápornými dôsledkami klimatických zmien, vrátane variability klímy a extrémov. Zraniteľnosť je funkciou povahy, veľkosti a rýchlosti klimatickej variácie, ktorej je systém vystavený, jeho citlivosti a adaptívnej schopnosti.

Schopnosť adaptácie *(Adaptability)*- vyjadruje schopnosť prírodného alebo humánneho systému prispôsobiť sa klimatickým zmenám (vrátane klimatickej variability a extrémov) na zmiernenie potenciálnych škôd, využitie príležitostí. alebo na vyrovnanie sa s dôsledkami.

Zmiernenie dôsledkov *(adaptačné opatrenia)* - označuje všetky ľudské pokusy o zmiernenie dôsledkov klimatických zmien.

Priložená schéma výskumného rámca klimatických zmien popisuje jednotlivé kroky posúdenia zraniteľnosti a môže slúžiť na všeobecnú orientáciu. Údaje zobrazené v schéme sú príklady určené na to, aby boli rôzne postupy výpočtov transparentnejšie.
Výber, výpočet a zlúčenie jednotlivých indikátorov zahŕňajú nielen vedecké znalosti ale aj normatívne rozhodnutia o tom, ktoré aspekty takých koncepcií ako sú klimatické zmeny, citlivosť, alebo schopnosť adaptácie, majú byť zachytené a posudzované. Okrem toho je výber indikátorov tiež formovaný dostupnosťou a kvalitou štatistických údajov.
Implicitne, výber údajov tiež obsahuje možnosti výberu týkajúce sa podkladových klimatických scenárov a modelov.

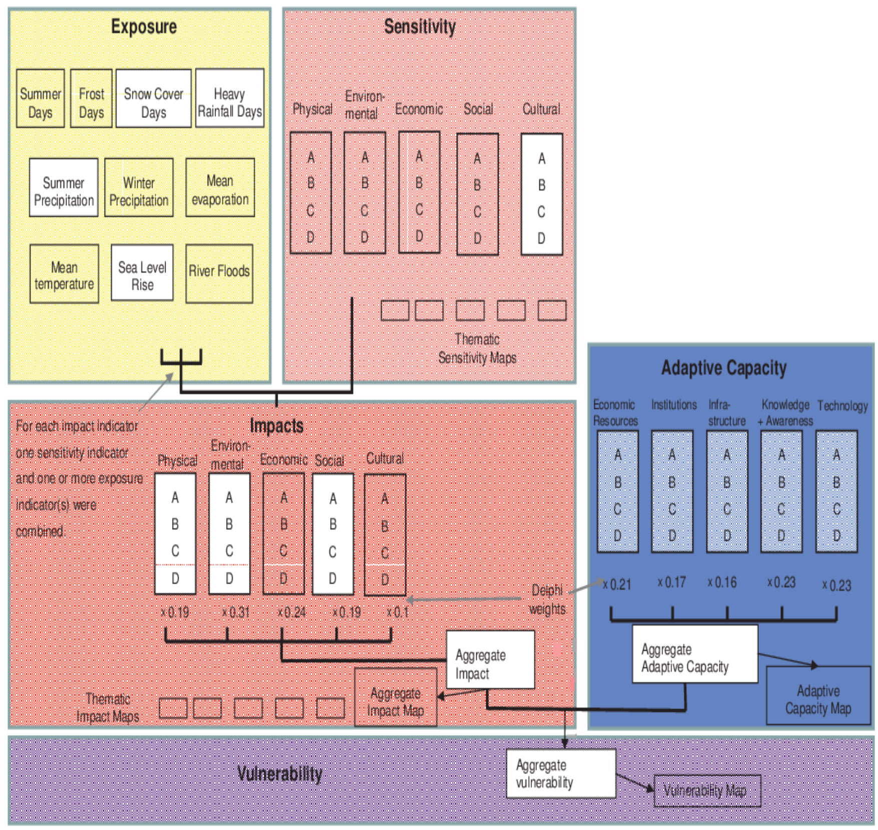


Figure 2: Overview of the ESPON Climate vulnerability assessment methodology

Obrázok 1 Výskumný rámec klimatických zmien - Celoeurópske hodnotenie zraniteľnosti založené na regionálnej typológii expozície, citlivosti, dopadu a zraniteľnosti. (*Fűssel.M., Klein., 2007, IPCC 2007, 2013).*

VÝSLEDKY A DISKUSIA

V úlohe boli analyzované efekty klimatických zmien v podobe adaptačnej kapacity regiónu v sektoroch regionálnej ekonomiky: vodné hospodárstvo, poľnohospodárstvo, lesné hospodárstvo, zdravotníctvo, cestovný ruch, doprava, sídelné prostredie, energetika a biodiverzita. Rovnako bola posúdená adaptačná kapacita mikroregiónu Požitavie- Širočina. Zhodnotenie časového priebehu vybraných teplotných, zrážkových a kombinovaných ukazovateľov klimatickej zmeny za obdobie 1961 – 2014 v regióne Nitrianskeho

samosprávneho kraja (NSK) *(Lapin, M., 2001,2002,2003, Šembera. I., et al,2015*) ukazuje na nasledovné skutočnosti.
Teplotné ukazovatele majú zreteľne vyjadrený vzrast priemerných aj extrémnych teplôt vzduchu vo všetkých ročných obdobiach na celom území kraja. Priemerná ročná teplota vzduchu aj počet letných a tropických dní rastie, čo spôsobuje nielen skorší nástup vegetačného obdobia, ale aj zvýšený nárast vĺn horúčav v letnom období. Naopak, pokles počtu ľadových a mrazových dní ukazuje na celkove vyšší výskyt miernejších zím, ktorých kladnou stránkou sú nižšie energetické nároky na vykurovanie, no zápornou možnosť vyššieho výskytu zimných povodní. Zrážkové ukazovatele nemali za spracované obdobie výrazný trend.. Suma zimných zrážok v uvedenom období stagnovala a suma letných len slabo rástla. Výskyt intenzívnych zrážok tiež nevykazoval časový vývoj. Do trendov ukazovateľov zmeny klímy, ktoré sú výsledkom kombinácie teplotných a vlhkostných (zrážkových) ukazovateľov v podstatnej miere zasahuje vývoj teploty vzduchu. Trend aktuálnej evapotranspirácie v suchých oblastiach NSK rastie, no výraznejší je vzrast potenciálnej evapotranspirácie. Tento vývoj znamená vysúšanie vrchných vrstiev pôdy. Aj v počte dní so snehovou pokrývkou je klesajúci trend spôsobený podstatnou mierou vzrastom teploty vzduchu v zimných mesiacoch *(Lapin M., 1995).*
Zmeny v cirkulačných pomeroch atmosféry zrejme spôsobia, že južná časť NSK bude zasiahnutá otepľovaním klímy a aj súvisiacou zmenou iných klimatických prvkov viac ako severná časť NSK. To sa prejaví predovšetkým v zhoršených podmienkach zavlaženia pôdy a v častejšom výskyte sucha. Na druhej strane, významné zvýšenie intenzívnych konvektívnych zrážok na úkor trvalých zrážok s menšou intenzitou bude mať za následok nevyrovnaný režim zavlaženia pôdy a častejší výskyt prívalových povodní v celej oblasti NSK. V malej nadmorskej výške bude závažným negatívnym dôsledkom oteplenia klímy oveľa častejší výskyt vĺn horúčav súčasne s vysokou absolútnou vlhkosťou vzduchu.

Sektor vodného hospodárstva
Scenár hydrologického cyklu SR predpokladá, že väčšina územia bude poznačená poklesom odtoku. Pre časový horizont 2030 sa predpokladalo, že takmer 64 % plochy územia sa bude nachádzať v pásme poklesu -5 až -20 %, v časovom horizonte 2075 viac ako 77 % plochy územia Slovenska v pásme poklesu -20 až -40 %. Obdobne sa pokles odtoku prejaví aj v sledovaných výškových pásmach, kde sa zachovanie súčasného stavu predpokladá len v nadmorských výškach nad 800 m n. m. v časových horizontoch 2010 a 2030. V ostatných výškových pásmach sa predpokladá mierny až výraznejší pokles odtoku. Najvyšší je vyhodnotený pre oblasť nížin, kde sa pre časový horizont 2075 predpokladá pokles dlhodobého priemerného ročného odtoku o viac ako -27 %. Mierny rast odtoku, resp. zachovanie súčasného stavu sa predpokladá v rámci sledovaných povodí iba pre povodia západného Slovenska a to iba pre časové horizonty 2010 a 2030 (*Majerčáková,O.,1997, Petrovič P., et al1998)*
Klimatické zmeny budú významne ovplyvňovať aj využiteľnosť vodných zdrojov. Pre obdobie 1931-1980 a súčasný stav obyvateľov vychádza využiteľná voda 2,84 tis. m^3 za rok na obyvateľa. Pri poklese vodných zdrojov ovplyvnených klimatickou zmenou a náraste počtu obyvateľov môže v suchých rokoch výrazne klesať až na kritickú úroveň. Pri nezmenenom vývoji klímy k časovému horizontu 2050 by sme pri takomto trende mohli očakávať, že

využiteľné zdroje vody nám poklesnú o 40 až 50% (teda klesnú na hodnoty okolo 1,42 (tis. m^3/rok/obyvateľ *(Fekete, V., 2014).*

Z aplikácie scenára vyplývajú aktuálne negatívne dopady klimatických zmien v podobe povodní. V dotknutom území Nitrianskeho kraja bolo identifikovaných 44 obcí s potenciálne významným povodňovým rizikom: okres Nitra 14 obcí, okres Levice 7 obcí, okres Nové Zámky 8 obcí, okres Zlaté Moravce 15 obcí. (*Plán manažmentu povodňového rizika čiastkového povodia, Váh, Hron, Ipeľ, 2014,, MŽP SR)* U obcí mikroregiónu Požitavie – Širočina sú navrhnuté konkrétna opatrenia Slovenského vodohospodárskeho podniku, š.p. Banská Štiavnica),

ktoré zmenšujú maximálne prietoky povodne a chránia územia pred zaplavením: úprava vodných tokov, výstavba protipovodňových línií pozdĺž vodných tokov, výstavba vodných hrádzí a poldrov, zariadenia na prečerpávanie vnútorných vôd, odstraňovanie nánosov a porastov na brehu vodných tokov. Štúdia doplnila návrh opatrenia, ktoré zvyšujú retenčnú schopnosť dotknutého územia obce, spomaľujú odtok vody z územia do vodných tokov, podporujú akumuláciu vody, podporujú protierózne úpravy na poľnohospodárskej pôde a úpravy na urbanizovanom území dotknutej obce.

Sektor poľnohospodárstva

Dôsledky klimatickej zmeny sa budú prejavovať vo väčšej miere v sektore poľnohospodárstva. Priebeh počasia počas vegetačného obdobia výrazne bude ovplyvňovať výšku úrod poľnohospodárskych plodín. Pri predpokladanom náraste výparu a bez výraznejšieho zvýšenia atmosférických zrážok bude ohrozená suchom časť Podunajskej nížiny ohraničená mestami Nitra, Levice, Šahy s výskytom veľmi úrodných pôd (ľahké a stredne ťažké pôdy, černozeme, fluvizeme) *(Sobocká et al.,2005*). Významným nástrojom na elimináciu sucha sú funkčné závlahy, ktoré hodnotíme pre dotknuté územie ako existenčno-stabilizačný faktor poľnohospodárskej výroby. Medzi pozitívne dôsledky zmeny klimatu môžeme zaradiť predĺženie obdobia bez mrazov o 20-30 dní a posunutie začiatku vegetačného obdobia za začiatok marca. Očakávaný teplotný vzostup vytvorí podmienky pre pestovanie teplomilných plodín (*Minďaš, J., et a.l 2011, Šiška., M., Takáč ,J., 2008).*

Sektor lesné hospodárstva

Výstupy prípadovej štúdie hodnotí budúce environmentálne riziká v lesnom hospodárstve v podobe významného narušenia lesných ekosystémov s výskytom smreku. Nepredpokladá sa však, že bude v krátkodobom výhľadu dochádzať k výraznému posunu vegetačných stupňov.

Ako základné prvky expozície pre sektor lesného hospodárstva boli určené: priemerná denná teplota vzduchu a vodná bilancia. Výsledky vodnej bilancie v hlavnom období vegetácie v súčasných podmienkach ako aj v podmienkach zmenenej klímy podľa scenára CCCM *(Lapin et al. 2000)* naznačujú, že v podmienkach súčasnej klímy je vegetačné obdobie lesov Nitrianskeho kraja vystavené vyššej potenciálnej evapotranspirácie v porovnaní so spadnutými zrážkami. Na základe toho lesné spoločenstvá (hore uvedené) sú nútené v teplej časti roka existovať zo zásob zimnej vody v pôdnom profile. Zvyšovanie teploty vzduchu a zmenšovanie úhrnu zrážok v teplom roku na území NSK vedie k zmenšovaniu relatívnej vlhkosti vzduchu. Predpokladá sa, že v dnešnej lesnej oblasti s prevahou výskytu 1. dubového lesného vegetačného stupňa sa vytvoria v budúcnosti menej priaznivé podmienky pre vysoký

les, čo povedie k vzniku stepných až lesostepných vegetačných formácií (xerotermná krovinová vegetácia). Lesy v nížinách a pahorkatinách dotknutého územia bude ohrozovať hlavne sucho. Pravdepodobne budú narastať aj škody spôsobené povodňami na brehových porastoch a v lužných lesoch. Predpokladá sa častejší výskyt požiarov (*Čaboun.V., 200*8).
Klimatické zmeny budú ovplyvňovať okrem iného aj škodlivé prejavy biotických škodcov.
Stúpne význam huby *Dothistroma septospora*, ktorá spôsobuje červenú sypavku borovice čiernej a lesnej. Na vlhkých a teplých stanovištiach môžu byť ohrozené duby, gaštan jedlý, buky, hubami *Phytophtora cinnamoni* a *P.cambivora*. V dôsledku zvýšeného stresu drevín stúpne význam tracheomykóznych húb a duboch *Ceratocystis, Ophiostoma* a na javoroch *Verticillium*. Vážne poškodenia môžu byť spôsobené na topoľoch rakovinovým ochorením spôsobovaných hubou *Cryptodiaporthe populea*. V južných oblastiach je možné predpokladať intenzívnejšiu inváziu nepôvodných druhov hmyzu z mediteránnej oblasti. K rizikovým patria druhy koníkov *Dociostaurus maroccanus*. Ďalšie druhy listožravých druhov motýľov a vošiek *(Šiesta národná správa o klimatických zmenách v SR, MŽP SR, 2013).*

Sektor energetiky

Pod pojmom energetika sú zahrnuté ekonomické aktivity spojené s výrobou elektriny, tepla ako aj ostatné procesy spaľovania v priemysle, verejnom sektore a domácnostiach. Je to v súlade s metodikou inventarizácie a projekcie skleníkových plynov IPCC. Energetika je zdrojom najväčšieho objemu skleníkových plynov, predovšetkým CO_2 zo spaľovania fosílnych palív.
V rámci analýzy dopadov klimatických zmien na sektor energetiky Nitrianskeho kraja sa táto štúdia zamerala na to, ako postupné otepľovanie zníži potrebu vykurovania a tým aj spotreby palív a tvorby emisií. Okrem kvantitatívnych údajov (spotreba palív v TJ) emisie v kt. boli tieto výsledky aj vyjadrené v monetárnych jednotkách t.j. v znížení palivových a externých nákladov výroby tepla. Dopad klimatických zmien však z hľadiska ekonomiky jednotlivých subjektov bude pozitívne pôsobiť v prípade sektorov 1A4a a 1A4b kde majitelia výrobcov tepla sú aj ich spotrebitelia, zatiaľ čo u ekonomických subjektov v rámci sektoru 1A1a to predstavuje zníženie tržieb za dodávku tepla. Na druhej strane tieto subjekty však budú naďalej musieť prevádzkovať zariadenie bez odpovedajúceho znižovania kapacity. Z toho vyplýva aj potreba udržania si prevádzkovej kapacity vykurovania. Pre zdroje zabezpečujúce dodávku tepla pre externých odberateľov t.j. pre zdroje sektoru 1A1a bude musieť v budúcnosti URSO stanoviť inú štruktúru kalkulácie ceny tepla, kde fixné náklady budú mať väčšiu váhu ako doteraz oproti nákladom palivovým. Klimatické zmeny v sektore energetiky môžu mať dopad na zásadné rozdiely medzi ponukou a dopytom po energii. Nárast priemernej zimnej teploty sa môže prejaviť na poklese dopytu pri vykurovaní, na druhej strane pri zvýšení priemerných letných teplôt a ich extrémity môže mať za následok jej zvýšenie (klimatizačné a chladiarenské procesy) *(Balajka, J., 2010, NEEDS, INTEGRATED PROJECT, Priority 6.1. 2001).*

Sektor cestovného ruchu

Pre poznávaciu turistiku sú predovšetkým významné vlny horúčav v dlhšie trvajúcom období s maximálnou teplotou vyššou ako 30°C a iné extrémne zmeny s dôsledkom rizika povodne. Cestovný ruch je citlivý na kolísanie klímy a jej zmeny. Klíma určuje dĺžku a kvalitu turistickej sezóny a má významnú úlohu pri výbere destinácie pre dovolenku. Významne ovplyvňuje prírodné zdroje, ktoré tvoria predpoklad pre turistiku: snehové podmienky pre zimné športy, biodiverzitu, kvalitu vody a pôd. Opačný, negatívny vplyv klímy na prírodné podmienky sú extrémy počasia: záplavy, lesné požiare, výskyt rias vo vode, infekčné choroby a pod.

Pre dotknuté územie s významnou *letnou turistikou* viazanou na pobyt pri vode (termálne kúpaliská, vodná turistika, rybolov) s predpokladaným vývojom počtu dní s priaznivými podmienkami sa očakáva zlepšovanie podmienok pre turistiku, sezóna sa bude predlžovať s väčšou využiteľnosťou kapacít ubytovania a služieb. Dopyt turistov v regionálnom merítku bude ovplyvňovať ponuku športových a voľnočasových aktivít, budovanie infraštruktúry, zabezpečenie informovanosti a bezpečnosti turistov.

Zimná turistika v dotknutom území je závislá na priaznivých snehových podmienkach a spoľahlivosti lyžiarskeho areálu. Pre úspešnú prevádzku areálu je potreba , aby sa lyžovalo aspoň sto dní v roku. Scenár zmeny klímy pre dotknuté územie jednoznačne predpokladá zhoršenie podmienok pre zimné športy a znižovanie počtu dní s intenzívnym snežením.

Pre lokality zamerané na poznávaciu turistiku ako je mesto Nitra a jej okolie sa predpokladajú vlny horúčav v dlhšie trvajúcom období s maximálnou teplotou vyššou ako 30˚C.

Dopady na biodiverzitu

V Slovenskej republike zatiaľ nie sú definované kritéria pre hodnotenie klimatických zmien na biodiverzitu, ani žiadny systém kvalifikácie biodiverzity na ekosystémovej úrovni. Podľa záverov rozsiahleho projektu Hodnotenie ekosystémov na začiatku tisícročia (*Millenium Ecosystem Assesment, MA 2005)* sa do konca 21. storočia stane zmena podnebia najdôležitejším činiteľom pôsobiacim na biodiverzitu *(Plesník, J., 2007, Vačkář et al., 2008).* Odhaduje sa, že rastom priemernej globálnej teploty o viac ako 2˚C sa približne 20-30% druhom rastlín a živočíchov zvýši riziko ich vyhynutia. Zvlášť citlivé k zmenám teploty sú migrujúce druhy organizmov *(Thomas, C.D., et al. 2004).*Tieto zmeny budú mať za následok ochudobnenie pôvodnej biologickej rozmanitosti a jej celkovú homogenizáciu. Úbytok sa dotkne vzácnych druhov s veľmi špecifickými nárokmi na životné prostredie. Klimatická zmena ovplyvní hlavne ekosystémy kľúčové pre ukladanie uhlíku, ako sú lesy, nestabilné monokultúry tvorené nevhodnými druhmi drevín, trávne ekosystémy, mokrade a rašeliniská (TEEB 2009).

Ostatné sektory

Zmeny klimatu a hlavne riziká zvýšenej extremity počasia sa budú prejavovať aj na zdraví obyvateľstva *(Šuta. M., 2011*), v doprave *(PIARC 2012*), v sídelnom prostredí (*Hudeková,Z., 2014*). S ohľadom na závažnosť rizík sa predpokladajú dopady v týchto sektoroch len nárazovo.

Adaptačné opatrenia

Adaptácia na klimatické zmeny je zadefinovaná ako prispôsobenie prírodných a ľudských systémov v reakcii na skutočné alebo očakávané klimatické podnety alebo ich účinkov, ktoré zmierňujú hrozby klimatické zmeny alebo využíva prospešná zariadenia. K základným dokumentom , ktoré Európska komisia k problematike adaptácia pripravila sú: *Zelená kniha*

(*KOM 2007, 354), Biela kniha (KOM 2009, 147)* a *Stratégia EU pre adaptáciu na zmenu klímy (KOM 2013, 216)*. Slovenská republika prijala dokument *Stratégia adaptácie SR na nepriaznivé dôsledky zmeny klímy,* schválenou uznesením vlády SR č. 148/2014.
Adaptačné opatrenia v tomto príspevku sú zameraná na adaptačné prístupy v hlavných sektoroch hospodárskej činnosti v regiónu u jednotlivých technických riešení až po návrh významných zmien v činnosti sektorov vodného hospodárstva, poľnohospodárstva a lesného hospodárstva. Ich rozsah bol ovplyvnený nedostatkom údajov na likvidáciu škôd, nákladoch a prínosoch adaptačných opatrení, spôsobu monitorovaní a vyhodnotení už stávajúcich opatrení. Schopnosť adaptácie je závislá na dostupnosti finančných zdrojov, technológiách, dostupných informáciách, vhodnom plánovaní a celkovej infraštruktúre.

Sektor vodného hospodárstva

1. Dobudovanie systému vodných nádrží pre potreby ochrany pred povodňami, zásobovania obyvateľstva pitnou vodou a zabezpečenia vody pre poľnohospodárstvo a priemysel. Taktiež pre ekologické požiadavky krajiny, tokov a udržanie hladín podzemných vôd.
2. Dobudovanie systému protipovodňovej ochrany povodí (ochranné hrádze, suché poldre a pod.).
3. Revitalizácia objektov zahrádzania bystrín a postupná realizácia hydromelioračných opatrení v lesnom hospodárstve a poľnohospodárstve pre zvýšenie protipovodňovej ochrany územia v najohrozenejších povodiach dotknutého územia.
4. Obnova rybníkov a malých vodných nádrží, obnova mokradí.
5. Úprava vodohospodárskych meliorácií pozemkov.
6. Opatrenia pre vsakovanie, akumuláciu a využitie dažďových vôd na jednotlivých nehnuteľnostiach, uplatňovať v územnoplánovacích dokumentáciách a v dokumentáciách komplexných pozemkových úprav, odvodňovanie urbanizovaných celkov novou koncepciou nakladania s dažďovou vodou.
7. Uzávera výstavby v inundačných územiach tokov, prípadne odstránenie nevhodných objektov.

Sektor poľnohospodárstva

1. Vyššie teploty vyvolávajú rýchly vývoj plodín, ktorý tiež ovplyvní väčšinu agrotechnických operácií. Súčasne s tým sa vyskytujú aj určitá riziká, napr. kratšia doba rastu plodín , ich predčasný vývoj na jeseň a vyšším rizikom výskytu chorôb a škodcov, nedostatočné otužovanie plodín a poškodenie epizódami vpádov studeného vzduchu v zime a na jar.
2. Opatrenia na zvýšenie úrodnosti pôdy s ohľadom na pokles dostupnosti hnojenia organickými hnojivom. Teplota pôdy je v priamej súvislosti s rýchlosťou rozkladu pôdnej organickej hmoty a pozberových zvyškov (ľahko rozložiteľných frakcií), tj. aj mineralizácie dusíka a ďalších živín. Vyššia teplota (pri dostatočnej vlhkosti) pôdy na jeseň a v zime bude zvyšovať i obsah nitrátov a tým aj riziko vyplavenia do vôd. Opačne bude pôsobiť nižšia vlhkosť pôdy a vysychanie povrchových vrstiev v dôsledku nižších zrážok, absencia alebo krátke doby trvania snehovej pokrývky a vyššej evapotranspirácie.

3. Výsadba vetrolamov ako prostriedku na obmedzenie rizika veternej erózie a zníženia aridizácie krajiny. Vetrolamy priaznivo ovplyvňujú vyrovnávanie teplotných rozdielov, ovplyvňujú mikroklímu prostredia zvýšenou tvorbou rosy, zachytávanie snehu, zníženie neproduktívneho výparu. Primárnou funkciou vetrolamu je ochrana pôdneho povrchu pred eróznym pôsobením vetra.

4. Optimalizácia závlahových systémov a závlahových dávok. Adaptácia zameraná na zlepšené hospodárenie s vodou v rámci porastu je účinným nástrojom pre zlepšenie odolnosti rastlín voči epizódam vysokých teplôt, ktoré pri pôsobení v kritickej fáze začiatku tvorby semien majú veľmi nepriaznivé dopady na výnos. Vo väčšej miere je potrebné využívať automatické systémy indikácie podmienok (rastlina, pôda, atmosféra) v spojení so systémami a technologickým vybavením (na pr. kvapková závlaha, metódy čiastočnej závlahy koreňovej zóny) na základe znalosti o vplyve stresu.

5. Ochrana pred zvýšeným tlakom infekčných chorôb a škodcov. Dopad zmeny klímy spočíva v zmene podmienok pre výskyt škodcov a chorôb. Všeobecne sa konštatuje, že zvyšujúca sa teplota vzduchu a pôdy zvyšuje ich rozšírenie a výskyt.

6. V spolupráci s Maďarskom sledovať výskyt a šírenie teplomilných chorôb a škodcov. Vykonávať prípadové štúdie vybraných škodlivých druhov z pohľadu ich ekologickej niky, zvýšení počtu generácií a výskytu nových inváznych patogénov.

7. Vyšľachtenie nových a vyselektovanie existujúcich odrôd vhodných pre vegetačné podmienky ovplyvnené zmenou klímy. Kľúčovým smerom šľachtenia je získanie vyššej rezistencie na sucho.

8. Navrhnúť podrobnejšiu rajonizáciu výrobných oblastí v NSK z pohľadu zmeny klímy a podmienok stanovíšť pre pestovanie poľnohospodárskych plodín, a to s ohľadom na stále početnejší výskyt meteorologických extrémov. S tým je spojené aj prehodnotenie dotačnej politiky podpory farmárov a prvovýrobcov.

9. Medzi dôležité adaptačné opatrenia, o ktorých panuje široká zhoda štátov EÚ je vybudovanie systému integrovaného agrometeorologického monitoringu a výstrahy. Jeho výstupy musia smerovať k poľnohospodárskej prvovýrobe.

10. Návrhy preventívnych opatrení je potrebné založiť na analýzach nákladov a úžitkov.

Sektor lesného hospodárstva

1. Pestovať priestorovo a druhovo porasty s čo najväčším využitím prírodných procesov, pestrej drevinnej skladby, prirodzenej obnovy a variability pestovateľských postupov, posilňovať hydrický vplyv lesa s osobitným dôrazom na zachovanie biodiverzity lesných spoločenstiev.
2. Zabrániť degradácii pôd a tým maximalizovať množstvo uhlíku viazaného v pôde.
3. Podporovať druhy a ekotypy lesných drevín znášajúcich klimatickú zmenu.
4. Uplatňovať opatrenia udržujúce vysokú a stabilnú produkciu drevnej hmoty.
5. Predĺžiť zákonné lehoty k zalesneniu a zabezpečeniu porastov vo väzbe na prirodzenú obnovu lesa.
6. V rámci lesníckej typológie posúdiť možnosti zmien lesných vegetačných stupňov.
7. Zamerať dotačné pravidlá k podpore adaptačných opatrení znižujúcich dopady klimatickej zmeny.
8. Podporovať ekologicky vhodné zalesňovanie poľnohospodárskych pôd.

9. Podporiť pestovanie porastov rýchlorastúcich drevín na poľnohospodárskej pôde.
10. Zavedenie integrovanej ochrany lesa proti kalamitným a inváznym druhom zavlečených škodcov.

DISKUSIA

Prípadová štúdia využila koncepčný rámec ESPON Climate a na tomto základe bola schopná vytvoriť súdržnú metodológiu posúdenia zraniteľnosti Nitrianskeho samosprávneho kraja.

Teplotné ukazovatele majú zreteľne vyjadrený vzrast priemerných aj extrémnych teplôt vzduchu vo všetkých ročných obdobiach na celom území kraja. Naopak, pokles počtu ľadových a mrazových dní ukazuje na celkove vyšší výskyt miernejších zím.

Zrážkové ukazovatele nemali za spracované obdobie výrazný trend.. Suma zimných zrážok v uvedenom období stagnovala a suma letných len slabo rástla. Výskyt intenzívnych zrážok tiež nevykazoval časový vývoj. Do trendov ukazovateľov zmeny klímy, ktoré sú výsledkom kombinácie teplotných a vlhkostných (zrážkových) ukazovateľov v podstatnej miere zasahuje vývoj teploty vzduchu.

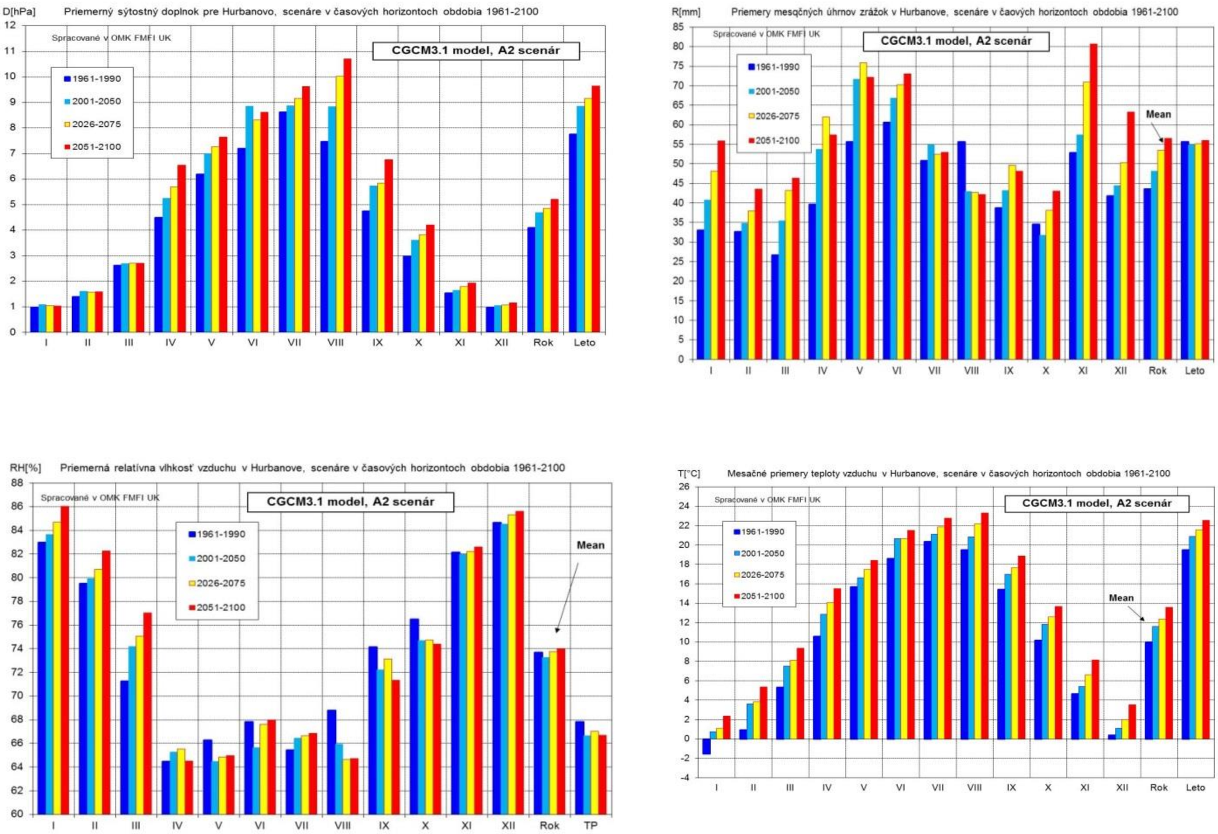
Trend aktuálnej evapotranspirácie v suchých oblastiach NSK rastie, no výraznejší je vzrast potenciálnej evapotranspirácie. Tento vývoj znamená vysúšanie vrchných vrstiev pôdy. Zmeny v cirkulačných pomeroch atmosféry zrejme spôsobia, že južná časť NSK bude zasiahnutá otepľovaním klímy a aj súvisiacou zmenou iných klimatických prvkov viac ako severná časť NSK. To sa prejaví predovšetkým v zhoršených podmienkach zavlaženia pôdy a v častejšom výskyte sucha. Na druhej strane, významné zvýšenie intenzívnych konvektívnych zrážok na úkor trvalých zrážok s menšou intenzitou bude mať za následok nevyrovnaný režim zavlaženia pôdy a častejší výskyt prívalových povodní v celej oblasti NSK.

V malej nadmorskej výške bude závažným negatívnym dôsledkom oteplenia klímy V malej nadmorskej výške bude oveľa častejší výskyt vĺn horúčav súčasne s vysokou absolútnou vlhkosťou vzduchu.

Výber, výpočet a zlúčenie jednotlivých indikátorov zahŕňajú nielen vedecké znalosti ale aj normatívne rozhodnutia, ktoré aspekty takých koncepcií ako sú klimatické zmeny, citlivosť alebo schopnosť adaptácie, majú byť zachytené a posudzované.

Adaptácia na klimatické zmeny je zadefinovaná ako prispôsobenie prírodných a ľudských systémov v reakcii na skutočné alebo očakávané klimatické podnety alebo ich účinkov, ktoré zmierňujú hrozby klimatické zmeny alebo využíva prospešná zariadenia. Adaptačné opatrenia v prípadovej štúdii sú zameraná na adaptačné prístupy v hlavných sektoroch hospodárskej činnosti v regióne u jednotlivých technických riešení až po návrh významných zmien v činnosti sektorov.

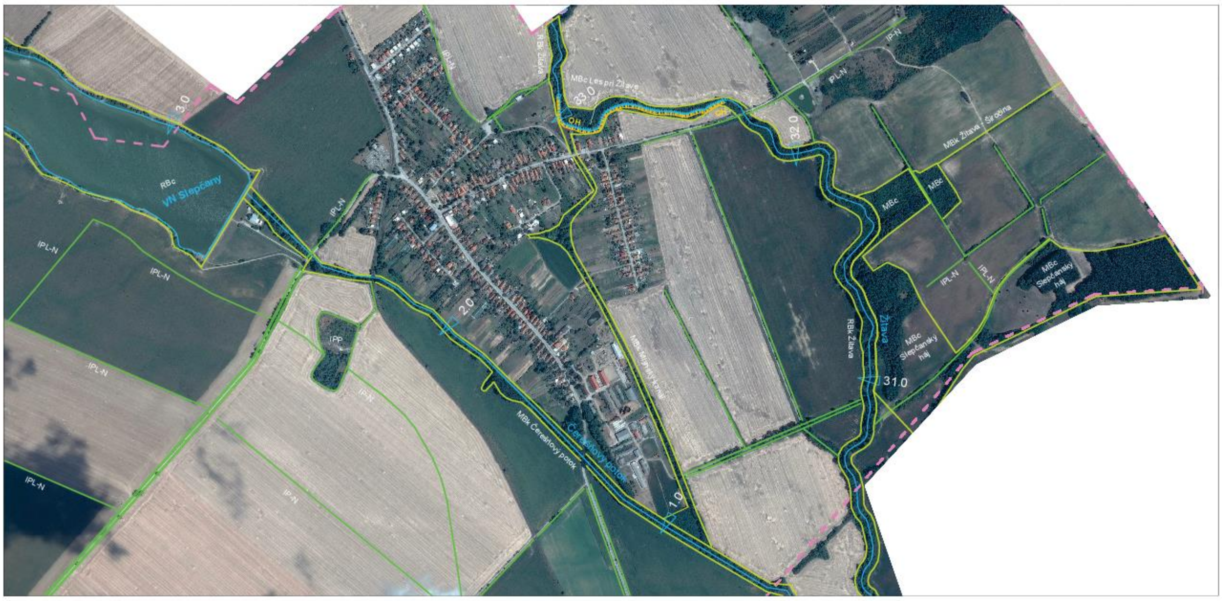
Rozsah návrhu adaptačných opatrení bol ovplyvnený nedostatkom údajov na likvidáciu škôd, nákladoch a prínosoch adaptačných opatrení, spôsobu monitorovaní a vyhodnotení už stávajúcich opatrení. Schopnosť adaptácie je závislá na dostupnosti finančných zdrojov, technológiách, dostupných informáciách, vhodnom plánovaní a celkovej infraštruktúre. ale aj normatívne rozhodnutia, ktoré aspekty takých koncepcií ako sú klimatické zmeny, citlivosť alebo schopnosť adaptácie, majú byť zachytené a posudzované.



Graf 1 Modifikované výstupy stanice SHMÚ Hurbanovo, Modelu OGCM3.1, EMISNÝ SCENÁR SRES A2, Scenáre v časových horizontoch obdobia 1961 – 1990, 2001 – 2050, 2026 – 2075, 2051 – 2100, Priemerný sýtostný doplnok, priemery mesačných úhrnov zrážok, priemerná relatívna vlhkosť vzduchu, mesačné priemery teploty vzduchu

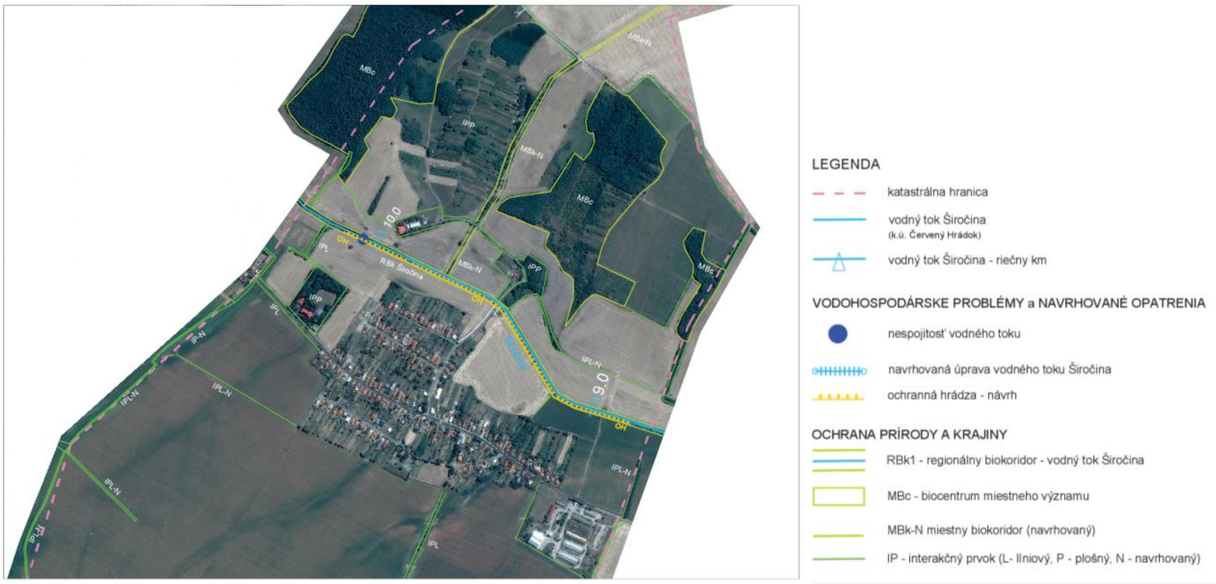
Obrázok 2 Návrh adaptačných opatrení pre dotknutú obec Malé Vozokany v sektoroch vodného hospodárstva a poľnohospodárstva (EKOJET s.r.o.)

Obrázok 3 Návrh adaptačných opatrení pre dotknutú obec Veľké Vozokany v sektoroch vodného hospodárstva a poľnohospodárstva (EKOJET s.r.o.)



Obrázok 4 Návrh adaptačných opatrení pre dotknutú obec Slepčany v sektoroch vodného hospodárstva a poľnohospodárstva (EKOJET s.r.o.)

Obrázok 5 Návrh adaptačných opatrení pre dotknutú obec Vieska nad Žitavou v sektoroch vodného hospodárstva a poľnohospodárstva (EKOJET s.r.o.)



Obrázok 6 Návrh adaptačných opatrení pre dotknutú obec Červený Hrádok v sektoroch vodného hospodárstva a poľnohospodárstva (EKOJET s.r.o.)

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