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LANDSCAPE PARKS COMPLEX
OF THE SILESIAN VOIVODESHIP

POLISH GEOGRAPHICAL SOCIETY
Katowice Branch

ANTHROPOGENIC ASPECTS OF LANDSCAPE TRANSFORMATIONS

6

Sosnowiec

Sosnowiec – Będzin 2010

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Oimahmad Rahmonov

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Investigation of groundwater level changes on the Szolnok-Túri Plain

Introduction

More than the half of the area of Hungary is flatland with the special hydrological feature of excess water inundation. In addition to floods excess water inundation considerably damages agriculture, traffic and urban environment as well. The problem of excess water inundation became of countrywide significance in the 19th century [Pálfai, 1988]. As several natural and anthropogenic factors play role in its formation, its investigation is complex.

Besides climate, relief, soil conditions, land cover as well as the anthropogenic factor, the hydrological conditions of the given area are relevant. The status of the groundwater level determines the water holding capacity of the topsoil and the layers below, or directly increases the area of excess water inundation in the case of break-through [Pálfai, 1994]. Its investigation is essential when characterising an area from the point of view of excess water inundation.

The aim of this study was to analyse the groundwater level fluctuation, as one of the factors influencing the formation of excess water inundation, on the Szolnok-Túri Plain in the Nagykunság region (Great Cumania), in the Middle-Tisza region. The analysis of data series forms part of an investigation with the point of view of excess water inundation. In this study other factors are not analysed.

Among the various definitions of groundwater the definition of Rónai [1985] is the most proper in the Hungarian Plain: "*The first water layer beneath the ground surface, which is mainly but not exclusively recharged from the infiltration of rainfall. Usually it has unconfined water table but not everywhere; dissolved materials show significant local differences.*"

In Hungary groundwater observation started in the 1930s with setting up a monitoring well system, then in the 1950s the VITUKI developed it to a nationwide network (Rónai, 1978; Stelczer, 2000; Szalai, 2004]. Now more than 2000 wells are operating [Vízügyi Adatbank, 2010].

The process of the hydrological data of the sample area goes back to several decades. Rónai explored the groundwater conditions on the Great Hungarian Plain for the period until the middle 1950s [Rónai, 1961, 1985; Rónai, Somogyi, 1969). Later Csordás & Lóki [1989] analysed the groundwater level changes in the period 1955–1980. This study processes the data of the last period. It's important to investigate the trend and fluctuation of groundwater level changes as they can play a significant role in the development of excess water inundation in the area.

Location and characterisation of the model area

The area of Nagykunság (Great Cumania) is mainly covered with Pleistocene and Holocene deposits. Blown sand occurs only in patches, especially on its northern part, which are mainly covered with loessal sand. South of the Berekfürdő–Fegyvernek line in the Szolnok-Túri Plain (fig. 1), which is bordered in the east by the Hortobágy-Berettyó, surface is monotonous. Loessal clay, silt and meadow clay are characteristic. Only the scattered sand dunes and the abandoned loops, meanders as well as the mounds give variety to the landscape.

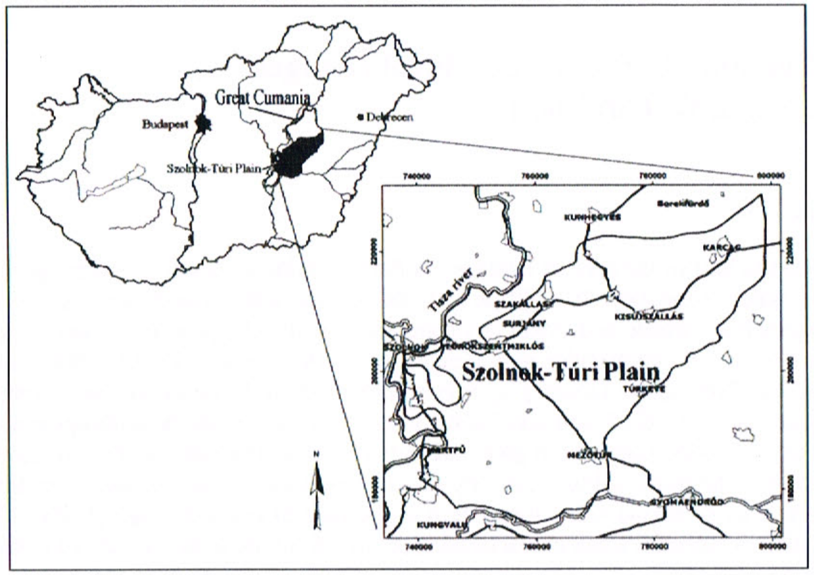

Fig. 1. The location of Szolnok-Túri Plain

According to Rónai [1961] the groundwater table is not flat in the Nagykunság. In north-east–southwest belts the groundwater level is deeper. According to data analysed until the middle 1950s groundwater table occurred even 6–10 metres deep. Rónai [1961] found that the groundwater level fluctuation increases from 4 to 6 metres in south direction, and can reach 8 metres near rivers. Temporary fluctuation proved to be 1–2 metres while the groundwater level change of a longer period was 4–6 metres from the 1930s to 1960.

Later studies [Csordás, Lóki, 1989] showed increasing groundwater levels. Groundwater level depth values written by Rónai weren't observed between 1955–1980. Average groundwater level fluctuation was of medium scale (35–70 cm). They pointed out the groundwater level increasing effect of humid periods.

Material and method

12 groundwater level gauging reference wells of the investigated area and its region constituted the basis of the analysis (fig. 2).

Data were processed by mathematical-statistical methods for the period 1989–2008. Microsoft Excel software was used to sort the data and determine their general statistical parameters.

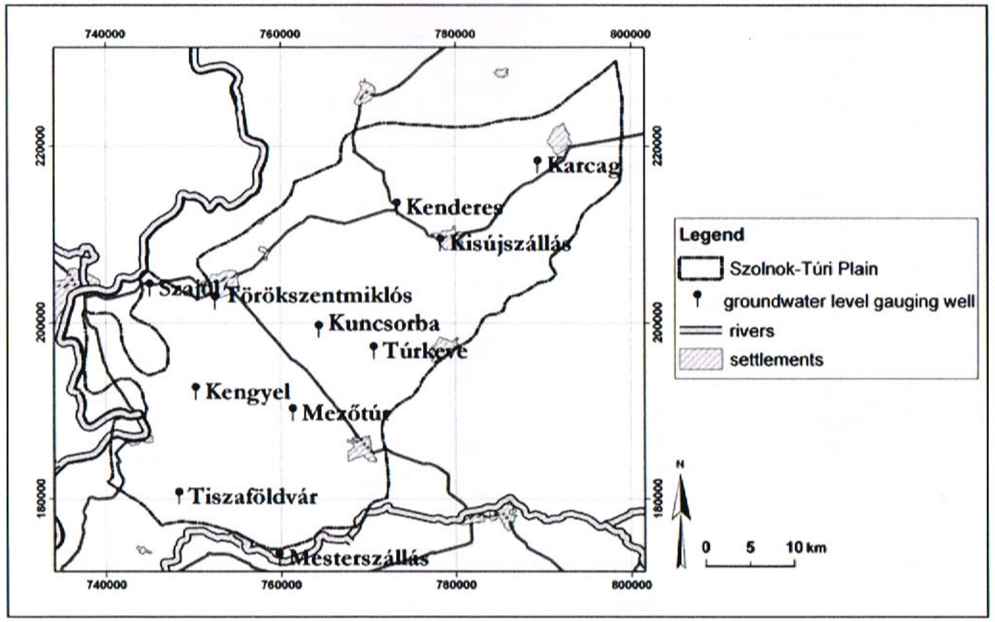

Fig. 2. The location of the analysed groundwater level gauging wells

Annual and monthly average groundwater levels were determined, which show the annual groundwater regime and indicate the long-term groundwater level changes and trend. Minimum and maximum values give information about the water level fluctuations annually and in the studied period.

From the point of view of excess water inundation development the direction of groundwater level change is of great importance, as in the case of higher water level soil becomes saturated earlier and water is more likely to appear on the surface. The scale of fluctuation indicates the extremities of the groundwater regime. Its significance lies in the fact that average groundwater level doesn't show the maximum values occurring after a period of higher precipitation, causing excess water inundation.

Results and conclusions

The annual period of the groundwater regime can be observed in the model area as well. Following the minimum levels in autumn and winter the groundwater levels rise and reach a maximum value in spring and early summer (fig. 3).

According to earlier studies the time when the highest groundwater levels occur shifts more and more to early summer from east to west [Csordás, Lóki, 1989]. The data of the studied period outline this tendency as well. In the eastern parts of Szolnok-Túri Plain maximum values are found in April, while approaching the Tisza they were measured in May and June. Minimum values occurred in September (Kisújszállás), October and November. In this case such regularity as in the case of the highest water levels can't be determined.

In the last 19 years the average annual fluctuation was high in almost every groundwater level gauging well of the model area in contrast with the period before the investiga-

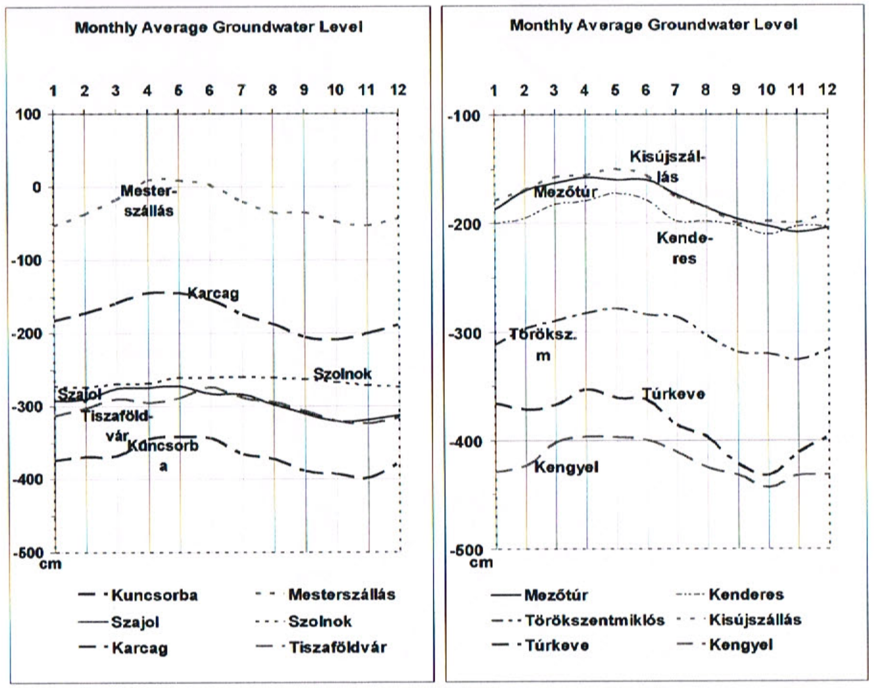

Fig. 3. Monthly average groundwater levels

tion (table 1). In the favour of comparison the Csordás & Lóki [1989] classification (0–34 little, 35–70 medium, 71< large) was used to characterise the fluctuation. The scale of fluctuation doesn't show any tendency approaching the Tisza, the balancing effect of surface water can be observed only in Szolnok (47.05 cm), which can be said a medium value.

On the whole the increase of groundwater level fluctuation can be observed in the studied area.

In general the scale of fluctuation is in connection with the soil conditions. Wells with high water level fluctuation (Szajol, Mesterszállás, Karcag, Kuncsorba, Törökszentmiklós, Túrkeve) are located on soils with good or medium infiltration capacity, while wells showing lower fluctuation (Tiszaföldvár, Kenderes) lie on soils with unfavourable water management features. In the latter case an aquiclude near the surface prevents the precipitation from the infiltration into the soil, decreasing the scale of fluctuation. Where this connection doesn't exist other factors cause the fluctuation such as anthropogenic or meteorological influences.

Groundwater levels rose compared to the first year of the studied period except 3 wells (Szajol, Tiszaföldvár, Kisújszállás) (table 1). The rise in the case of 3 wells (Mezőtúr, Túrkeve, Kengyel) exceeded 100 cm. The increasing trend of groundwater levels shows periodic fluctuation. As the data of 2008 form part of a decreasing tendency, the average groundwater level difference between the first and last years can be deceiving. Fitting a trendline on the groundwater level curve, even in the case of Szajol a moderate rise can be observed despite supposing the highest decrease for this well (fig. 4 – bottom).
Groundwater levels show 3 periods of high water level in the studied period: the very early and very late 1990s and 2006. These phenomena can be explained with the change of mete-

Table 1. The data of the analysed groundwater level gauging wells in the studied period

Ref. No.	Name	Depth of well (m)	Average groundwater level (cm)	Maximum (cm)	Minimum (cm)	Average annual fluctuation (cm)	Rise (cm)
002109	Kuncsorba	10.77	-369.72	-85	-553	115.95	85.5
002208	Mesterszállás	6.92	-27.07	130	-236	126.2	92
002122	Szajol	8.2	-294.46	12	-461	142.3	-110
002192	Szolnok	7.8	-266.90	-180	-362	47.05	31
002089	Karcag	7.28	-177.54	3	-375	117.95	53
002133	Tiszaföldvár	9.75	-301.43	-100	-426	88.75	-96
002110	Mezőtúr	10.88	-176.90	-8	-335	97.3	113
002080	Kenderes	10	-194	-13	-389	91	17.5
002103	Törökszent-miklós	9.6	-300.96	-70	-501	115.85	51.5
002116	Kisújszállás	12	-176.52	-15	-321	99.15	-40.5
002119	Túrkeve*	8.88	-384.30	-117	-544	103.4	138.5
002106	Kengyel	8.72	-419.14	-113	-558	81.65	140

*gappy data

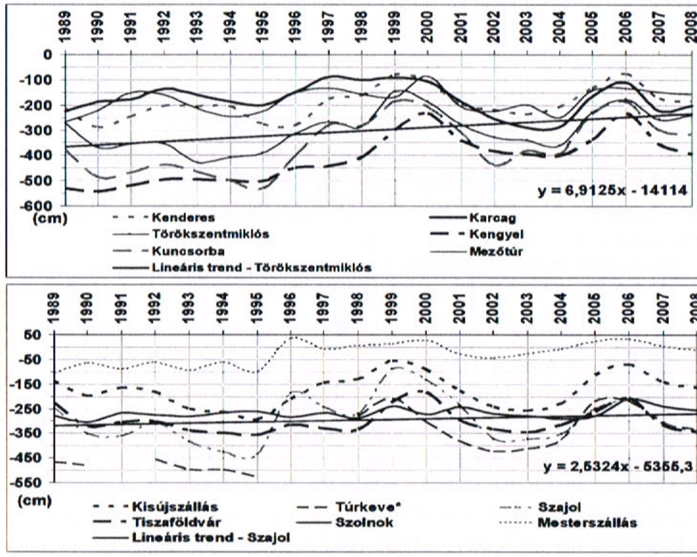

Fig. 4. Change of the groundwater levels

orological conditions. In the second half of the 1990s higher precipitation resulted in extreme hydrological situations, floods, excess water inundation as well [Szlávik, 2003]. As an effect of excess precipitation in winter 2005 and spring 2006 flood passed on the Tisza River in 2006 to a similar extent to 1999. The influence of excess precipitation can be detected in the water regime of the monitoring wells.

Summary

In the model area the maximum groundwater level value usually occurs in April and May while the minimum value can be observed between September and November. The average annual fluctuation is high, about 100 cm, which is higher than experienced in the earlier years. The rise has allowed drawing the conclusion that extremities are getting larger through the years. The scale of fluctuation shows correlation with the soil conditions of the area. The depth of water table decreases in the analysed period. Earlier investigations pointed out this tendency as well.

Periods of high water levels correlate to the hydrometeorological conditions of the area. The model area is mainly under cultivation, which can be damaged by the excess water inundation to a large extent. The rise of groundwater level can be shown, which results in the faster saturation of the soil. Thus the water holding capacity decreases which can lead to excess water remaining on the surface in the case of less permeable soils. Consequently the groundwater level is a factor that significantly influences the formation of excess water inundation and needs to be continuously monitored.

In the near future it will be worth investigating the other factors leading to the development of excess water inundation and comparing their effects and interference.

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Tourism as a way of revitalization of post-industrial landscape: the Industrial Heritage Trail in Ruhr Area (Germany)

Introduction

Post-industrial landscape is a part of industrial heritage of former industrial areas which are to find all over the Europe. They had been formed as a result of intensive development of heavy industries started in the 18th century by industrial revolution. Nowadays, due to the decline in coal mining and steel production, these regions are losing their original function and have to deal with many various problems, such as unemployment or developing wastelands of old industry. They also need to find a new way to develop and revitalize.

The notion of 'revitalization' refers to sequence of planned actions with a view to converting spatial and functional structure and economic revival of wastelands [Kaczmarek, 2001]. A good way of revitalization of post-industrial areas seems to be developing cultural tourism based on industrial heritage understood as industrial culture remnants, of great historical, technological, social, architectonic or scientific value, which contain among others all kind of industrial buildings and landscapes. The post-industrial tourism includes elements of industrial heritage, which have lost their original purpose, reused into tourist attractions or objects connected with tourism (e.g. restaurant, hotel) [Badulescu, Bugnar, Badulescu, 2005; Conesa, Schulin, Nowack, 2007; Kronemberg, 2007; Xie, 2006].

The aim of this paper is to show that it is possible to revitalize post-industrial landscape by developing it into a tourist attraction. It would be shown on an example of Ruhr area in Germany, which used to be the biggest industrial region in Europe, famed for its coal mines, steel works and also polluted environment and which is now Europe's fourth largest metropolitan area, consisting of a number of post-industrial cities with well–developed services, especially tourism. In the paper the regional tourist project entitled "The Industrial Heritage Trail" will be presented. In particular, there will be described landscape parks created for the trail in place of industrial objects.

Revitalization of Ruhr Coalfield Area

Revitalization of Ruhr coalfield area started in 1960., when there was a crisis of coal surplus. It was fallowed by another crisis – in steel industry in 1970. Coal mining and steel production weren't commercially viable anymore and many mines and foundries had to be closed down. As a result three questions appeared:

1. What to do with post-industrial areas?
2. How to change Ruhr area's image?
3. How to fight with unemployment?

The big step to solve these problems was International Building Exhibition (IBA) Emscher Park 1989–1999. It was a programme created to give an impulse for new ideas and projects for the future of the Northern Ruhr area – the Emscher river region. One of its main goals was to preserve and restore impressing landscapes and unique building examples of the industrial age as the heritage [Parent, 2005; Willms, 2005].

Thanks to IBA many projects were created and then fulfilled. According to one of them – the regional tourist project, which is in the responsibility of the Regional Association of the Ruhr, "The Industrial Heritage Trail" was created (fig. 1). The trail connects the most important post-industrial tourist attractions in region, which are now well marked out and widely promoted and therefore easy to visit. This trail is nowadays one of Europe's most successful thematic tourist routs [Lange, 2004; Willms, 2005].

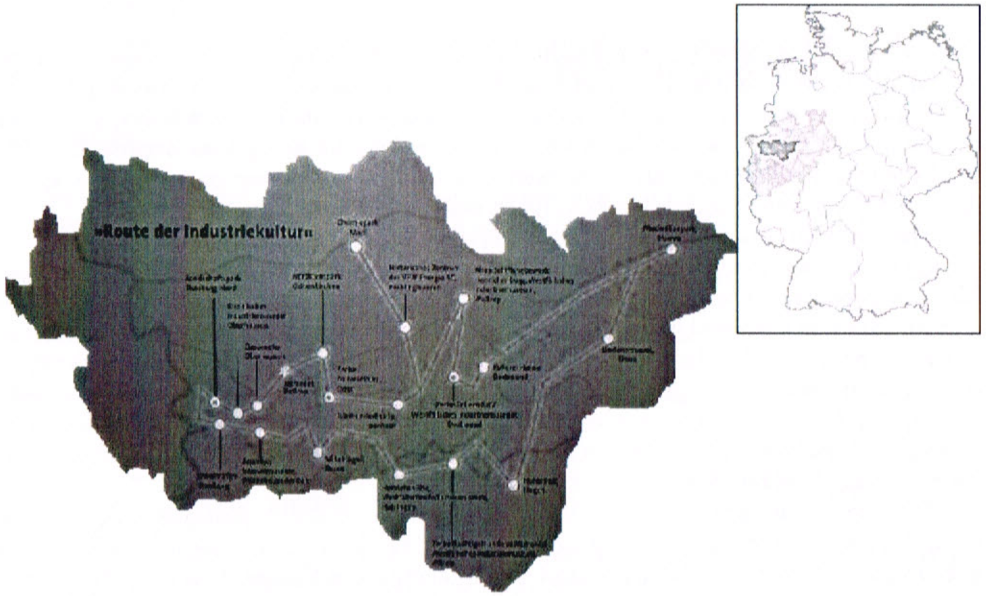

Fig. 1. The Industrial Heritage Trail in Ruhr area (Germany)

The Industrial Heritage Trail

"The Industrial Heritage Trail" leads threw 15 cities. The project consist of the 400 km long main route and 25 theme trails. The main route connects 25 outstanding industrial heritage sites, so-called anchor points (tab. 1). With the main route are also connected 14 panorama points and 13 significant workers' settlements. Theme trails are prepared for more demanding visitors and they show a lot about the many-sided aspects of Ruhr area's industrial heritage and history. Some of them are about industry in particular city, others concern different branches of industry, another reveal industrial attendant objects.

Table 1. Previous and current function of anchor points of the Industrial Heritage Trail

Anchor point	Previous purpose	Current function
The Zollverein World Heritage Site in Essen	The Zollverein colliery complex (mine and coking plant)	Cultural centre with museum, art gallery, design centre, casino
The Bochum Hall of the Century	Exhibition pavilion than used as workshop and warehouse	Exhibition hall
German Mining Museum in Bochum	-	Museum
The Reckilnghausen Transformer Plant	The Transformer Plant	The Museum of Electricity and Life
Chemical Industry Estate in Marl	The Hülls Chemical Works	A comprehensive service and manufacturing estate for a wide range of chemical industry firms
Old Henrichenburg Shiplift in Waltrop	A lift for ships	One of the sites of the Westphalian Industrial Museum
Zollern II/IV Colliery in Dortmund	The Zollern II/IV Colliery	Museum of Social and Cultural History of Ruhr area's Mining in the 20th Century
Hansa Coking Plant in Dortmund	The Hansa Coking Plant	The headquarters of the Foundation of Industrial Monuments and Historical Culture
German Occupational Safety and Health Exhibition (DASA) in Dortmund	-	Exhibition centre
Maximilian Park in Hamm	The Maximilian colliery	The leisure park with cultural objects
Linden Brewery in Unna	The Linden brewery	Arts centre with several bars and restaurants
Hohenhoff in Hagen	The villa of the Osthaus family	Museum
Westphalian Open-Air Museum in Hagen	Workshops in the Mäckinger Valley	Open-Air Museum
Nightingale Colliery and Mutten Valley in Witten	The Nightingale Colliery and brickworks	One of the sites of the Westphalian Industrial Museum
Henrichshütte in Hattingen	Steelworks	One of the sites of the Westphalian Industrial Museum
Railway Museum Bochum – Dahlhausen	-	Museum
Villa Hügel in Essen	Villa of the Krupp family	The seat of the Ruhr Cultural Foundation
Ruhrland Museum in Essen	-	Museum
Aquarius Water Museum in Mülheim an der Ruhr	The Water tower	Museum
Duisburg Inner Harbour	Inner harbour	Residential, working and leisure area
German Inland Waterways Museum in Duisburg	Indoor bath	Museum
North Duisburg Landscape Park	The Meiderich Ironworks	Landscape park
Rhineland Industrial Museum in Oberhausen	The Altenberg zinc factory	Museum
Oberhausen Gasometr next to CentrO	Gas storage	Exhibition hall
Nordstern Park	The Nordstern Colliery	Landscape park

Most of objects co-creating the trail used to be industrial plants. There are former collieries, steelworks, ironworks, coking plants, workshops, breweries, chemical works and factories, which thanks to revitalization gained a new function (tab. 1). Many of them became cultural objects like museums, exhibition halls, art galleries and landscape parks, which are now eagerly visited by tourists.

Another part of "The Industrial Heritage Trail" are panorama points. Some of them are located on mining tips, which are no longer wastelands. They were converted into recreation places, kind of parks, where people can stroll and rest or practice sports. Some of them are also used by artists or scientists – on their tops there are sculptures or scientific installations. For example: on the top of Schwerin tip in Castrop-Rauxel there is a huge sundial and on the tip of the Prosper colliery in Bottrop there is a Tetrahedron, at the top of which is a circular viewing platform. Another landmarks, designed by artists, are to find on Rheinelbe tip in Gelsenkirchen and Schurenbach tip in Essen. On the first one there is a construction called "stairway to heaven", and on the other one – the 15 m high steel slab.

The most interesting mining tip in Ruhr area is Hoheward tip in Herten, which is actually the biggest one in this region. This tip has been converted into a landscape park and on its top there is an astronomical park. Nowadays there are two astronomical objects: sundial with the obelisk showing hours and the horizon observatory. In the future another astronomical installations will be built.

Landscape parks on the trail

The important part of industrial heritage is post-industrial landscape. It deserve preservation because its element (like e.g. water towers, pithead towers or mining tips) are 'witnesses' to industrial history of the area and also to its structural transformation. The most popular way of preserving landscape is to establish a landscape park.

On the main route of "The Industrial Heritage Trail" there are three landscape parks created in place of former industrial plants: Maximilian Park, Nordstern Park and North Duisburg Park. All of them are full of astonishing conversions of industrial buildings and therefore willingly visited by tourists.

Maximilian Park in Hamm was formed on the site of Maximilian colliery. Its symbol is a glass elephant, built onto the disused coal washery. From the elephant, whose head is accessible by lift, it is possible to watch the whole park. In the park there is a lot of greenery. The special attractions are Butterfly House and Scented Garden. Apart from that in old colliery buildings there are located cultural objects like concert halls, galleries, restaurants and The Natural Museum.

Nordstern Park in Gelsenkirchen is another landscape park made on the site of mine. It is localized in the vicinity of Emscher river and Rhine–Herne Channel. One of its attractions is the open-air amphitheater on the channel bank with a jetty for pleasure boats. The other attractions are: mock mining gallery, 'children's land' and climbing garden. The park includes also trading and residential areas.

North Duisburg Landscape Park was created in place of ironworks. It is an unusual site. Its attractions are placed on old industrial buildings. There is a free-climbing zone amongst the old ore bunkers and a water-filled gasometer is now an underwater diving centre. There is a restaurant in warehouse too. The park is a place for hiking and cycling. It is also a special venue for concerts, performances, film shows, discos and light shows by night. There is finally a lot of place for children. They may slide down the drain into the bunker or play in jungle gym. The Park has also its own farm with goats and horses.

Conclusions

The post-industrial tourism helped Ruhr area to change its image. It is no longer 'Europe's largest black country', it became clean, green and well developed. Tourism helped to create new workplaces, helped also to convert the environment into more friendly both for visitors and for inhabitants. Finally it helped to revitalize post-industrial landscape. Mining tips aren't wastelands anymore, also old industrial buildings gained new functions. So the industrial heritage is preserved.

The aim of this paper was to show that it is possible to revitalize post-industrial landscape by developing it into a tourist attraction. The example of Ruhr area confirmed it. Tourism stimulates regional economic development, by demanding appropriate infrastructure: roads, accommodation, catering industry and by creating new workplaces. It may attract investors, it may prompt the locals to act. Postindustrial tourism is also a chance for old industrial buildings and sites. Converting them into tourists attractions or into objects accompanying tourism is a way of preserving and revitalizing them in the same time.

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Gábor DEMETER

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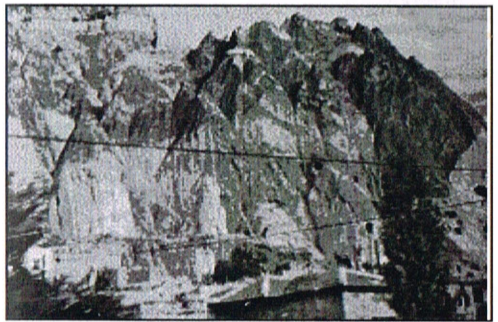
The role of degradation in creating semi-anthropogenic geomorphic and touristic values: the earth pyramids at Stob (Bulgaria)

The study focuses on answering the question whether overuse and degradation of the landscape may created creating unique geomorphic and geologic values. Certainly outcrops and mines may produce forms of great scientific importance, and therefore can be considered unique landscape values, but these are typically results of anthropogenic processes, while this study focuses on landforms created by accelerated natural processes, (re)induced by human activity.

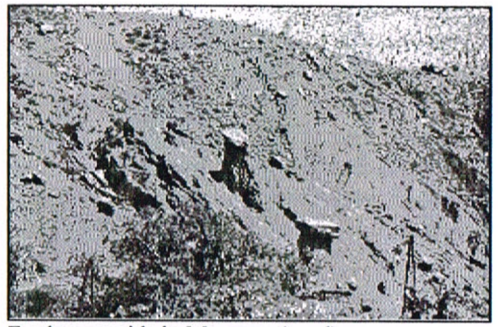
The question is also worth examination, whether a phenomenon that produces geomorphic values can be addressed as degradation at all? The transformation of the examined landscape produced turistically attractive forms in Stob (although their turistical significance has not been exploited yet), however it is unquestionable that geomorphic processes are responsible for the collapse of the traditional agriculture. Noone should think, that these processes were unpredictable. Indeed, it was the original landuse that produced altering circumstances, accelerating erosion, that – as a positive feedback – ruined the traditional way of life, pushing the once blooming rural area producing wool for the textile industry in the 19th century into poverty by the turn of 20th century.

The study examines the circumstances leading to the formation and persistance of originally unstable landforms, known as *earth pyramids* (*hoodoos*) at Stob, Bulgaria. Their outlook and appearance based on their visual physical features (shape, lack of soil cover, steepness, gullying, dissection) is quite similar to that of the hundreds of earth pyramids, *boulder caps* in Cappadocea (Üçhisar, Turkey; phot. 1), or the lonely *fairy chimneys* of Bükk Mts. formed on tuffs (phot. 1) [Martonné Erdős, 1972; Baráz, 2000], although the Bulgarian earth pyramids were not formed on volcanic material. These pyramids are similar to the forms of Kuršumlje or the boulder caps of Ritten, South-Tirol and Kvitskriuprestene in Norway, both formed on moraine clay, and also resemble to the *badland* of Kazár (Hungary) (phot. 1) or erosional forms created on mud volcanoes (Policiori, Romania). Similar gullying may occur in semi-arid areas (Morocco). Most of these are good examples of converging evolution in geomorphology, where different parent material and climate produces similar landforms (sometimes even the driving processes can be different).

Nevertheless, the aforementioned landforms were formed under natural circumstances without or with moderate human impact, unlike the Bulgarian example, where overgrazing was a crucial process in creating the present situation.



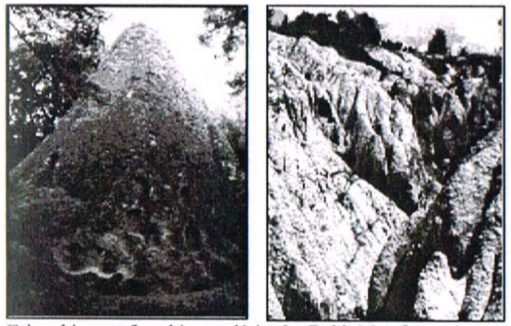
Fairy chimneys (tuff) in Cappadocea (Üçhisar), (phot. by the author)



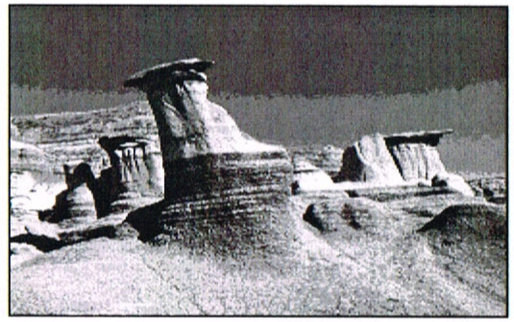
Earth pyramids in Morocco (sand) (phot. by G. Szabó)

Ritten, South-Tirol, Italy (clayey moraine)

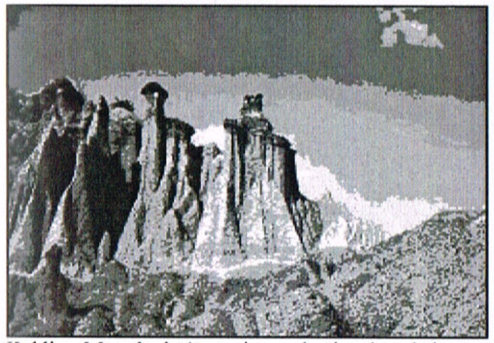
Hoodoos in Đavolja Varoš, Kuršumlje, Serbia



Fairy chimney (bee-hive rock) in the Bükk Mts. formed on tuff / the badland of Kazár (fluvial, formed on loose sediment) both in N-Hungary (phot. by the author)

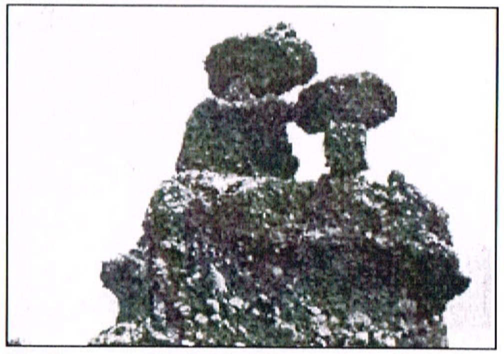


Hoodoos in Alberta (tuff)

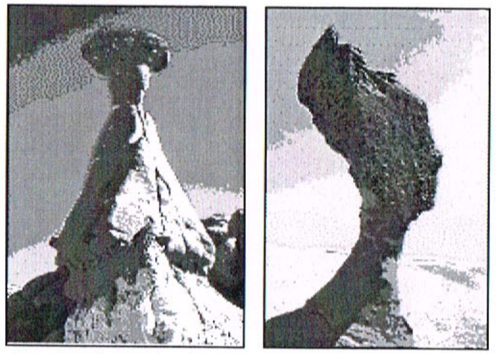


Kuklica, Macedonia (tectonism, selective denudation, wash-out of minerals)

Kvitskriuprestene Norway (moraine)



Bouder cap in Dachstein (chemical weathering) (phot. by Schaffer)



Hoodoo in Bryce Canyon, and in Taiwan

Phot. 1. Examples of convergent evolution in geomorphology: same forms may occur on different parent rock, in different climate, or as the result of different processes (pictures are from the internet, or made by Schaffer, or by the author)

The village Stob is located in the hilly foreland region of the Rila Mts. at 300–500 m altitude above sea level on the dissected piedmont surface of the Rilski river along the Struma valley (phot. 2). The accumulation surface composed of unconsolidated proluvial materials [Dinev, Misev, 1981] is now characterised by steep slopes and often 30–50 m/ha relief. The fact, that the area was formerly a glacis is proven by the abundance of the more than 40 m thick, reworked, unconsolidated brownish red material mainly consisting of coarse sand and gravels with acute edges, referring to short distance of transportation, sometimes with fossil soil stripes referring to periods of reduced accumulation. This inhomogenous ferroginous material (representing reworked and transported, chemically weathered material during the alternation of semi-arid – arid climatic conditions) alternates with 1–2 m thick zones of unweathered granite, gneis, quartzite, schist and limestone blocks and conglomerates, representing the reworked parent rock of the denudated, uplifted core mountain (Rila Mts.). These layers resist erosion much more compared to the reddish matrix, and the long, thin ridges are usually composed of this material.

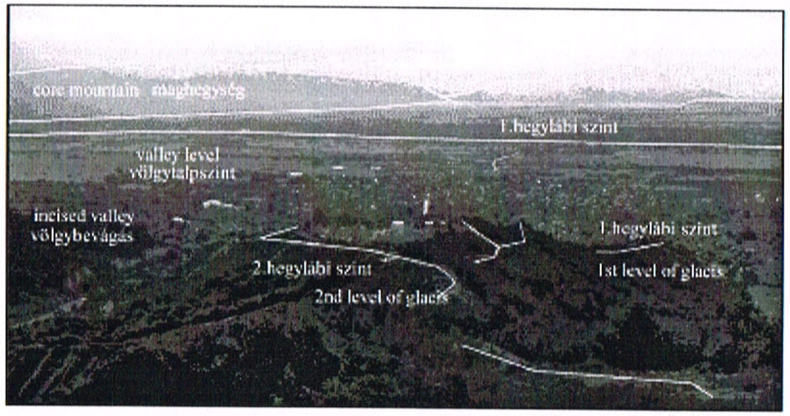


Photo 2. Morphologic levels at Stob and scenery from the pyramids

The repeated abundance of these conglomerate layers refers to many climatic or tectonic events, when the relative relief between the core and the foreland suddenly increased, such as the transporting capacity of water, that could carry away large blocks as well. The reason may be the periodical uplifting of the area or the variation of periglacial-semi arid-aridic climates (or both) (fig. 1). This complex, friable, deltaic sediment was accumulated at the foot of a slope as a result of an occasional torrential, loose and semi-compact alluvium.

Another theory emphasises that the material was brought there by the glaciers that once covered the high parts of Rila Mountain. „*The heterogeneous composition of the dust and the poor solder facilitate rapid dilapidation, thus the pyramids are carved in rusty red colored, thick – up to 40 m - river-glacier veil, accumulated at the foot of the mountain.*" [http://mystiquemountains.com]. The theory of Wagner is somewhat different, but can be connected to the moraine-theory as well: he has the opinion, that former valleys – incised in parent rock – are filled up with reworked material, and later torrents reworked the moraine (fig. 2). The formation of other European earth pyramids are also connected to glacier moraines: like Ritten in Italy, or Kvitskriuprestene, Norway. But this theory cannot explain the red colour of the sediments at Stob (while the moraine transported material composing the Kvitskriuprestene in Norway is white, leached) – unless it is a result of longlasting post-glacial warming when increased precipitation washed out iron from the granite and impregnated the 40 m thich sediments. The theory nor can explain the repeatedness of boulder layers (unless supposing several times of melting), neither the amount of transported material. In case of Kvitskriuprestene the reconstruction of the fossil surface supposed boulders located accidentally, no layers of boulders were found. The area of Stob cannot be regarded as covered by moraines, since it is to large (several kms^2) for the small Rila glaciers to produce huge surfaces of reworked deposits.

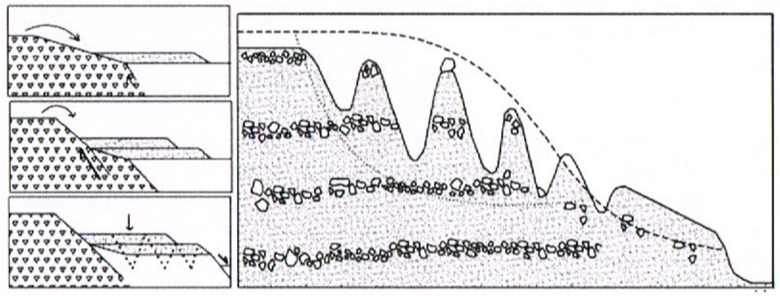


Fig. 1. The formation of Bulgarian earth pyramids according to the author (Kuklica-type pyramids)

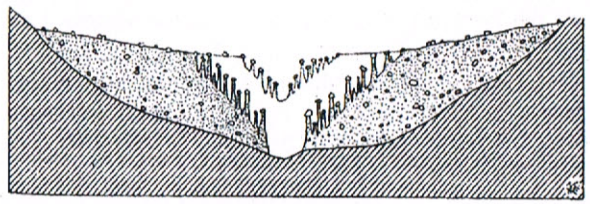


Fig. 2. Sketch of the formation of the earth pyramids according to Wagner (Ritten-type)

A reconciliation of the 2 theories may be possible, if we suppose that the reddish material of the glacis was accumulated previously, during the pedimentation process, and the glaciers (or meltwaters) of the Pleistocene dissected the area later carving U-shaped valleys into ridges (phot. 3). Nevertheless other sediments have different stories, their formation might start in the geological past: i.e. the stone figures of Kuklica in Macedonia were formed „*10 million years ago, by tectonic events and selective erosion, from minerals that dissolve in water. As the time passed, nature created masterpieces. The local population says that every 5–6 years new figures appear*" (a distinction should be made between the age of sedimentation and the age of forms, which can be very young as well). The different origin (converging evolution) of earth pyramids is summarised in table 1.

Photo 3. Steep U shaped valley referring to incision taking place under different climatic conditions: whether supposing Mediterranean torrents, or meltwaters of Pleistocene, it is evident that the transport capacity of waters were higher than nowadays

The present geomorphology of the landscape is the joint result of a tectonic uplift (or the sinking of the nearby Struma alluvial plain along fault lines perpendicular to the waterflows arriving from the core, like Rilski river) and a climatic change in the late Pleistocene, resulting deep incised valleys dissecting the surface of the glacis. The unstable slopes merging without terraces to the huge valleys – which are dominated now by smaller torrent flows of low water quantity and sediment transport capacity – were also formed in this period.

In the early Holocene the whole area – dissected by subsequent gullies perpendicular to the mean valley – was covered with forest vegetation. This forest was cut down due to the population increase in the Middle Ages, as cultivation in the valleys produced no more enough food. Husbandry, which was a secondary, supplementary way of livelyhood became a new alternative. Sheep and goat herds were grazing the slopes in historical times producing substantial raw material not only to subsist, but to support textile industry with wool at the time of industrial revolution. Unfortunately, clearcuts and animal husbandry resulted overgrazing, enhanced runoff and soil loss on the especially unconsolidated sediments, and the decline of husbandry itself. Together with the abundance of relatively steep slopes it accelerated the process of degradation. The dynamic equilibrium state of the area was modified and shifted towards an increased material transport, contrary to the relatively small precipitation and water transport (compared to earlier periods). It is evident, that some of the forms have already existed in the Middle Ages, and still exist (the name of a fairy chimney is a Turkish word Kulé = Tower, but this is only a "terminus ante quem" datation), but the age of their formation is unknown: they can be either few thousand or few hundred years old. These forms are not in standstill (see Kuklica). Under the influence of rain, heat and wind, the shape of the forms is changing, as some are destroyed, some rock hats fall and new pyramids are originated.

At Stob frozen earth-waves and earth curtains were formed beside fairy chimneys. The latter were preserved by the boulders on their top, preventing the unconsolidated material

Table 1. A summary table on the origin of fairy chimneys (hoodoos)

Material	Accumulating process	Gullying process	Climate/ colour	Form	Example
proluvium (sand-boulder)	glacis formation	fluvial dissection (torrents or meltwaters), deforestation, semi-anthropogenic	mediterranean, redish	fairy chimneys, boulder caps, badland	Stob, Melnik
moraine (clay-sand-boulder)	prograding glacier meltwaters	torrent waters natural	leached, white, yellow, brown	fairy chimneys, boulder caps, badland	Ritten, Kvitskriuprestene
tuff, volcanic m. (pyroclastic, tuffite, intra- and extraclastic boulders)	volcanic explosive processes	fluvial, erosion, slope retreating natural	not distinctive	fairy chimneys, boulder caps, badland	Bükk Mts. Üçhisar, Đavolja Varoš
unconsolidated (any) consolidated	not distinctive	tectonism and /or chemical weathering	not distinctive	fairy chimneys, boulder caps	Kuklica Kőszegi Mts. Dachstein Mts.

from being transported. Therefore these fairy chimneys look like boulder caps (sometimes of different origin, see Schaffer [1919]) and refer to the former height or width of the ridge. Thus, photo 4 refers to the denudation caused by anthropogenic effects. The process may continue to the next layer of boulders, if the fairy chimney loses its protective cap. Therefore nor the geomorphologic age of these forms, neither the original height of the surface can be estimated.

Photo 4. Earth pyramids wittnessing the original altitude of the ridges. Parallel linear forms seen at the bottom are the result of overgrazing

Since the population is now giving up grazing, reforestation take place in the area. This endangers the sustainability of the versatile, unique landscape, which has cultural values as well. Beside a chapel from the 10th century and some ruins from the Roman times, at least 2 myths are connected to the formation of the fairy chimneys. One of the stories tell, that the bride and the groom were not allowed to see each other before wedding, therefore the girl was veiled while escorted to the village of the husband. Once one of the relatives, or the bride could not resist temptation and unveiled the girl. Both were turned into rock according to the legend. The second story is about a girl, who fell in love with a boy from a neighboring village. Unfortunately, the boy was Muslim and the mother of the girl did not want her to get married with the boy. The youngsters decided to escape, but the mother revealed their plan and cursed them. Both were turned into fairy chimneys.

Other earth pyramids at Stob – see photo 5.

Gullying and valley regression resulting the consumation of the ridges

Earth pyramids: the conglomerate and boulder layers consolidate the fine reddish sediments

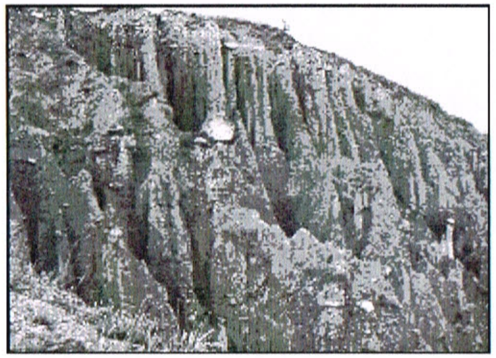


Photo 5. The Bulgarian earth pyramids at Stob (photo by the author)

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http://mystiquemountains.com

Anthropogenic aspects of landscape transformations	6	Faculty of Earth Sciences, University of Silesia Hall City Office Sosnowiec Landscape Parks Complex of Silesian Voivodeship Polish Geographical Society, Katowice Branch Sosnowiec – Będzin 2010	23–28

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Anthropogenic denudation in mining areas: a case study of "Andaluzja" mine, Silesian Upland

Introduction

The problem of anthropogenic denudation has been raised in numerous works, especially since the second half of the 20th century [Korzhuev, Timofeev, 1959; Zapletal, 1969; Rathjens, 1979; Nir, 1983; Goudie, 2005 and others]. In Poland, geographic literature is focused on anthropogenic denudation in agricultural land [Dylik, 1958; Gerlach, 1967; Jahn, 1968; Lach, 1984; Sinkiewicz, 1998], whereas in mining areas, the process is studied less frequently [Żmuda, 1973; Jania, 1983; Dulias, 2005; Kupka,Szczypek, Wach, 2005; Aleshina, Snytko, Szczypek, 2008; Solarski, Pradela, 2010]. Results of studies indicate that the removal of earth material in mining regions – particularly in coalfields – is taking on several times bigger proportions and rate than agrotechnical or natural denudation [Dunrud, Osterwald, 1980; Bell, Stacey, Genske, 2000, McNally, 2000; Gavrilenko, Yermakov, 2002; Martinec et al., 2005; Harnischmacher, 2007 and others]. Therefore, working out universal methods of research of anthropogenic denudation is an important task for anthropogeomorphology.

One of the main mining regions in Poland is Silesian Upland. Between mid 18th century and the year 2007, 7.4 billion tons of hard coal were extracted there, from which up to 72% of total extraction was conducted in the Upper Silesian Coal Basin (10.3 billion tons). As a result of underground coal extraction, most part of the Upland was found within the range of mining subsidence that caused lowering of the surface by several to twenty metres, and locally by over 25 m. According to Migoń [2006], denudation can be regarded as a specific kind of mass-movements when the displacement occurs only vertically, and the horizontal component of movement equals zero. From this point of view, the rate of surface lowering due to mining subsidence (mm/year) can be regarded as anthropogenic denudation rate [Dulias, 2006a].

The aim of the following paper is to present methods of calculating anthropogenic denudation in mining areas on the example of one hard coal mine ("Andaluzja") situated on the Silesian Upland. Anthropogenic denudation rates were calculated on the basis of balance of extraction and morphometric analyses. The results were presented in comparison with anthropogenic denudation in other mining areas as well as agricultural and quasi-natural land.

Research methods

Anthropogenic denudation rates were calculated on the basis of removal of rock from the substratum by means of two methods: 1) from the balance of coal and waste rock extraction, and, 2) from morphometric analyses based on archival and contemporary cartographic materials.

Data on coal extraction were taken from the study by Luksa [1959] and "Statystyka przemysłu węglowego" [1945–2007]. Waste rock output was estimated on the assumption that there is one ton of extracted coal to 0.2 ton of waste rock on average (Kupka, Szczypek, Wach, 2005]. Assuming after Żmuda [1973] that in the Upper Silesian Coal Basin one ton of coal has a volume of 0.74 m^3, and one ton of waste rock – a volume of 0.38 m^3, the volume of extracted mineral (the volume of mining workings) was calculated. Next, on the basis of data on the percentage of used exploitation methods, the volume of workings directed to roof-fall and stowing was established. Obtained values were multiplied by subsidence rates accordingly: with roof-fall exploitation by 0.7, and with stowing by 0.15 [Borecki 1980], and then they were added and divided first, by the surface of the mining area and then, by the duration of mining activity. The obtained rate of surface lowering (anthropogenic denudation rate) is expressed in mm/year.

In morphometric analyses German Topographische Karte 1:25 000 [1883] and Mapa topograficzna 1:10 000 [1995] showing the hypsometric situation in 1993 were used. Based on these maps, hypsographic curves for the pre-mining and mining periods were drawn. Surface measurements of particular height-intervals were performed for the counter interval every 5 m. With the use of hypsographic curves – mean height of the area for both research periods was calculated. The surface lowering rate was obtained as a result of dividing the difference between mean heights of the area by the years of mining activity and it was expressed in mm/year.

Research area

"Andaluzja" coal mine is situated on the Silesian Upland. Most part of the mining area belongs to the Siemianowice Upland, and only a small part of it, north of the Brynica valley, belongs to Bobrowniki Hills. The coal mine opened in 1911, and its area comprises 7.74 km^2. Carboniferous substratum is entirely covered with Triassic rocks whose thickness is 130–200 m. Zinc and lead ores occurring in Triassic metalliferous dolomites were exploited and processed by smelting and mining works "Orzeł Biały" in the southern part of "Andaluzja" coal mine. Triassic rocks have vast outcrops, yet in places, they are covered with Pleistocene clays, sands and gravels whose thickness equals 20–25 m.

Towards the end of the 19th century, the area of the mine rose to the height of 268–311 m a.s.l. – so maximum denivelation did not exceed 43 m [Topographische Karte, 1883]. Over almost flat surface of the Siemianowice Upland rose a few very moderate hills. The surface was scarcely cut by shallow dry valleys. More distinctive relief characterized Bobrowniki Hills which rose to the height of over 40 m above the Brynica valley. The entire coal mine area belongs to the catchment of this river. The first water-bearing horizon lay in the Quaternary deposits, but the most significant horizon was found in the Triassic rocks at a depth of several dozen metres. The area was woodless and used mainly as agricultural land.

Anthropogenic denudation rate

Within the boundaries of "Andaluzja" coal mine, between 1911–2007, 158.8 mln tons of hard coal and approximately 30.8 mln tons of waste rock were extracted (a total of 184.6 mln tons of mineral), the majority after the World War II. From under 1 km^2 of the mining

area, as much as 23.9 mln tons of coal and rock were extracted on average. The output of ores is not precisely known because the statistics shows the total output from all mineshafts of "Orzeł Biały" located in different parts of the Silesian Upland.

Exploitation of hard coal, and zinc and lead ores caused the lowering of the surface by over 14 m in places. Eventually, 3 large subsidence basins developed of thickness from ten to twenty metres and width of 0.8–1.2 km, and one basin 7 m deep and 0.6 km wide. Due to continuous deformations, the southern part of the area (about 50% of the surface of the mine) was excluded from the Brynica catchment. Basins are divided by high railway embankments and waste heaps into a dozen or so smaller non-drainage hollows; thus the watersheds are both natural and anthropogenic. Despite the young age of the basins, shallow and long rainwash channels have already developed in them. Shallow exploitation of zinc and lead ores caused the emerging of 91 discontinuous deformations in the form of sinkholes, cracks and escarpments during 1974–1990. The diameters of the sinkholes reached 28 m and their depth 7 m; they were all filled in. As a result of ores exploitation, the Triassic water-bearing horizon was considerably drained, and the Quaternary one was almost entirely drained. In order to prevent the outpouring of the Brynica, it was necessary to heighten the escarpments several times along the section influenced by subsidence. Water table in the river is found 7.2 m above the surrounding area.

The loss of 0.125 km^3 of rock from the substratum of the mine caused the subsidence of the volume estimated at 0.06 km^3. During 97 years (1911–2007), the surface of the mining area lowered by 7.9 m on average. The anthropogenic denudation rate equalled 82 mm/year on average, but it differed in time. At the beginning of the coal mine activity, the surface was lowering at the rate of 11 to 33 mm/year, whereas almost half of the volume of subsidence ensued during the twenty years between 1971–1990 when the rate of denudation reached 195 mm/year. Such a high value of the indicator results from large extraction in that period (the extraction at that time often exceeded 4 mln tons annually) parallel to limited use of stowing.

The anthropogenic denudation rate was also calculated by means of hypsographic curves method [Dulias, Kupka, 2009]. Towards the end of the 19th century (1883), that is, in the pre-mining period, mean height of the ground equalled 283.6 m a.s.l. As much as 36.4% of the area was located at 280–285 m a.s.l. – this flat corresponds to Neogene planation surface. Towards the end of the 20th century (1993), mean height of the ground was 278.6 m a.s.l., which means that during the 83-year-long-mining period (1911–1993) the area of the coal mine lowered by 5 m on average. Within its boundaries, new height – interval appeared – 260–265 m a.s.l., and maximum denivelations increased from 43 to 51 m. In 1993, heights over 275 m a.s.l. occurred at 39.6 % of the area, whereas in 1883, at only 9.4%. The denudation rate equalled 61 mm/year on average. During this period (1911–1993), the volume of subsidence calculated from the balance of extraction equalled 0.05 km^3, which gives average lowering of the surface by 6.8 m at the rate of 81 mm/year on average. Thus, rates obtained with the use of hypsographic curves method have lower values than those calculated by the first method (from extraction balance) – average lowering of the surface is 1.8 m less, and the denudation rate is 20 mm/year lower. This stems from the fact that in the counter drawing on a topographic map from 1993, two large and a few smaller waste rock heaps situated at the coal mine grounds were taken into account. These were not considered in the calculations in the first method due to the lack of data. Rock volume indicator equalled 36.4% in 1883, and 32.4% in 1993. The studied area is characterized by mature relief, and anthropogenic denudation speeded the process up – during 83 years, the rate decreased by 3.9%.

The results obtained for "Andaluzja" coal mine do not differ from those calculated for other parts of the Upper Silesian Coal Basin with the use of different methods, namely hypsographic curves, numerical relief model, and satellite radar interferometry (tab. 1). Anthropogenic denudation rates calculated for mining areas situated in various mesoregions of the Silesian Upland equal 11 to 130 mm/year (tab. 1). On the other hand, anthropogenic denudation rates in agricultural land equal, for example, 0.15–2,67 mm/year in the Sudetes Mountains [Latocha, 2005], 2–3 mm/year in the Kuyavian Lakeland [Sinkiewicz, 1998], and 3 mm/year in the Low Beskid [Gil, 1976]. Natural chemical denudation in various regions of Poland is a hundred or even a thousand times smaller than the anthropogenic denudation in mining areas of the Silesian Upland, and it equals, for example, 0.014 mm/year in the Tatra Mountains [Krzemień, 1984], 0.022 mm/year in the Lublin Upland [Maruszczak, 2001], and 0.05–0.189 in the Nida Basin [Chwalik, 2006].

Table 1. Anthropogenic denudation in mining and agricultural areas (*author's calculations)

Area	Denudation rate mm/year	References
Anthropogenic denudation in mining areas		
Przemsza Basin	17	Jania, 1983
Rybnik Plateau (Pniówek and Zofiówka Mines)	41	Aleshina, Snytko, Szczypek, 2008*
Rybnik Plateau, (Borynia Mine)	71	Madowicz, 2001
Rybnik Plateau, (Chwałowice Mine)	39	Dulias, 2006b
Murcki Plateau, (8 mines)	46	Kupka, Szczypek, Wach, 2005
Dańdówka Plateau (Porąbka-Klimontów Mine)	26	Dulias, 200 a
Rachowice High Plain (Knurów and Szczygłowice Mines)	29	Wojciechowski, 2007*
Siemianowice Upland (Andaluzja Mine)	61–82	Dulias, Kupka, 2009
Bytom Plateau and Przemsza Basin, Dąbrowa Coalfield (8 mines)	11	Dulias, 2007a
Miechowice Upland (Miechowice Mine)	69	Dulias, 2007b
Miechowice Upland (eastern part)	39	Solarski, Pardela, 2010
Kochłowice Hills (Halemba Mine)	130	Dulias, unpublished data
Anthropogenic denudation in agricultural areas		
Sudeten Foothills	16	Hlibowicki, 1955
Low Beskid	3	Gil, 1976
Kuyavian Lakeland	2–3	Sinkiewicz, 1998
Sudetes Mountains	0.15–2.67	Latocha, 2005
Natural chemical denudation		
Tatra Mountains	0.014	Krzemień, 1984
West Roztocze Upland	0.02	Janiec, 1997
Nida Basin	0.05–0.189	Chwalik, 2006
Lublin Upland	0.022	Maruszczak, 2001

Conclusion

The case of "Andaluzja" coal mine indicates that hard coal exploitation causes significant changes of the relief of the Silesian Upland. As a result of mining subsidence, the surface lowered by a few metres on average, and anthropogenic denudation rates equalled several

dozen mm/year on average, which made them at least several hundred times bigger than natural denudation rates. Non-drainage basins developed in the relief and approximately 50% of the mining area was excluded from the fluvial system. New (young) basins play an important role in the circulation of matter because they function as local denudational bases where deposits accumulate. The rate of natural "filling in" of such non-drainage sedimentation basins will probably be several hundred times slower than the anthropogenically conditioned rate of their emergence.

The applied methods of calculating the anthropogenic denudation rate are quite meticulous, however, they seem to reflect well the rate of surface lowering in the mining area. Results obtained by means of two different methods differ slightly, but this stems from the fact that the volume of waste rock gathered on heaps was not taken into account in the first method (owing to the lack of data from mines). It is estimated that such a correction would bring almost identical results.

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Anthropogenic landforms in the area between Rokitnica and Miechowice (Upper Silesia, Southern Poland)

Introduction

In the area of the Upper Silesia the influence of human factor on the current landscape is obvious. It is related with the very much strongly developed hard bituminous coal mining and zinc and lead mining, as well as zinc and lead metallurgy, power and heat engineering, engineering industry, etc. The landscape of the Upper Silesia is characterized mainly by a presence of: tailings piles, mining subsidence basins, very often flooded with water, etc. However it is also possible to observe „non-mining", usually less visible, impact of the man on environment. In most cases the current landscape of this area is a result of anthropogenic transformations associated with mining as well as triggered with other human activities, which overlap. The area of interest doesn't constitute the exception in this respect.

Human impact on the environment can be considered as changes in morphology, animal and plant world, soil and air composition, river network and water relations, etc. This paper focuses only on landforms which are the results of human activity in the area between Rokitnica and Miechowice. The main aim is to determine their spatial interrelationships. Observed today morphology of that area is a result of the natural and anthropogenic processes. Hence, it has been selected for detailed analysis of changes, primarily in landform features and topography of the terrain, made or initiated by the human activity at different times. As a matter of expediency the changes in environment associated with the farming, animal husbandry which didn't cause significant shifts in the morphology of that area here will be omitted.

Location and history of the study area

The area of research covers part of the land located between the villages of Rokitnica in the West and Miechowice in the East, in the Upper Silesia region in Southern Poland. The first one states at present the north side of the Zabrze city, while the second one is the western district of the Bytom city. The study area occupies about 3 km^2, and is mainly covered by forest (fig. 1).

The first mentions of Rokitnica come from the 13[th] century – Rokitniz 1211 [Borek, 1988]. It was established on the little watercourse named Rokitnica (synonymous names: Rokitnicki Stream, Mikulczycki Stream, Żernicki Stream). That stream constitutes the right-bank inflow of the Bytomka River, which is flowing to Kłodnica River, and this flows to the Odra River. At first in this area an agricultural activity dominated. Industrial charac-ter that area got at the

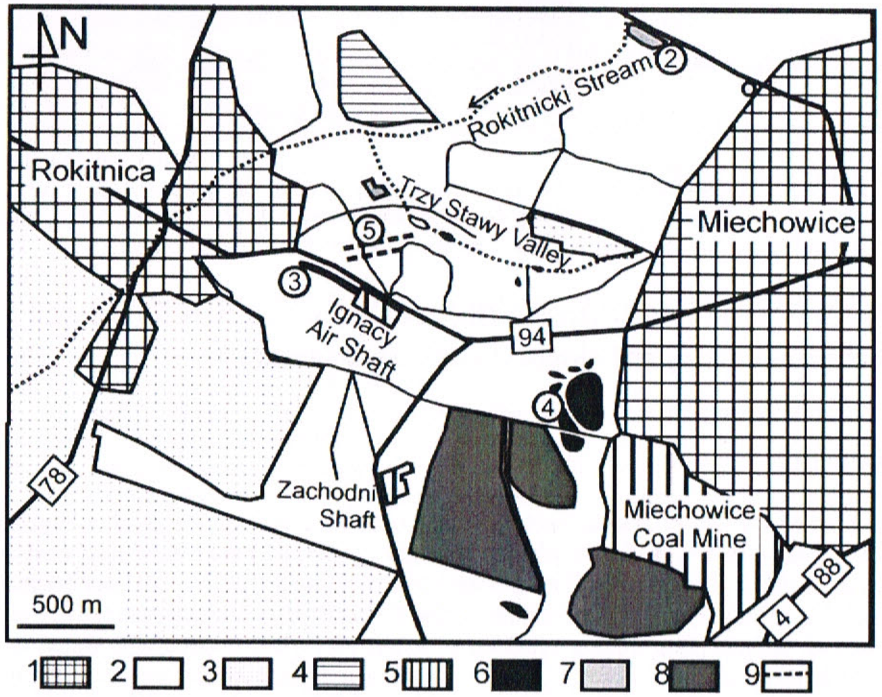

Fig. 1. Chosen anthropogenic landforms between Rokitnica and Miechowice:
1 – urban area, 2 – forest, 3 – field and meadows, 4 – allotments, 5 – mines and mining infrastructure, 6 – ponds, 7 – tailings pile connected with Zn-Pb mining, 8 – tailings piles connected with coal mining, 9 – escarpments connected with faults reactivation caused by mining activity; numbers in circles – locations of photos 1–4

end of 19th and at the beginning of the 20th century above all in relation to the building of working-classes housing estate for miners from the Castellengo coal mine, among others the famous Ballestrem housing estate [Cempulik et al., 2004; Pierszalik 2008a, b].

The history of Miechowice village, as the previous one, is very long and strictly connected, probably even more, with mining activity. According to local legend the village was founded in 1041 by the king Kazimierz Odnowiciel [Dybel, Hebliński, 1988]. From the beginning its development was related with exploitation of Ag, Pb and Fe ores, later (in 19th century) also with exploitation of Zn ores, as well as hard bituminous coal deposits – the Miechowice Coal Mine [Dybel, Hebliński, 1988].

Human activity in shaping the morphology

On the analyzed area man has repeatedly changed the morphology of the land. Since the medieval times and even earlier up to this day, we can distinguish four main types of human activity, which influenced land modifications:

1. Agriculture and farming.
2. Fish farming.
3. Silver, lead and zinc mining.
4. Hard bituminous coal mining.

The first stages of human activity in that area related with farming and agriculture are characterized by a relatively small influence in shaping the land surface. However, its impact, although minor can not be ignored and forgotten, because is acting from the moment of settling of the first people on that area up to this day. The main impact on the landscape consists in the change of character of a land use from forests, or meadows to field crops. Such change causes greater erosion of the area and increases the susceptibility of the mass movements.

The fish farming has been separated from the first group due to the significant changes in hydro-system on analyzed area, which it causes. The fish farming has resulted in the formation of many ponds blocked with weirs, together with smaller ponds in the side valleys which stated as reproductive ponds. The best example of such ponds can be observed in the Dolina Trzech Stawów (the Valley of Three Ponds; fig. 1). These are usually relatively small bodies of water, not exceeding 200 m^2. Currently this entire system of weirs, mucus and barriers is destroyed. As a result the Pierwszy Staw (the First Pond) is overgrowing and only a trained eye or the information from the local community allow for the identification of the place of this former body of water (fig. 1 – the first from the West). Other remaining ponds are polluting (very often treated as local, natural garbage dump) and also undergoing overgrowing.

The most significant changes in the morphology of the analyzed area were initiated in the second half of the 18th century, with maximum during the 19th and the 20th century, in relation to the development of both silver, lead and zinc (firstly only silver and lead), as well as hard bituminous coal mining. The exploitation of Triassic Zn-Pb-Ag ores in this area left: many tailings piles of different sizes, hollows over buried mineshafts, as well as foundations of mine buildings. These forms are relatively small, as the largest tailings pile in the analyzed area, located in its eastern part has dimensions: 60 m long, 30 m wide and 20 m height (fig. 1, photo 1). The majority of these tailings piles have already underwent the self-rehabilitation and overgrown with trees such as: birch-tree, willow, spruce, larch, etc. Ho-wever it is still possible to observe on them ores of zinc and lead, as well as silver and iron, in the form of:

- sulphide ores, e.g.: galena (PbS), sfalerite (ZnS), pyrite (FeS_2);
- oxidized ores, e.g.: calamine (oxidize Zn-Pb ore), limonite [$FeO(OH){\cdot}nH_2O$].

So far a detailed study on the impact of this historic exploitation on soil minerals composition hasn't been done. However results from comparable areas of Jaworzno and Olkusz show a negative effect of this past human activity on soil minerals composition. These soils are characterized by the high yields of heavy metals such as: Zn, Pb, Cd, Tl, Mn [Cabała, Sutkowska, 2006]. On the analyzed area similar results can be expected.

The strongest impact on the morphology of the analyzed area is caused by the exploitation of the hard bituminous coal through Castellengo Coal Mine (later renamed into Rokitnica, Mikulczyce-Rokitnica or Mikro Coal Mine, in 1973 incorporated into Pstrowski Coal Mine, currently the coal deposits are exploited by Siltech Sp. z o.o.) and Preussen Coal Mine (after 1945 renamed into Miechowice Coal Mine; fig. 1). The first one started exploitation in 1899, while the second in 1902 [Jarczyk, 1986; Dybeł, Hebliński, 1988]. Almost all possible effects on the surface of the mining activity can be observed in this small area. Tailings piles, subsidence basins very often filled up with water, escarpments of reactivated faults, strong surface water drainage belong to the most important.

Probably the best visible changes in environment caused by hard bituminous coal mining dominate in the southern part of the analyzed area (on the South from the national road No. 94; fig. 1). There is over 400 m long, 20 m wide and from 5 to 15 m high tailings pile, oriented sublongitudinal (parallel to the national road No. 94; fig. 1), built as a result of drilling of the Ignacy air shaft, which belongs to the Miechowice Coal Mine (fig. 1, photo 2). This anthropogenic landform is mainly made of medium- and fine-grained quartz sandstone, as well as mudstone and siltstone, also with small fragments of coal. Also in the southern part of the analyzed area, but more close to Miechowice is much bigger and still active (at present built and enlarged) tailings pile of the Miechowice Coal Mine (covers area of about 700 m x 400–600 m; fig. 1, photo 3). In contrast to previously described this tailings pile is associated with actual exploitation of hard bituminous coal by the Miechowice Coal Mine and it is possible on it to find: quartz sandstone, mudstone and siltstone (very often with carboniferous plant fossils, such as: *Sigillaria, Stigmaria, Lepidodendron, Lepidostrobus, Calamites, Neuropteris, Pecopteris, etc.*), spherosiderite, pyrite (FeS_2) and others. Fragments of coal are also relatively numerous. The tailings pile is divided into two parts: the eastern part is already rehabilitated as a forest, while the western part is constantly built. This second part is in the area of the former waste dump.

Photo 1. Tailings pile related to Zn-Pb mining near Rokitnica (phot. by author)

Photo 2. Ignacy air shaft and tailings pile (phot. by author)

Photo 3. Mining subsidence basin filled with water close to Miechowice Coal Mine with tailings pile on the background (phot. by author)

Photo 4. Escarpment induced by mining-caused reactivation of faults (phot. by author)

On the analyzed area there are at least six subsidence basins filled with water, all of them close to that tailings pile described above (fig. 1). The dimensions of the biggest one are: over 300 m long, almost 200 m wide and about 10 m deep (photo 3). Fragments of trees which originally grew in this area, still can be seen in such anthropogenic ponds. Some of them play the role as fish ponds (photo 3).

The last, but not so common structure formed by deposits exploitation is, well seen in morphology of the area, escarpment above reactivated fault by the mining activity. There are at least three up to 0,5 m height and about 300 m long escarpments oriented WNW-ESE in the study area (fig. 1, photo 4).

Discussion and conclusions

The area between Rokitnica and Miechowice has long been substantially influenced by human activity. The most powerful and therefore the most visible human impact on terrain morphology has taken place during the last two centuries. It is mainly connected with Zn-Pb, as well as hard bituminous coal mining and other branches of industry related with it. In general the results of mining deformations can be divided into two groups: positive and negative forms. Tailings piles are the best and the most obvious example of the first group while ponds created in the mining subsidence basins are the most characteristic representative of negative structures.

In the study area these mining transformations of land overlap previous morphology, also remodeling by human, although not in that scale.

Even though, or probably because of that, this particular area is very interesting and has been long popular not only in local community as place for recreation. Already in 1858 in that area the Park Leśny (The Forest Park) was founded by Hubert von Tiele-Winkler, opened to community in 1927 [Pierszalik, 2008b]. During preparatory works the main part of the local natural fauna has been removed and replaced with exotic species such as: American tulip tree *(Liriodendron tulipifera)*, Arolla Pine *(Pinus cembra)*, Eastern White Pine *(Pinus strobus)*, European Black Pine *(Pinus nigra* Arn.), Canadian Hemlock (*Tsuga canadensis* L.), *Thuja* (*Thuja* L.), etc. [Cempulik et al., 2004]. At that time formed also paths, bridges, cross-junctions, gazebos, cleaned ponds and springs. Today there are two educative-recreation paths: The Gajdzikowe Górki (Gajdzikowe Hills) and The Miechowicki Las (Miechowice Forest).

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Changing landscapes as a result of water regulation works on the example of a Nagy-Sárrét

Introduction

The Nagy-Sárrét belonging to the lowest situated lowland landscapes of Hungary was a wetland area prior to the water regulation works. Today, however, its name lost its meaning caused by the dewatering of the swamps and marshlands giving the name of the area. It has to be noted that there were some kind of water management in the area prior to the water regulation works in the 19th century resulting in the start of agriculture in some of the settlements, however, as it will be presented below, results of work performed until that time were completely destroyed during the Turkish invasion.

Present paper aims to present the reasons, process and results of the water regulation works, the most significant anthropic activity in the area in the last one and a half century. Studying the mentioned period it is clear that these works caused the most striking changes in the appearance of the landscape.

The termination of periodical water cover in the area was one of the most important results of the regulation works. As a result the wetland started to dry out, densely installed canal network substituted the marshland serving not only for dewatering the inland waters of the area but also the irrigation demands due to increasing lack of water.

Location and description of the study area

The study area is a characteristic small landscape of the Berettyó-síkság called Nagy-Sárrét, extending over 650 km^2. It is located along the border of Békés and Hajdú-Bihar counties in the eastern part of the Great Hungarian Plain (fig. 1).

Regarding its relief conditions, the area elevated to 85–110 m a.s.l. is an alluvial fan flat covered by loess-like sediments and developed at the western end of the Sebes-Körös alluvial fan [Marosi, Somogyi, 1990]. It is bordered by river highs in the north and south forming an almost completely closed depression with poor runoff conditions.

The area of the Nagy-Sárrét developed by the Berettyó and its tributaries was around 800 km^2 at the time of surveying prior to the water regulation works (between 1820 and 1830). It was also named the Sárrét of Berettyó referring to the supplying river. The Ancient Berettyó originated from the Réz Mountain over the border and its bed vanished practically at Bakonszeg and the river flowed into the depression of the Nagysárrét without a

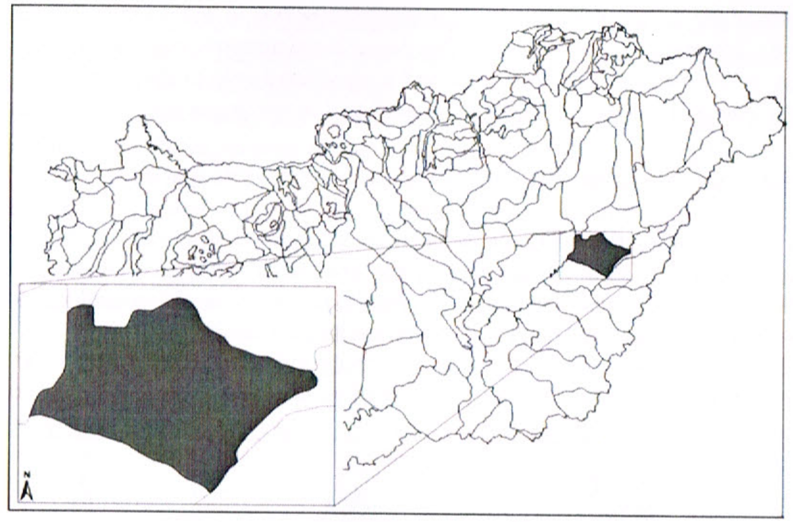

Fig. 1. Location of the study area

constant route. Fig. 2 shows numerous abandoned river beds also proving that rivers changed their running in time [Papp, 1956].

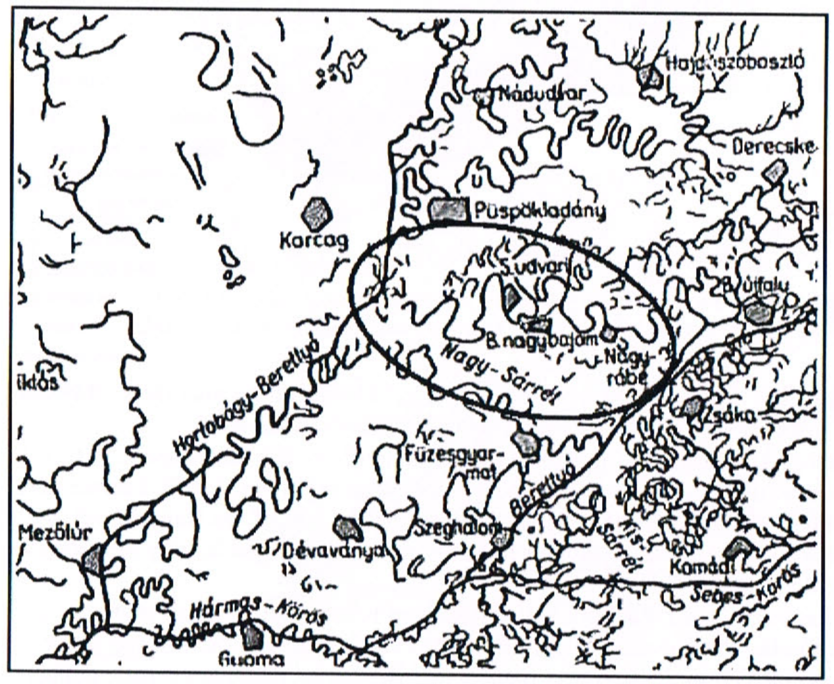

Fig. 2. Abandoned river beds of the Nagy-Sárrét (after Papp A.: Abandoned river beds of the Sárrét regions)

Waters of the area belong to the Hortobágy-Berettyó in the west and to the east the Kálló – the main canal catchment area. The dense canal network was used primarily for the dewatering of the swamps and then it gained a significant role in the irrigation of the area. These canals drive the water of spring snowmelt and inland water away even today as well.

Antecedents of the water regulation works in the 19th century

It is hard to imagine that lakes and wetlands occupied areas where agricultural cultivation prevails today (fig. 2). Old maps and description show those conditions. Figure 3 shows the conditions prevailed immediately prior to water regulation works regarding water cover within the borders of today's small landscape. Dark colouring depicts areas covered by water permanently or for most of the year. Hatching indicates areas covered for longer-or-shorter time periods at the time of flooding. Small white areas are free of water cover.

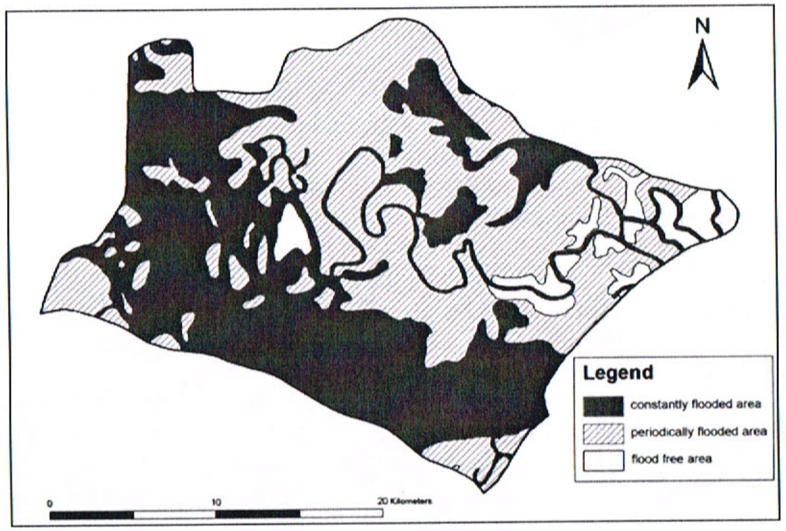

Fig. 3. The Nagy-Sárrét prior to the water regulation works (after the Water covered and flooded areas in the Carpathian Basin prior to the water regulation and dewatering works)

Searching for the reasons of wetland development in the area three important factors can be regarded based on our geographical and historical knowledge.

- First reason originates from the natural conditions. The landscape is part of the Körös basin which is a Pliocene-Pleistocene depression [Rónai, 1985]. Furthermore it is the deepest situated part of the basin. Regarding the soil of the Nagy-Sárrét, the upper 10 metres involve water retaining red clay contributing significantly to wetland development in the area.
- It has to be noted that, as I have mentioned before, the "puszta" character of the Great Hungarian Plain in the 18th and 19th centuries developed mostly as the result of the Turkish destruction. Researchers believe that Hungarian inhabitants made deliberate floodings to protect themselves against the Turkish invaders but settlements of agricultural wealth in the 16th and 17th centuries vanished later as wetlands advanced in the area.

- Finally the consequences of deforestation due to Turkish (and then Austrian) public administration orders transformed the water network of certain landscapes almost completely due to increased soil erosion.

Therefore there were hardly any results of the water regulation works prior to the 18th century as due to the above reasons wetland developed in the area. Ihrig [1973] also mentions that the Berettyó region became a wetland at that time (at the time of Turkish invasion). Settlements elevated as small islands from the swamps and for transport generally boats and rafts were used. Swamps even "swallowed" the rivers as well.

Inhabitants learnt to adapt to the landscape and lived collecting lifestyle. They were fishermen, marsh-dwellers and fowlers who lived "together" with the landscape. However, feeding of the increasing population and prevention of rapidly spreading diseases made water regulation works necessary.

Major phases of water regulation works and their effects on water network

Historical perspective of river regulation is smaller in eastern Hungary than in the western parts, however, it can be stated that this time period had decisive significance in the survival and development of the inhabitants. Thus the term "new conquest" for the works done.

Regulating the Berettyó was an inevitable action of development as it frequently flooded surrounding settlements. Regulation plans for the Körös and the Berettyó were made by Huszár M., Bodoky K. and Kecskés K. Works started based on the plans in 1855 and were carried out in several phases: between 1855 and 1879, between 1879 and 1895 and after 1895. Phase 3 is discussed only until 1940 here.

Works are discussed according to these phases and only the most important rivers are presented. Water network of the Körös-Berettyó network prior to and after regulations is given in fig. 4.

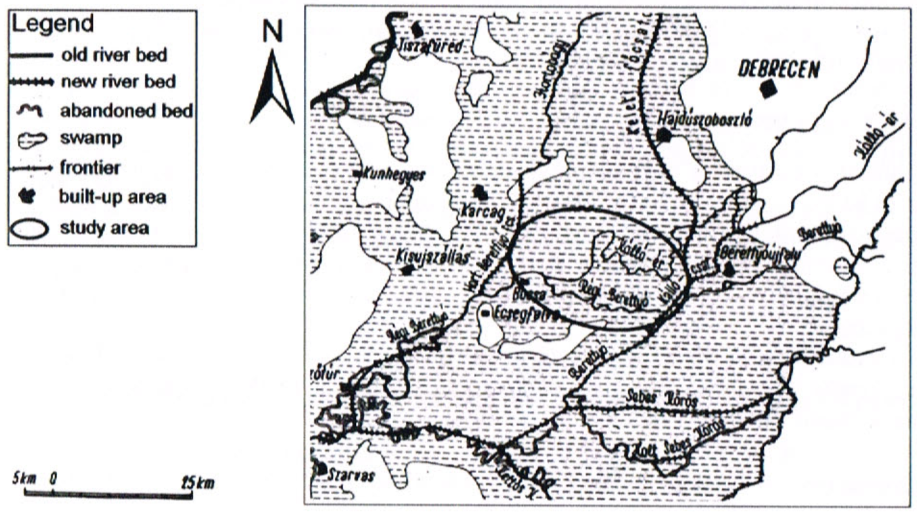

Fig. 4. Change of river courses in the area (based on the regulation of the waters in the Körös-Berettyó valley)

Phase 1 (1855–1879)

In the case of the Berettyó it is important to discuss a few steps that affected the area of today's Nagy-Sárrét as well.

- First step was to demolish mills and mill dams in order to provide free run for rivers.
- A next step was to close several tributary of the the river including the Kék-Kálló that lost its way, following large curves, in the swamps of the Nagy-Sárrét. Its main bed was directed into the Berettyo before reaching the Sárrét. This section is known today as the Kálló Main Canal.
- It was mentioned before that the Berettyó was lost completely in the swamps of the Nagy-Sárrét west of Bakonszeg and reached its mouth below Mezőtúr with large bends below Bucsa. Third important step was the digging of a new bed for its water from Bakonszeg till Szeghalom and the Sebes-Körös between 1854 and 1865 and in this way it was closed from the Nagy-Sárrét. As a result the length of the section between Bakonszeg and the mouth was reduced from 146 km to 32 km.
- Finally it is worth mentioning that embankments on both sides of the river 60 m from it were constructed in this phase.

Phase 2 (1879–1895)

1879 brought changes in the regulation of the Körös rivers as the original plan was modified in this year. Construction of the canals went on and two of them are discussed.

- One of them is the Hortobágy-Berettyó main canal running in the western part of the small landscape, the section of which above Bucs was named originally Hortobágy as the right side tributary of the Berettyó river. In 1879 a new bed section was started to be built that was connected the Hortobágy river to the mouth section of the abandoned Berettyó. With this it inherited the section of the bed of the Berettyó below Bucsa.
- The other is the Sárrét main canal built in 1887 crossing the small landscape from SW to NE. It directs temporary inland water to the Hortobágy-Berettyó.

In this phase only one work worth mentioning was performed along the Berettyó river: the rivermill at Kismarja was demolished.

Phase 3 (after 1895)

Technical constructions of flood prevention in the area were mainly completed by 1895. It has to be mentioned, however, that the Hamvas main canal also directing away inland waters was built between 1901 and 1910. But this period was mostly the time of improvement, expansion and maintenance works like river canalizing for example. Several further cuts were made along the Berettyó river together with significant embankment strengthening actions.

Construction of the current canal network (fig. 5) followed numerous old beds of former streams. The network makes water storage possible that helps irrigation and protection against inland water as well.

Summary

The study area is a good example of how significant changes may occur within relatively short time in a landscape due to anthropic effects. The present paper discussed conditions

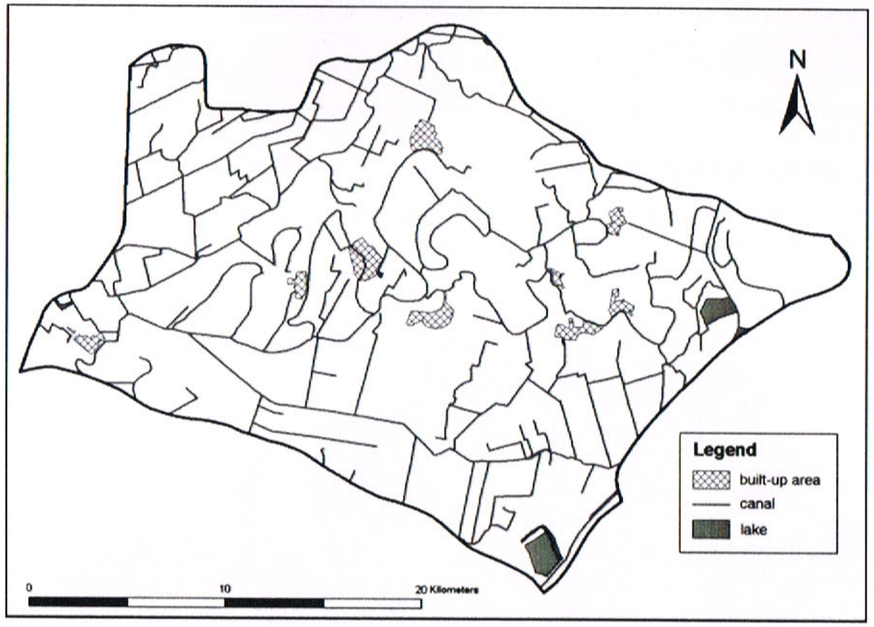

Fig. 5. Major elements of the canal network in the Nagy-Sárrét 150 years after the river regulation works (based on the data of the competent water authority, the TIKÖVIZIG)

Summary

The study area is a good example of how significant changes may occur within relatively short time in a landscape due to anthropic effects. The present paper discussed conditions justifying river regulation, the resultant changes and the consequences.

In Hungarian terms it can be stated that nowhere else were so many new beds built as in the Körös-Berettyó valley: rivers losing their way in the wetland area of the Sárrét were replaced by a new canal network. Most parts of the area became dry giving place for agriculture and enabling further development of the society. In this region, regulation of rivers presented a second conquest.

However, negative consequences of river regulation have to be considered as well. The landscape once rich in water has to face the lack of water today similarly to other parts of the Great Hungarian Plain.

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Relationship between river terraces and settlements on the example of the Borzsa valley

Introduction

One form of anthropic surface forming is associated with settlement development. Settlement development and growth involve the further shaping of an already transformed area. This change, however, is almost completely irreversible as the already transformed area changes completely and the stability of the area is related to the activity of man. Settlements, however, have fundamental conditions the most important of which is the long-term guarantee of the safety of the population. In areas of variable relief flood-free areas close enough to arable lands and rivers are the most suitable. Best areas in the case of river valleys are high flood-plains and river terraces.

Transcarpathia experienced significant social-economic transformation in the past one and a half decades. Increasing privatization and intensity of agriculture resulted in significant increase of the grade of human activity. As a result settlements in certain parts of the region developed significantly with new streets opened and houses built.

High floods were frequent in the years of the turning of the century, mostly new buildings were lost. Anthropic events relate back to human life together with careless "regional planning" justify the current problem.

The aim of the present paper is to locate different terrace levels in the catchment area of the Borzsa river along the complete length of the river valley. To explore the relationship between settlements and terraces and to identify those settlements that are most exposed to flooding.

Geography of the study area

The study area is the catchment area of the Borzsa river (its area is 1827 km^2) belonging to the Tisza water network in the central area of Transcarpathia (Fig. 1) between the catchment area of the Nagyág and Latorca rivers [Kész, 2008b]. Transcarpathia is the westernmost region of the Ukraine neighbouring Hungary, Slovakia, Romania and Poland.

The northern and central parts of the catchment area are mountains that can be separated into two subparts. The Borzsava-havas belonging to the Havas range of the North-eastern Carpathians is located to the north separated by the Vecsa (left tributary of the Latorca) and the Nagyág from the Róna-havas and the Kraszna-havas. The Borzsa-havas can be bordered by a line marked by the Szolyva and Prohodnyij streams within the catchment area. South of this line are the volcanic mountains. The Borló-Gyil between the Latorca and the Borzsa and the Nagyszőlős Mountains between the Borzsa and the Nagyág (fig. 1). The southern part of the area is the Salánk plain separated from the Bereg-Szatmár flat by the Tisza. The flat is enclosed by the Nagyszőlős Mountains, Helmec mountain, Remete ridge and Beregszász mountain. Northeast of the Salánk plain the Ilosva basin is located.

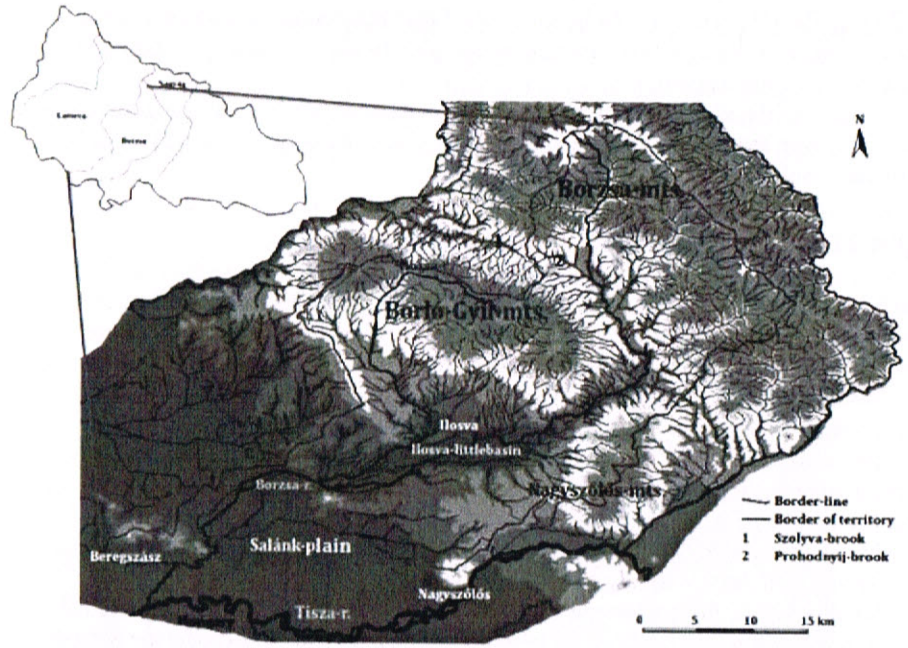

Fig. 1. Catchment area of the Borzsa

Research antecedents

Studying the problem of river terraces among geomorphological investigations has more than 100 years of history in Hungary. In Transcarpathia such studies had variable intensity. The primary reason behind this was the fact that the area was shifted among several states from-time-to-time. Significant disadvantage in geomorphological research was also the fact that it was always a border-side (periphery) region. In the first years of the last century research focused on the identification and description of geomorphological processes. The first river terrace research in Transcarpathia can be associated with Posewitz [1893]. Following World War I Transcarpathia was handed to Czechoslovakia thus it was not possible for Hungarian scientist to carry out research. However, two Czech scientists are worth mentioning who made significant progress in studying the geomorphology of the area. Sauer [1926] completed the geomorphological description of rivers in Máramaros while Kral [1930] studied the physical geography of the Borzsa river. Works dealing with the study-area solely were not published later.

From 1939 Transcarpathia was given back to Hungary for a short period of time. Complete surveying of the area was one of the aims of the researchers at that time. Thus several publications were published regarding the topic [Radvánszky, Izsák, 2006]. Primarily Bulla [1941a, b] and Kéz [1942] studied the terraces of the Upper Tisza and its tributaries. The former gives the overview of the terrace networks of the Carpathian Basin. His research can be regarded as the first synthesis as he considered the number and relative elevation of the terraces as around identical. He defined three terrace levels along the Borzsa: II. (5–10 m), III. (25 m), IV. (60 m). It has to be mentioned that his results considering the Borzsa, Latorca and Ung rivers cannot be regarded as completely valid because he studied these catchment areas only superficially.

Research of the study area from 1947 was associated with Russian geographers and geologists from who the works of Szvidorenko [1976] and Adamenko & Gradetskaya [1987} had significant results.

Applied research methods

Determination of the terrace levels in the catchment area was performed in several steps. Using the results of former terrace researches I surveyed the height of terraces at several points of the Borzsa valley in the field. Based on field observations I determined those valley sections where terrace levels show differences to their general appearance regarding the occurrence or lack of certain elements.

Later a digital elevation model was prepared [Kész, 2008a] on the basis of which terrace levels were determined. Control was performed using sections with the scale of 500 m along the river valley. Considering the produced map, terrace I is missing as the DDM could have not enable its determination due to small relative height range, even though it was detected everywhere during the control analysis.

Digitalization of the settlement, road and railway network of the area made their adjustment to the terrace levels possible. In total 89 settlements were taken into the database of the area, 27 of them were neglected as they cannot be associated with the terraces of the Borzsa as they are located in the flood-plain of the river. These settlements are found in the southern part of the Salánk plain and in the southern foreground of the Beregszász Mountains.

Relationship between the settlements and the terrace levels was performed based on the following principle. The height of the centre of the settlement was determined. Centre of the settlement was identified by the location of the church as this can be regarded as the core of the settlement from which the settlement grows. If there are several churches in a settlement the one closer to the centre of the settlement was regarded. Following this I determined the height above seal level of the river at the point where the distance between the centre and the river is the shortest. Settlements were classified into 4 groups based on the relative height compared to the middle water level of the river and the distance between the river and the settlement centre. These were regarded in order to show the risk of flooding in the settlements. Terraces I and II were regarded to have high risk for flooding based on the water levels of the Borzsa in the last ten years (middle water is 226 cm, maximum water is 979 cm at Salánk). Higher terraces can be regarded to have no risk for flooding. Considering distance, flooding risks up to 4000 m as this was the maximum water cover reached by the river.

Considering the expansion of the settlements, the safety of the buildings to be built regarding flooding is important therefore I determined the lowest points of the settlements.

These were regarded as most prone to flooding. As before the middle water level of the associated river was measured. Based on the distance from the river and the relative relief those settlements were determined that have parts that would face serous danger in case of flooding. However, in this the course of the river also plays a role.

Results

The following average relative height values were obtained in the course of determining the terrace levels in the field: I. 3–4 m, II. 5–15 m, III. 20–27 m, IV. 40–45 m, V. 65–75 m, VI. 100–110 m, VII. 150–160 m. The line drawn at Dolha in the river valley separates the northern areas of incomplete terraces from the southern areas of complete network of terraces. Fewest terrace levels appear in the section between Baranka and Dolha as there is a gap here in the valley.

Terrace levels grouped by height categories are presented in a section of the valley in fig. 2. Widening of the valley floor towards southwest is clearly visible, distance between the river and the settlements (Misztice, Bilke, Szajkófalva) also increases. Public roads, railways and the inner roads of settlements (especially in the case of Bilke) run parallel to the terraces.

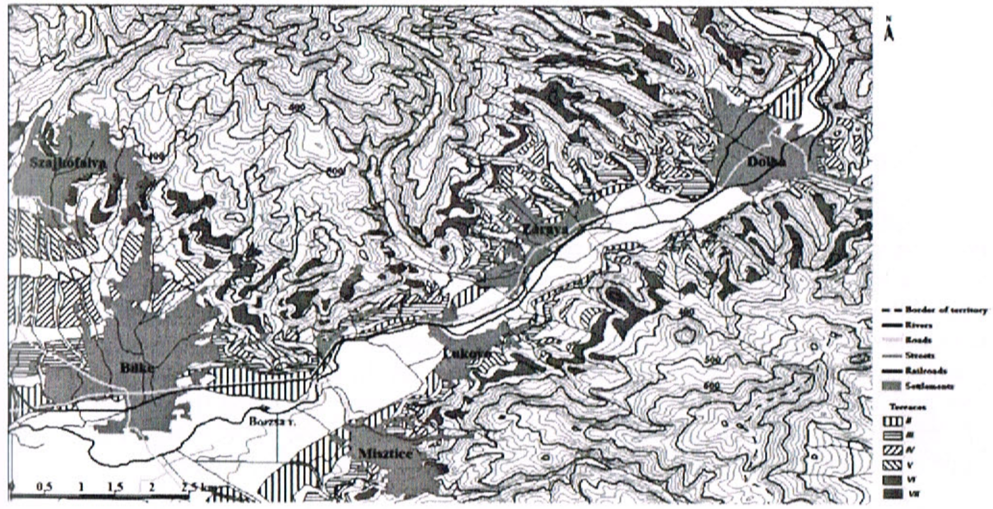

Fig. 2. Borzsa terraces in the section between Dolha and Bilke

Studying the relationship between the settlements and the terraces, it can be stated that only 5 settlements are not associated to terraces. These settlements are located in the Salánk plain, except for Felsőkaraszló, and in the high flood-plain (Vári, Sárosoroszi, Bene, Borzsova). Average relative height of the settlement centres compared to the river is 43.39 m. This elevation would correspond to terrace level IV but most of them (18) are located in the height of terrace level II. (Number and rate of settlements according to terrace levels based on the relative height of the settlement centre: I. 7 pcs., 12%; II. 18 db, 31 %; III. 5 db, 8.6%; IV. 8 db, 13.9%; V. 5 db, 8.6%; VI. 4 db, 6.9%; VII. 6 db, 10.4%. In the flood-plain: 5 pcs., 8.6%.) Significant differences were detected among the settlements regarding their distance from the rivers as well. Therefore settlements were classified according to their distance from the rivers, their relative height conditions and the flood risk as well. As seen in Figure 3 settlements were classified in 4 different groups.

Groups are the following:

1. Settlements exposed to flood risk. Number and rate of settlements in the group: 25 pcs., 43.1%.
2. Settlements still threatened by floods. 8 pcs., 13.8%.
3. Settlements located in secure height. 10 pcs., 17.3%.
4. Settlements located in neutral areas considering flooding. 15 pcs., 25.8%.

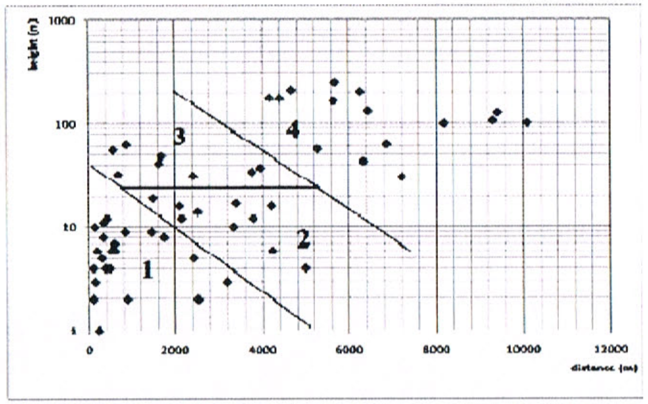

Fig. 3. Classification of settlements according to their relative height, distance from rivers, and flood risk

Considering the expansion of settlements, it is characteristic that settlements at lower terrace levels adapt to the conditions of the terrace surface and roads follow the particular levels. As lower levels are more united, more extended and are located closer to the rivers, size of the settlements on these levels exceed significantly that of settlements on higher terrace levels. Expansion of the latter settlements require significant surface forming. Expansion involves the artificial increase of the terrace levels. In the case of lower settlements new buildings are built occasionally not on the terrace level but in the flood-plain. Floods of variable height threaten settlement parts built in the high flood-plain. Figure 4 shows the flood risk of the studied settlements based on the height of their lowest points.

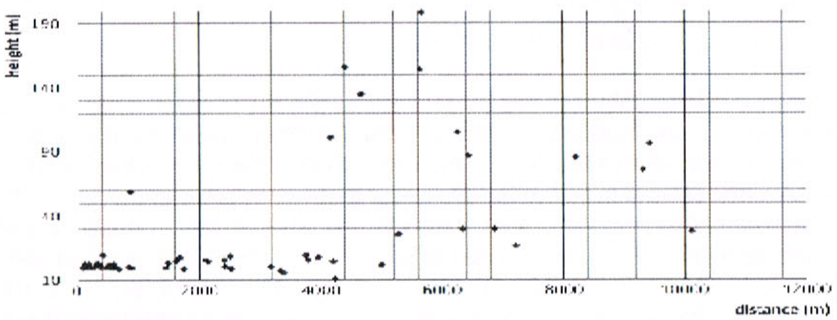

Fig. 4. Settlements according to their lowest points and the distance from the river

12 settlements (20.6%) have parts the relative height of which equals or stay below the height of the appropriate part of the river. If those settlements are considered as well that are located only 1 m higher than the river then 22 settlements (37.9%) have parts threatened by flooding. If the difference between the maximum and the middle water level measured at Dolha and Salánk as 2.97 and 7.53 m then the same number is 36 (62%). Those settlements are most exposed to flooding that are located at the lower section of the river, at lower elevation and close to the river. Based on this, 5 settlements are regarded most critical: Alsókaraszló, Magyarkomját, Sárosoroszi, Bene, Borzsova as seen in fig. 5. It has to be noted that Vári is not classified among these settlements but it has to be grouped here as the Borzsa joins the Tisza at the settlement and flooding of the Tisza generally impounds it.

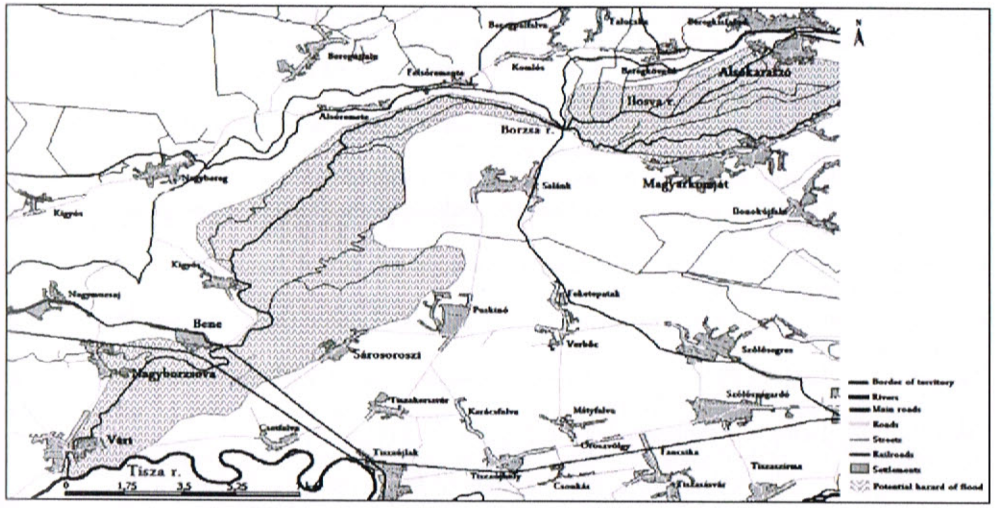

Fig. 5. Areas most threatened by floods

Summary

The present paper discussed the terraces in the valley of the Borzsa river and their relationship with the settlements of the area. Terraces I–VII were determined and described in the river valley.

Close relationship was determined between the settlements – except for the southern part of the Salánk plain – and the terraces. Centres of most of the settlements are located at terrace level II. Based on the relative height level difference between the settlements and the appropriate section of the river and according to the distance between the settlements and the rivers and the flood risk of the settlements they were classified into 4 groups. Most settlements were classified into group 1 that involves flood exposed settlements, 25 in numbers (43.1%).

Based on distance from the rivers, relative height difference and the course of the river those settlements were determined that have high risk of flooding. These are the following: Füzesmező, Alsókaraszló, Magyarkomját, Bene, Borzsova.

Based on the results we can state that there are 36 settlements (62%) in the river valley that have parts threatened by flooding.

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Bats *Chiroptera* in an anthropogenic environment on the example of the town of Czeladź (Silesian Upland)

Introduction

No full inventory of fauna has been taken in any town in the world or any other large and naturally varied area. Among all animals constituting city fauna birds have been examined the most extensively so far [Luniak, 2006]. Research on bats is not easy, it requires a lot of time and effort as well as special equipment so elaborations on this topic are not frequent. Bats of Viena were described quite well [Spitzenberger, 1990]. What is worth mentioning among not-numerous elaborations in Poland is research on bats of Warsaw whose inventory was thoroughly taken by Lesiński & Fuszara [2001].

Bats show a lot of plasticity in selecting inhabited environments. Their locomotor abilities allow them to penetrate many different wcosystems (forests, human settlements, fields, meadows, peripheries of water reservoirs). It is not possible to distinguish species strongly related to just one type of environment [Fairon, Busch, Petit, 1995]. Their winter and summer roosts are usually different. Areas almost completely devoid of bats are treeless fields and alpine layers in the mountains. During preying time almost all species of bats disply relation with tree-covered areas, where numerous and various insects live [Lesiński, Fuszara, 2001].

Research was conducted within administrative borders of the town of Czeladź located in northeast part of Silesian Voivodship, which is in the southwest part of Poland. The town is in the centre of the Upper Silesian Industrial Region.

Until the 19th Century the town had a rural character. Later on the region was an important centre of hard coal extraction [mines: "Saturn" ("Saturn") and "Piaski" ("Sands")]. The town turned into an industrial centre. At present the region is strongly transformed due to surface and in-depth exploitation (quarries, subsiding troughs, hillocks). In the southern and eastern parts there are water reservoirs formed as a result of ground settlement taking place due to historical underground exploitation. Water quality is impaired in most cases. Town area is 1657 ha, number of inhabitants tops 34 000, population density per 1 square km is 2076,2 inhabitants.

Methodology

Until now there was no data concerning chiropterofauna of the town of Czeladź. Mentions of the occurrence of this group of animals can only be found in the paper "Natural valorization of the town of Czeladź" [Tokarska-Guziak et al., 1995]. The research was conducted from may 2005 until june 2006. Considering level of complexity of research on bats resulting from their night activity and the fact that bats choose places inaccessible to men as their shelter, a few varied research methods were applied:
- Catch of bats was conducted with the use of D 70/16 chiropterologic nets over the Brynica river, a pond, ornamental ponds and forest paths. The catch lasted from dusk until dawn;
- Remote monitoring lead with the application of a light detector operating only in heterodyne system (Peterson D-100, Pettersson D240x) without the option of recording and detectors Pettersson D980 i Sony WM -D6C with the option of full recording;
- Searching for places of potential occurrence of bats in summer (tree cavities, nest boxes, penetration of buildings – lofts);
- hibertation places were searched for (shelters, basements, tunnels, buildings, churches);
- analysis of owl pellets (Asio otus);
- a survey was conducted (leaflets were distributed).

Results

As a result of the catch 4 species of bats were ascertained (table 1). The catch of bats in the field was not always successful, even though flying bats had been observed.

Table 1. A list of bat specimen caught in the town of Czeladź during the research period

No.	Species	Number of specimen
1	*Nyctalus noctula*	2
2	*Myots myotis*	4
3	*Plecotus auritus*	5
4	*Myotis daubentonii*	19

As a result of remote monitoring occurrence of nine species of bats was stated: *Myotis daubentonii, Myotis nattereri, Eptesicus serotinus, Eptesicus nilssonii, Vespertilio murinus, Pipistrellus pipistrellus, Pipistrellus nathusii, Nyctalus noctula, Myots myotis.*

Some sounds of small species were not recorded due to technical difficulties (eg. small signal range).

As a result of penetration of tree cavities and their equivalents – nesting boxes, no species of bats were discovered, even though droppings were found, which indicated periodic occurrence of bats in the boxes. A significant number of boxes contained birds' nests and wasps' nests.

As a result of penetration of building lofts single specimen of the following species were discovered: *Plecotus austriacus, Plecotus auritus, Eptesicus serotinus.*

Analysis of owl pellets did not show any remains of bats.

As a result of distribution of surveys no reliable data concerning the occurrence of bats in the town of Czeladź was obtained.

As a result of searching for places of hibernation the following species have been discovered: *Barbastella barbastellus* (a shelter at Dehnelów Street), *Myotis daubentonii* (remnants of an "adit" in a park at Musiała housing estate), *Plecotus austriacus* (basements at Będzińska Street), *Plecotus auritus* (a railway culvert at Wojkowicka Street). In the church of św. Stanisław (St. Stanislaw) at Bytomska Street one dead specimen of *Eptesicus serotinus* was found.

All in all, as a result of the field work, 12 species of bats were reported to occur in the area of the town of Czeladź:

1. *Myotis myotis* (Borkhausen, 1797)
2. *Myotis daubentonii* (Kuhl, 1817)
3. *Myotis nattereri* (Kuhl, 1817)
4. *Eptesicus serotinus* (Schreber, 1774)
5. *Eptesicus nilssonii* (Keyserling & Blasius, 1839)
6. *Vespertilio murinus* Linnaeus, 1758
7. *Pipistrellus pipistrellus* (Schreber, 1774)
8. *Pipistrellus nathusii* (Keyserling et Blasius, 1839)
9. *Nyctalus noctula* (Schreber, 1774)
10. *Plecotus auritus* (Linnaeus, 1758)
11. *Plecotus austriacus* (Fischer, 1829)
12. *Barbastella barbastellus* (Schreber, 1774)

Discussion

Current population of bats in the town of Czeladź is a result of many factors: climatic, trophic and anthropogenic, both positive and negative, not all of them have been satisfactorily recognized by science [Wołoszyn, 2001].

Originally the flora of the area consisted mainly of forests – fertile deciduous and mixed forests, beech forests covering the upheaval, oak-hornbeam forests on eastern and south eastern part. In northern and north eastern part of the town there used to grow suboceanic mixed forests. Alder-ash forests used to grow in the Brynica valley [Tokarska-Guzik et al., 1995].

Currently there are no natural fragments of plant communities left in this area. Apart from ruderal, rural and park flora, what is worth mentioning are half natural spontaneous successions in unexploited places (hillocks, fallows, subsiding troughs, banks of water reservoirs). Most part of the area was chnged into a cultural and urban industrial landscape as a result of settlement and industrialization.

Majority of species of bats in Poland are connected with forests. For some species a forest serves only as a place to prey, while for others is gives shelter – crevices, tree cavities. The number of natural shelters is being constantly reduced. This type of environment is very often substituted by park green abundant in old trees with additional artificial shelters. Just as it was in the case of birds, recently special boxes for bats are becoming more commonly used [Gerell, 1985].

Bats use a variety of ecosystems within their life span. Apart from already mentioned forests, they also use areas which are quite strongly urbanized. Some bats stay in a completely different environment during the day than when they prey. For almost all bats procreation and hibernation take place in diametrically different environments. Even populations of the same species show significant differences as far as choosing the environment is concerned. However, knowledge of this subject is still very poor [Lesiński 2006].

The town of Czeladź, with anthropogenically transformed terrain, is characterized by a differentiated chiropterofauna. In the area with no natural environments having only substitute environments as many as 12 species of bats have been discovered. Out of 25 species of bats inhabiting Poland it is almost a half. Occurrence of such a large number of spieces is most certainly caused by a mosaic-like character of the area. There are built-up areas, open terrains, woodlands, green enclaves (parks, allotments, cemetaries), ponds and a river. This indicates great adaptability of certain species of bats. Changes force animals to use anthropogenic elements. Place of prey is important and it may be even a few kilometres distant [Lesiński, 2006].

Observation of the occurrence of bats in the area of the town of Hoyerswerda (Germany) showed the occurrence of 10 species of bats (Schmidt 2002). The number of species of bats in Warsaw was 13 and in the central, strongly urbanized part 10 [Lesiński, Fuszara 2001].

Ther is more data concerning winter shelters for bats in towns: Mines, adits [Kłys 2008], consolidations [Bogdanowicz, Urbańczyk, 1983; Harmata, 1994; Jurczyszyn et al., 2002], basements, shelters [Kowalski, Krasnodębski, Lesiński, 2002], sewerage system [Grzywiński, Kmiecik, 2003]. Lesiński [2006] suggests, taht winter shelters in towns are characterized by higher temperature and humidity, which is influenced by a mild climate of towns.

It turs out that bats are not an uncommon group in towns. At leas some part of the species quickly adapts and uses niches made by a man.

Protection of nature in a town, including bats, requires abiding general rules applying in this field. Maintaining potentially largest habitat diversity and creating a network of green areas will ensure convenient living donditions for a large number of species. Areas that may serve as a food base in a town are mainly fragments of natural environments; parks, greens, lawns and playgrounds. Such refuge places may also be church gardens, areas surrounding schools, kindergartens and hospitals. Humid areas, such as ornamental ponds and watercourses are of great importance, as they are both watering places and places of prey for bats. There should also be ecological passages joining all the areas. What may function as such a passage are river valleys, avenues with trees and bushes, lanes along railway tracks with proper plants and series of green areas.

Rapid development of engineering and technology, e.g. employing ultrasound detectors, allows to increase efficiency of research methods which, in addition, are not aggressive and do not pose any threat for bats. The methods make it possible to learn not only the location and quantity of bats, but also their activity, physiological processes and ecology.

Acknowledgements. The present paper is the realization of the task "Investigation of the number and species of bats in Czeladź commune, identification of their habitats, activity and determining methods of their protection". The recipient of the paper is Czeladź commune and the National Fund for Environmental Protection and Water Management in Katowice. On the basis of agreement No. B-RM/453/131/05 of 15th Sep 2005. Permit of the Secretary of State for Environment DOPog-4201-04A-6/04/al.

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Anthropogenic aspects of landscape transformations	6	Faculty of Earth Sciences, University of Silesia City Hall Office Sosnowiec Landscape Parks Complex of Silesian Voivodeship Polish Geographical Society, Katowice Branch Sosnowiec – Będzin 2010	52–56

Roman KUPKA[1], Jolanta PEŁKA-GOŚCINIAK[2], Tadeusz SZCZYPEK[2], Stanisław WIKA[3]

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Nature protection in the area of industrial city (a case study of Katowice)

According to the Convention on Biological Diversity of UN, ratified by Poland in 1996 year, the approach to protection of the natural resources has changed. It means that not only naturally rich areas should undergo protection (e.g. national parks and reserves, where mature and stabilised ecosystems predominate, but semi-natural and anthropogenic ones as well [Gliwicz, 1992]. Different succession and degeneration stages are preserved in them; they indicate direct or indirect influence of human, and through it – cultural diversity and traditional ways of management in the past. For that reason, all species and groups of species are valuable, because thanks to their existence the proper functioning of occurring there ecosystems is possible [Liro et al., 1998].

Natural values in the industrialized and urbanized terrains (complicated mosaic of natural or semi-natural phytocenoses of small area, development stages of ecotone character, systems of pioneer, changeable ruderal vegetation, arranged greenery, „refuges" of animals) enjoy therefore bigger and bigger interest. These values are investigated for two reasons: 1) cognitive – for registration of changes in the distribution of rare species of native flora and spreading of expansive plants [Sudnik-Wójcikowska, 1987; Jackowiak, 1992], and 2) application (practical) – for needs of spatial planning and nature protection as well [Borysiak, Kasprowicz, Pawlak, 2000]. Thanks to these investigations relations between species distribution and spatial diversity of towns, and mutual proportions between the structure of open surfaces – biologically active and built-up – are more and more clear [Czerwieniec, Lewińska, 2000]. It is possible to track the spreading of new plants of foreign origination [Jackowiak, Celka, 1997]. Finding of hitherto unknown sites of rare species of native flora and fauna or the oldest of the weeds (archaeophytes), can betoken the moderate human pressure on the exact environment. It is of essential importance for the active nature protection. The nature protection in the invested areas is therefore characterized by large biodiversity and it is attractive [Tokarska-Guzik et al., 1995; Celiński, Czylok, Kubajak, 1996; Wika et al., 1996; Cempulik et al., 1998; Babczyńska-Sendek et al., 1999 and others.]

Proper use and renewal of resources and individual elements of the nature, and natural complexes and ecosystems as well is of very essential significance for the active nature protection. Some authors [Szczypek, Wika, Woźniak, 1991] paid earlier attention to the fact, that naturally valuable surfaces at suburban zones should undergo protection: gardens, orchards, plough lands, wastelands with ruderal vegetation, small water reservoirs with interesting vegetation.

The typical example of industrial city is Katowice. But despite of its big-city character, and in consequence – significant transformation of the natural environment, many places of unique natural values preserved here. There are as follows: forests, water-logged meadows, ponds, fragments of non-regulated rivers and streams.

To protect naturally valuable objects in the area of Katowice city the strategy of „offensive conception of nature protection" was implemented. Its task is to create the consistent ecological system of protected areas (ESOCh) [Kupka, 1997; Tokarska-Guzik, Rostański, Kupka, 2002]. Its essence comes down to the formation (or rebuilding) continuity of green areas, which should connect with analogous systems in neighbouring, adjacent towns. This system – ESOCh – makes therefore the continuous spatial arrangement of open terrains, naturally active, which secures the proper functioning of living natural resources. In this connection the shaping of proper climatic conditions takes place here to make recreation in contact with nature possible. ESOCh makes an ecological skeleton of the Upper Silesian Conurbation and system of protected areas in the Silesian province. This skeleton is composed of: 1) forest terrains (forests of Murcki and Panewniki), 2) river valleys with adjacent meadows (the Brynica valley with so-called Szopienice Lakeland, and the Mleczna valley with tributaries as well), 3) grassy communities at native grounds and 4) post-industrial wastelands (potential link of the system), 5) some areas of field crops, 6) terrains of urban arranged greenery and 7) connecting areas between main elements of the system [Kupka, 1998]. Aims of ESOCh are among others: protection of areas with special natural conditions, urban greenery forming and keeping, protection of existing and developing new natural connections between ecosystems for urbanized and industrial terrains, improvement of biological and social conditions of inhabitants' life.

Functions of ESOCh are as follows:
- ecological (environment-forming)
- climatic,
- social.

Fulfilling these functions means that the structure of urban ecological system should be the system composed of:
- system of nature resource supply and renewal, preventing degradation and resource reconstruction,
- system of regeneration, supply and air exchange, enabling the improvement of ecological state and urban climate,
- system of recreation and rest to provide regeneration of psychophysical strength of inhabitants.

To built ESOCh the recognition of existing natural resources of the city, pointing at especially valuable natural areas, and determining forms of the nature protection and way of their use were necessary. That being so areas of large natural values were distinguished [Tokarska-Guzik, Rostański et al., 1994].

Among the above-mentioned, valuable natural areas in the area of Katowice are numbered: 1) nature reserve „Las Murckowski" ("Murcki Forest"), 2) floristic reserve „Ochojec" (Okhoyets), 3) 16 objects of smaller range of different size and character, including among others natural-landscape complexes and ecological areas (Katowicki Park Leśny – Katowice Forest Park), fragments of other forests, valleys of small rivers, artificial water re-

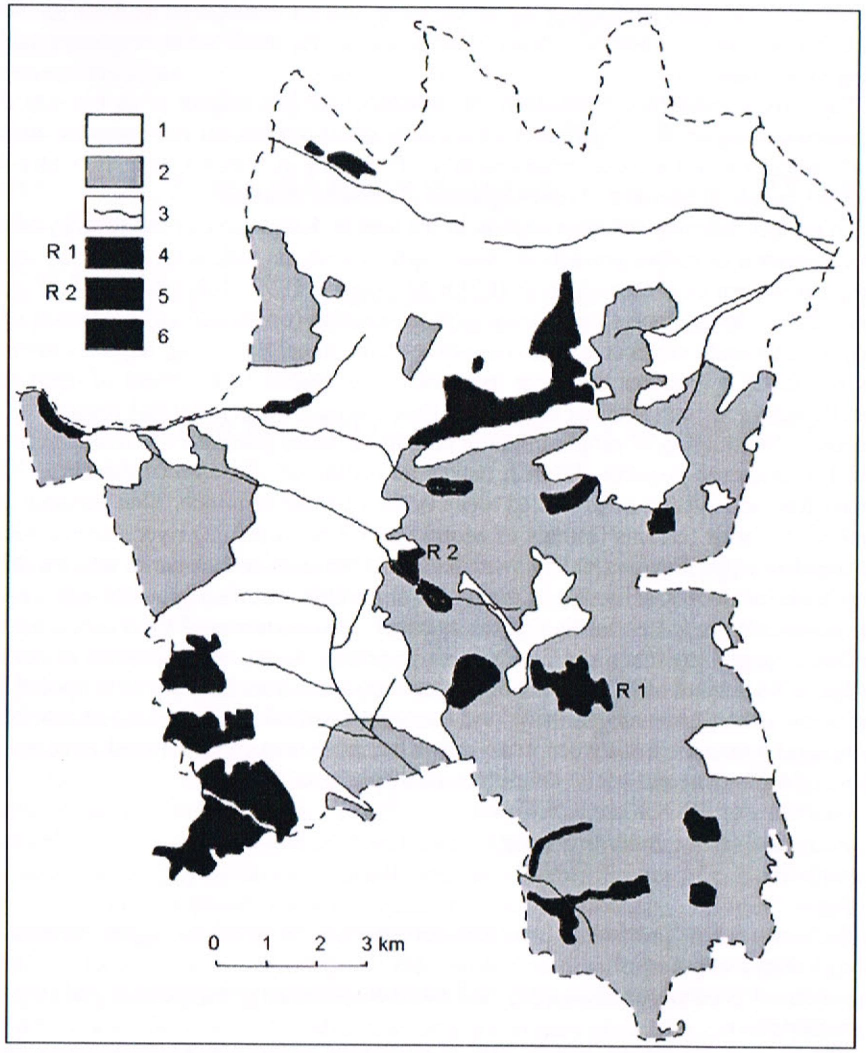

Fig. 1. Protected areas in the territory of Katowice
1 – urbanized and industrialized terrains, 2 – forest areas, 3 – rivers, 4 – nature reserve "Murcki Forest", 5 – nature reserve "Ochojec", 6 – other protected areas

servoirs, arable land – compare fig. 1). In the area of Katowice city 36 natural monuments also exist in a form of monumental trees, most of all oaks and beeches.

It is worth paying attention to 2 protected objects in Katowice: „Las Murckowski" and reserve „Ochojec".

The nature reserve „Las Murckowski" is a forest reserve, created in 1953 year and enlarged – in 1989. It occupies the area of 102,5 ha and is located at the slopes of Wzgórze Wandy („Wanda Hill" – 350 m a.s.l.). It protects the remains of former Silesian Primeval Forest. In this reserve area beech old-growth forest grows, which is more than 150 years old. There many monumental individuals of beech and oak occur as well.

The nature reserve Ochojec was formed in 1982 year. It occupies the area of 26,8 ha. It is a floristic reserve, which aim is to protect one of not numerous in Poland sites of claspleaf twistedstalk *Streptopus amplexifolius,* located outside the mountains. It is the most numerous– outside mountainous areas- concentration of this species in Europe (about 500 specimens).

Terrains, being elements of ESOCh, are not completely excluded from economic use, but it is necessary to: 1) take the conservation of all existing plantings and meadows with protected plants, animal breeding sites and animal refuges into account, 2) enable animal migration, 3) prevent localization of investments, which are harmful or which can worse the environment state, 4) limit the covering of terrain surface with impermeable substances.

Protection of – hitherto very devastated – valleys of small rivers, flowing through Katowice [Kupka, 2000; Tokarska-Guzik, Rostański, Kupka, 2002; Wistuba, Waga, 2006] is of very essential importance. The point is that these areas – as a main skeleton of ESOCh – will become moderately natural objects once again, regulated and concreted only in the most essential cases, polluted as little as possible, to – simply-without obstacles – fulfil their ecological functions and become places for walks and recreation again.

Large-city terrains, additionally strongly industrialised, dispose therefore precious natural values many times. They are of very large ecological importance and among others for that reason – it is necessary to pay attention to them and protect.

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Anthropogenic aspects of landscape transformations	6	Faculty of Earth Sciences, University of Silesia City Hall Office, Sosnowiec Landscape Parks Complex of Silesian Voivodeship Polish Geographical Society, Katowice Branch Sosnowiec – Będzin 2010	57–62

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Classification alternatives of field shelterbelts on the basis of a Hungarian study-area (Nyírség)

Introduction

Origin of planting field shelterbelts dates back to the 15th century when the Scottish Parliament ordered the plantation of field-protecting forests in order to protect agricultural products [Droze, 1977]. In the United States forests were planted in order to protect farms in the 19th century at the time of expansion towards the west. In order to protect lands against the dust storms experienced in the 1930s the American congress established the “Plains State Aforestation Plan” the main task of which was to plant field shelterbelts and to create the directorates of plantation. In northern China, forest belts were planted in the 1950s due to intensifying soil erosion. Furthermore, field-shelterbelt plantation programmes were initiated in several sites worldwide: Australia, Canada, New Zealand, the former Soviet Union, South America and in numerous developing countries as well.

The idea of bonding sand was raised first in the second half of the 18th century when running sand caused such damage especially in sandy regions where deforestation and unlimited grazing was intense, that measures were taken towards aforestation (aforestation of the sandy areas primarily at that time). This involved basically the Danube-Tisza Interfluve as running sand caused most damage in this region due to its sensitivity to drought. In the 1950s the plan for a national network was completed (primarily according to the soviet principles at that time) according to which protective forests would have been planted along the major rivers and the orientation of the field main shelterbelts connecting them would have been adjusted to the prevailing wind direction. Apart from these, applicable tree species, sapling requirements and planting methods were also regarded [Magyar, 1961].

Following the completion of the plans, plantation of field shelterbelts was started. Its aim was on the one hand to support agricultural production and on the other hand to help the wood supply of the country. Aforestation works therefore started in several collective (Túrkeve, Karcag, Kisújszállás), state (Hortobágy, Mezőhegyes) and experiment farms (Lovászpatona, Fertőd).

Field-protecting forest belts have very important roles in protection against wind erosion. Thus accurate survey of field-protecting forest belts is highly important as there is no accurate information on them. They are not involved under the authority of forestry (it manages belts wider than 21 m) but former owners (mainly collective and state farms) were defunct or transformed leaving unclear ownerships back resulting in the deterioration of forest belt networks.

Material and methods

Survey of the field shelterbelts important in protection against wind erosion was carried out in the central part of the Nyírség, a sandy region of Hungary fig. 1). The study area was chosen because it is extremely sensitive to deflation due to its soil conditions and because aforestations and plantation of field shelterbelts started as early as the 18^{th} century. Surveying of field shelterbelts was performed on the basis of topographic maps and the database of Google Earth supplemented by field observations and photos.

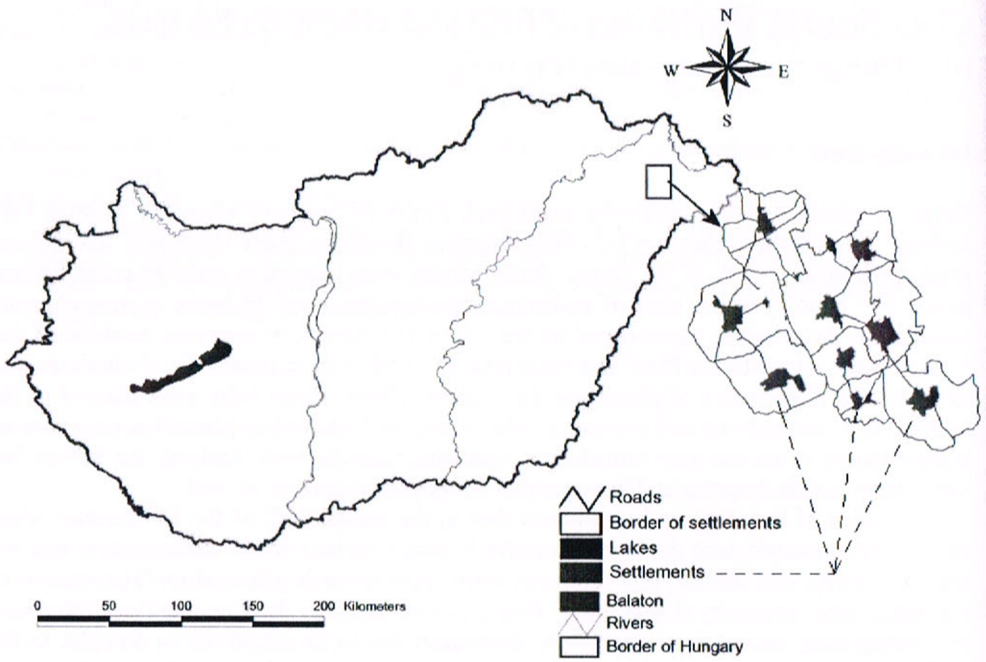

Fig. 1. Location of the study area

Field shelterbelts occurred on maps first in the 1:50 000 survey of the Hungarian Kingdom performed between 1940 and 1942. For the next period the topographic maps published in 1975 were applied (fig. 2). Unfortunately these do not show the row number and porosity of field shelterbelts. The belts were digitized from the maps from between the two world wars, the topographic maps of 1975 and the Google Earth surveys of 2005 using the software ArcView 3.2.

Attribute tables of the given polygons were filled by the following parameters:
- number of rows in the forest belt,
- porosity (structure) of forest belts,
- orientation of forest belts,
- length of forest belts,
- area of patch like forests,
- settlement name,
- function of field shelterbelts.

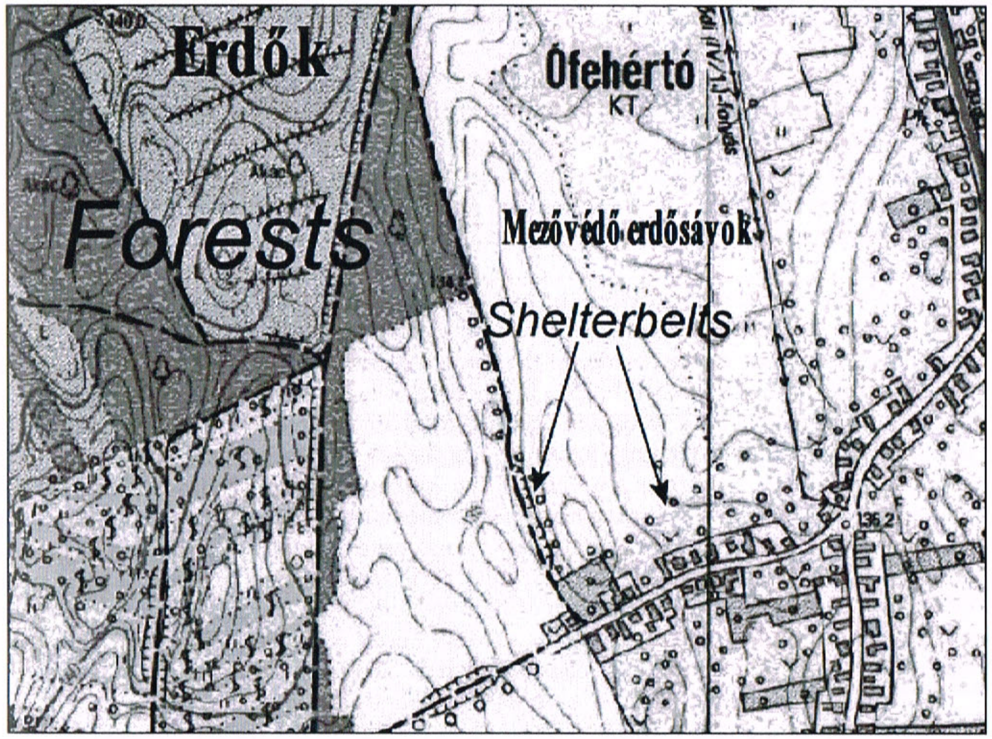

Fig. 2. Field protecting forest belts and woodlands on the topographic maps of the 1970s

Each parameter was evaluated by a point system and summing the points of the parameters the values of the forest belt was obtained. In this way, quality assessment and comparison of the field shelterbelts became possible. In the course of evaluating the forest belts by points their structure, porosity and orientation were qualified.

Due to the variability of the topic I only present changes in the length and area of woodlands and forest belts. Their evaluation will be presented in another paper.

Results

Based on the maps of surveys performed at different times I prepared the digital maps of field shelterbelts and aforestations of the study area and determined their change in space and time.

Map data of the 1940s show that around 10% of the study area was covered by forest. Largest fields were found between Baktalórántháza and Ófehértó and southeast from Ófehértó (the area called Nagy-erdő on the map). Its area is 17 km^2, i.e. 60% of the total woodland area. Regarding forest belts, most of them (114 km) were found in the area of Kántorjánosi. If the length of forest belts compared to one unit area is regarded then most forest belts were found in the surroundings of Őr where, on the other hand, forests are fewest. This might be explained by that forests were substituted by field shelterbelts.

The majority of field shelterbelts were placed along accommodation roads and they were also protecting pastoral lands. Unfortunately the maps contain no information on their structure thus the number of rows, longitudinal distance of trees can only be researched in archives.

The above might be explained by that at the start of aforestations (18^{th}–19^{th} centuries) forest plantation involved mainly sand aforestation, covering sandy areas by forest. This explains higher forest rates in the Nyírség compared to the rest of the Great Hungarian Plain. At that time, erodability of more bound soils was not considered thus no notice to their protection was given. This also resulted in that forest belts followed (and still follows today) mainly roads. Prevailing wind directions were not regarded at the time of their plantation.

Significant changes occurred in the extent of woodlands and field shelterbelts (Tables 1, 2). Extent of forests in the study areas was increased by 2.5 times in 30 years. Good example of this is the eastern border of the woodlands around Flórtanya where woodlands had been present earlier as well (25% of the areas was covered by forest at that time). Regarding settlements most woodland was planted around Kántorjánosi and Nyírkáta. This was obtained partly by extending already present forests and partly by afforesting the areas between forest belts. Examples are found in the eastern borders of Nyírgyulaj and around Flórtanya where forests were present but in a smaller area. Nyírkáta is a good example for the latter one. Occasionally completely new forests were planted as well: south of Őr and north of Nyírcsászári. Between the two time periods 80 km of new forest belts were established. Considering the orientation of field shelterbelts no changes occur as they were planted mainly along roads in the 1970s as well. Forest belts crossing arable lands were also planted along accommodation roads but the roads were cultivated later.

Changes in the extent of forest areas and forest belts occur again nowadays due to the transformation of the land ownership structure as a result of the regime change (Tables 1 and 2). Extent of forest areas was increased further in the study area according to the system mentioned before. Increasing forest areas are observed in the surroundings of Kántorjánosi, Nyírkáta and Baktalórántháza. Length of field shelterbelts, however, was reduced by 130km, below the value of 1940, although it occurred in different rates at certain settlements (*Table 2*). At some of the settlements (Baktalórántháza, Kántorjánosi) length of forest belts was reduced way below the 1940 value. On the other hand, there are settlements (Hodász, Nyírkáta) where length of forest belts has decreased continuously since 1940. This, however, does not mean necessarily that arable lands were left without shelter as I have already mentioned shelterbelts vanished frequently due to aforestations as they became part of the extended forest areas.

Where shelterbelts really vanished (e.g. along canals and accommodation roads) there old and cut forest belts were not re-planted. This was the task of collective farms but following their closure even ownership conditions are unclear thus it is uncertain whose task would be the management and re-planting of shelterbelts.

Changes in the extent of forest areas and forest belts occur again nowadays due to the transformation of the land ownership structure as a result of the regime change (Tables 1 and 2). Extent of forest areas was increased further in the study area according to the system mentioned before. Increasing forest areas are observed in the surroundings of Kántorjánosi, Nyírkáta and Baktalórántháza. Length of field shelterbelts, however, was reduced by 130km, below the value of 1940, although it occurred in different rates at certain settlements (*Table 2*). At some of the settlements (Baktalórántháza, Kántorjánosi) length of forest belts was reduced way below the 1940 value. On the other hand, there are settlements (Hodász, Nyírkáta) where length of forest belts has decreased continuously sin-

Table 1. Extent of forests in the study area in the Nyírség

	Bakta-lórántháza	Hodász	Kántor-jánosi	Nyír-császári	Nyír-derzs	Nyír-gyulaj	Nyír-káta	Ófehér-tó	Őr
1940									
area of forest (km^2)	11.54	0.38	0.61	0.98	0.22	1.46	2.40	11.53	0.00
ratio of forest cover (%)	32.74	1.42	1.46	7.41	1.28	4.07	6.20	26.69	0.01
1970									
area of forest (km^2)	15.88	3.48	7.90	2.88	2.08	5.28	13.53	17.24	1.13
ratio of forest cover (%)	45.06	13.13	18.97	21.74	12.25	14.77	35.02	39.92	6.36
2005									
area of forest (km^2)	19.51	4.25	10.13	3.26	2.98	5.92	17.10	16.18	1.28
ratio of forest cover (%)	55.34	16.06	24.33	24.65	17.49	16.56	44.26	37.47	7.20

ce 1940. This, however, does not mean necessarily that arable lands were left without shelter as I have already mentioned shelterbelts vanished frequently due to aforestations as they became part of the extended forest areas.

Where shelterbelts really vanished (e.g. along canals and accommodation roads) there old and cut forest belts were not re-planted. This was the task of collective farms but following their closure even ownership conditions are unclear thus it is uncertain whose task would be the management and re-planting of shelterbelts.

High ratio of forest cover (around 30%) in Great Plain terms (average forest cover in the Great Hungarian Plain is around 11%) is caused by special soil conditions and thus land-use. In the Nyírség where different types of sandy soils occur and the risk of deflation is high arable cultivation is hardly profitable compared to loess areas. Therefore more land is forested to reduce the effect of wind and to obtain some profit from the selling of timber.

Table 2. Change of length of field-protecting forest belts sorted by settlements between 1940 and 2005 (km)

	1940	1970	2005
Baktalórántháza	42.3	55.1	37.6
Hodász	57.3	57.1	45.9
Kántorjánosi	114.6	127.7	94.6
Nyírcsászári	28.0	41.7	34.5
Nyírderzs	36.9	52.6	41.1
Nyírgyulaj	73.9	89.1	74.3
Nyírkáta	75.0	61.3	49.9
Ófehértó	49.6	64.0	53.2
Őr	66.6	79.3	67.9
Összesen	544.8	630.2	499.4

Summary

Changes over time of the length of field shelterbelts and the extent of forest cover were analysed in a study area of the Great Hungarian Plain based on maps and aerial photos prepared in different time periods. Based on the results I have stated that the two parameters changed differently in the last few decades. Ratio of forest areas has increased continuously while the length of shelterbelts has decreased continuously since 1970. The two changes supplement each other: vanishing shelterbelts are gradually replaced by forest areas. This is advantageous from both wind erosion protection and sustainable land-use points of view as sandy soils are especially vulnerable to deflation and their productivity is small as well.

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Conservation of precious natural non-forest communities in the landscape parks of the Silesia Province in the years 2000–2009; an analysis of actions carried out

Introduction

The Landscape Parks Complex of the Silesian Voivodeship (ZPKWŚ) has been located within the present boundaries since 2000 and it covers an area of eight landscape parks. Its priority is to supervise the area of the landscape parks in the Silesia Voivodeship in accordance with the law, especially with articles 105 and 107 of the Nature Conservation Act (the Act of 16th April 2004 with later amendments), and to perform its statutory actions as defined by the Statute of the ZPKWŚ passed by the Act No III/41/6/2009 of 26th August 2009 of the Silesia Voivodeship Seymik, on the Statute of the ZPKWŚ.

The main objective of this analysis is to recapitulate the projects concerning active conservation of nature in non-forest communities carried out by the ZPKWŚ in the years 2000–2009 and to suggest further actions and methods of nature conservation.

The researched area

Non-forest communities protection in the landscape parks of the Silesia Voivodeship is mostly focused on two units: the Cracow-Częstochowa Upland, where the Eagles' Nests Landscape Park is situated, and the West Beskid Mountains with three landscape parks: the Silesia Beskid, the Żywiec Beskid and the Little Beskid.

The subject of the research performed

Non-forest communities are of precious character for their natural and landscape valour and are an important element of the Silesia Voivodeship nature and landscape. They are regarded as semi-natural communities, which resulted from agricultural activities, especially herding. They are characterised by high biodiversity and a high percentage of species found on red lists [Majchrzak, Witkowska, 2003; Krause, 2008; Majchrzak, Okoń, 2009 and others].

The following are the most important actively protected non-forest communities:

Xerothermic grasslands, which can be defined as stenothermic grassy communities of steppe character whose occurrence is dependent on climate, soil and orographic conditions

[Herbich, 2004]. Those communities have high biodiversity and high diversification. The biggest area of their occurrence is found within the Eagles' Nests Landscape Park and it can also be observed in patches within the Beskid Landscape Parks.

Epilithic grasslands are found on limestone walls, mainly in cracks and on rock shelves, where there is a thin layer of humus or pararendzina [Herbich, 2004]. They are particularly well formed on Upper Jurassic limestones (the Eagles' Nests Landscape Park). Typical plants comprise *Festuca pallens* and *Jovibarba sobolifera*. The exposition of rock walls determines the varieties within the community. The activities carried out consist mainly in conserving the variety, which is found in the sunny southern part with a high share of stenothermic species.

Molinia meadows of variable moisture content: in the Eagles' Nests Landscape Park, they occupy mostly local depressions and marshy areas at the foot of the morphological edge which marks the western border of the Cracow–Częstochowa Upland. Those are *Molinietalia* order meadows and their characteristic feature is colourful monocotyledonous and dicotyledonous perennial plants growing in rich, neutral or alkaline habitats, with calcium carbonate and of variable moisture content. The most important species found here are *Iris sibirica, Colchicum autumnale* and *Trollius europaeus*.

Non-forest communities in the mountains: their plant cover is diversified, with plant communities whose plant and animal diversity is significant. The conservation project comprises communities such as tall herbs with *Aconitetum firmi*, *Valeriano–Caricetum flavae, Sphagnetum magellanici, Gladiolo–Agrostietum, Carlino-Dianthetum deltoidis* and patches containing *Campanula serrata* of European significance (Natura 2000).

The work carried out

From 2000 to 2009, ZPKWŚ carried out the following activities concerning conservation of the communities mentioned above:

1. In the area of the Eagles' Nests Landscape Park, on xerothermic and epilithic grasslands, the work carried out consisted in removing juvenile specimens of trees and shrubs, mostly of species such as pine, birch, juvenile hornbeam, and, among shrubs, mostly hazel and blackthorn. The plots with juvenile trees and shrubs were conserved by means of periodic scything the uncovered surface. During the years mentioned above, such activities were performed on an area of about 90 ha (photo 1).

Photo 1. Xerothermic grasslands, Kroczyckie Rocks, The Eagles' Nests Landscape Park (phot. by D. Okoń, 2009)

2. The work aimed at conservation of meadows of variable moisture content consisted in a single scything in 2008. The area concerned was about 20 ha (photo 2 and 3).

Photo 2. *Molinia* meadow in Łazy region (phot. by D. Okoń, 2008)

Photo 3. *Molinia* meadows in Łazy region during scythe (phot. by D. Okoń, 2008)

3. In the area of the Beskid Landscape Parks, the activities concerning conservation of mountain pasture flora consisted in scything, including patches where bilberry had entered, and in removing juvenile specimens of trees and shrubs. The work was carried out in two stages. During the first one, in 2007, work was done on an area of about 126 ha, and during the second stage, in 2009, work was done on an area of about 340 ha (photo 4).

Accompanying activities

The activity of ZPKWŚ concerning conservation of non-forest communities consists in, first of all, carrying out works described in the section devoted to the range of actions. As the programme of non-forest communities conservation is being implemented, the issue of increasing the natural impact of the actions performed is discussed by nature conservation services and by scientific circles [Szymczyk, 2003 and others]. Work consisting in merely tree and shrub felling is only partially effective because of quickly reappearing tree and shrub suckers (photo 5). The most permanent effects may be ensured by multidimensional and complex activities, comprising first of all commencing extensive pasturage both on open areas and on those, where non-forest communities (in this case, xerothermic and epilithic communities of stenothermic character and Alpine meadows) are still present.

Following these discussions have been complex actions introduced for a few years now. The ZPKWŚ purchased sheep of the native Olkuska breed. The sheep were handed over to farmers, who herd them on the areas, which are of great natural value in the Eagles' Nests Landscape Park. These actions have perfectly matched the "OWCA PLUS" programme of economical mobilization and of the Beskid's and the Cracow–Częstochowa Upland's cultural heritage preservation, supervised by the Marshal Office of the Silesia Voivodeship [Fąfera, Kasztelnik, 2009 and others] and carried out from 2008 to 2010 in the Cracow–Częstochowa Upland and the Beskid Landscape Parks, with active participation on the part of the ZPKWŚ.

An important aspect is also the cooperation with the local society. Especially interesting is, among other things, the activity of the inhabitants of Podlesice (the Eagles' Nests Landscape Park) in cooperation with scientists and local authorities, concerning conservation of the biodiversity within the central part of the Eagles' Nests Landscape Parks – the Kroczyckie Rocks and the Podlesickie Rocks. One of the results of this is the introduction of controlled goat pasturage in the Góra Zborów geological features reserve.

Photo 4: Pawlusia mountain meadow during scythe, Beskid Żywiecki Landscape Park (phot. by R. Łatanik, 2009)

Photo 5. Xerothermic grasslands, Rzędkowickie Rocks, the Eagles' Nests Landscape Park, two years after preservation of nature work (phot. by D. Okoń, 2009)

Additionally, the cooperation with the Polish Mountaineering Association, gathering mountain climbers, is another important element of non-forest communities conservation.

In order to eliminate the threats described in the paper, lands of significant natural value have been purchased and transferred into permanent administration on behalf of the State Treasury, including non-forest communities such as xerothermic grasslands, epilithic grasslands and meadows of variable moisture content. An important element of these proceedings is the ecological education provided in the Educational Centres of the ZPKWŚ.

Assessment of antropopression within non-forest communities

A lot of studies and methodological guides suggest the need for conservation of non-forest communities (among others the guide on sites and species conservation Natura 2000, quoted above, Herbich, 2004; the Internet website of the Grasslands Naturalists' Club www.murawy.eu). As it was emphasized above, the common feature of all the communities described in this paper is that, strange as it may seem, most of them originated on post-forest sites as a result of human activity. Within the present boundaries of the Eagles' Nests Landscape Park, felling was carried out in order to acquire firewood. Then, on the deforested areas, pasturage and scything were carried out.

Pasturage in the mountain regions was associated with herding activities of Wallachian shepherds. The area for scything increased as a result of clearing and burning down forests. This gave rise to the non-forest communities described here. At present, observations suggest an opposite situation. Because the pasturage and scything activities have been terminated, generally for economic reasons, excessive succession of forest communities onto non-forest areas is taking place. Trees such as pine and birch (light-seeded trees) and shrubs, mainly blackthorn, enter first, causing moisture and temperature changes in the community and forcing non-forest species, often precious and rare, to recede. As a consequence forest communities may be expected to return to areas which are no longer used. The growth of entering trees and shrubs results in rocks being obscured (which diminishes their landscape value) and xerothermic complexes being shaded, which, in turn, causes transformation and impoverishment.

Another serious threat is penetration associated with the recreational and touristic function of the region. The penetration takes a number of forms, including rock climbing, hiking, mountain biking, integration business outings, or survival courses. Additionally, bonfires are lit, frequently in rock shelters or on flat inselberg tops, which destroys plants. Rock climbing, more and more popular, especially with amateur climbers, poses an enormous threat for grass species. The latest danger has come from property owners who put fences on their land, thus rendering conservation efforts impossible [Majchrzak, Okoń, 2009].

Summary

Non-forest communities are among the ones characterized by high biological diversity. Among the most important efforts made by ZPKWŚ in order to protect them are active attempts concerning nature conservation. These attempts will be continued in 2010. Following the example of previous years, non – forest communities will be scythed and juvenile specimens of trees and shrubs will be removed from them. Pasturage will be taking place on selected areas. Scientific assessment of conditions resulting from active conservation proceedings in the communities of the Eagles' Nests Landscape Park will be a significant aspect of the activities described above. The assessment will also consider areas, which should be protected by means of active proceedings, and a detailed schedule of all actions will be designed. The final result of all those activities will be a strategy aimed at conservation of selected non-forest communities in the Eagles' Nests Landscape Park for the years 2011–2020. In the Beskid Landscape Parks, the staff of the ZPKWŚ will inspect non-forest communities in the mountains after the activities of the previous years. The inspection is supposed to provide information on the condition of those areas and indications concerning future proceedings considering nature conservation.

Hopefully, it will be possible to use the results of the field inspection and the strategy also in other landscape parks, so that non-forest communities preserved in the landscape remain a harmonious composition of high biodiversity and man's activity.

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Ancient forests of the Opole Voivodeship in the light of dendrological research in The Boże Oko and Jaśkowice nature reserves

Introduction

In recent centuries, natural vegetation of the area of Opole Voivodeship underwent substantial changes. Anthropogenic changes in the original vegetation began in the late Atlantic period and Subboreal period for the Neolithic agriculture purposes. The process of deforestation continued in the Middle Ages. Despite the existence of large complexes of Silesian-Lusatia Primeval Forest (forests between Mała Panew and Stobrawa and large areas of forest on Nysa Kłodzka), areas with the most fertile soils were devoid of forests as early as in the 10th century. As a result of further development of the agricultural economy, forests retreated more and more towards lands of the poor soils and less accessible areas. Until the 17th century, wasteful exploitation dominated, so that at the turn of the 18th and 19th century forest acreage has been reduced by half in comparison to 10th century. 19th and early 20th century led to further changes to forest stand in the lands of Silesia. But these were mostly quality changes – artificially planted pine monocultures become characteristic. Stretches of forests: Stobrawa Forests, Swierklaniec Forests, Raciborz Forests, Pszczyna Forests and Niemodlin Forests are still preserved. Until the 20th century forest acreage has declined only in industrial districts [Nyrek, 1975; Łapiński, 2003; Orczewska, 2003; Fronczak, 2004]. Currently, fragments of Silesian-Lusatian primeval forest in the Opole region are preserved in 34 nature reserves [Kusza, Strzyszcz, 2005].

Tree-ring analysis and tree-age structure connected with land-use history has proven to be a robust approach for understanding long-term variation in forest dynamics and reconstruction the historical development of forests in terms of periodicity of disturbances, the impacts of yearly climatic variation and extreme weather phenomena, and populations dynamics. Such applications are widely used in ecological studies and have been applied by many authors [Norton, Palmer, Ogden, 1987; Fritts, Swetnam, 1989; Szychowska-Krąpiec, 1996; Abrams et al., 2001; Rozas, 2003; Splechtna, Gratzer, Black, 2005].

The aim of the study is dendrochronological assessment of the age of the forest stands and dendroecological analysis. Preliminary results are presented on examples of Boże Oko and Jaśkowice Nature Reseves and can be extended to other nature reserves.

Study area

Investigated nature reserves are located in Opole Voivodeship (fig. 1). Jaśkowice Nature Reserve is located on Niemodlin Plain, Proszkow forest inspectorate, Przysiecz forest district 120c. In the reserve, the object of protection is to preserve part of mixed forest with the presence of *Larix decidua* var. *sudetica*. Natural stand in reserve is composed of three species: *Larix decidua*, *Pinus sylvestris* in the age 165–190 years and *Quercus robur* in the age 65–85 years. The dominant species is *Larix decidua* and provides 70% of stand, *Pinus sylvestris* takes 20%, *Quercus robur* 10%. *Picea abies* currently appears one by one or in groups at the age of 170 years. The admixture includes also the *Betula pendula*, and the undergrowth includes *Calamagrostis arundinacea*, *Melica nutans*, and *Maianthemum bifolium* [Kusza, Strzyszcz, 2005].

Boże Oko Reserve is part of the Góra Świętej Anny Landscape Park. It is located in the massif of Chelm, the Forestry Strzelce Opolskie. The reserve is covered with beech forest, at the age of 130–160 years. The admixture is composed of *Larix decidua*, *Picea abies*, *Carpinus betulus*, *Betula pendula* and *Pinus sylvestris*. The undergrowth includes about 60 species of vascular plants. There noticed also protected species as *Epipactis palustris*, *Galium odoratum*, *Asarum europaeum*, *Hedera helix*. The relief of the reserve is diverse, there are numerous karst funnels, dry valleys with wide bottoms and steep slopes [Park Krajobrazowy "Góra Świętej Anny", 1998; Kusza, Strzyszcz, 2005].

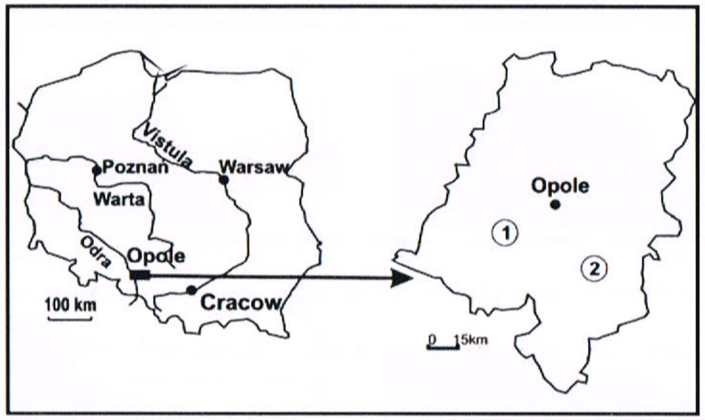

Fig. 1. Location of study area:
1 – Jaśkowice Nature Reserve, 2 – Boże Oko Nature Reserve

Materials and methods

Samples were collected in the forest districts: Strzelce Opolskie and Prószków. Three dominant species were chosen: *Fagus sylvatica*, *Pinus sylvestris* and *Larix decidua*. Latin names of plant species are derived from Mirek et. al. [2002]. Samples were collected before the growing season of 2010, by coring with Pressler borer. Such method did not cause any greater damage to the trees while adequate hole protection is provided. Approximately 10–15 cores were taken from every species. In order to avoid disturbances of the tree ring course, samples were collected from trees with correct conformation, with no signs of damage.

In order to obtain images of cross-section of wood tissue standard dendrochronological preparation was applied. In the first stage the number of annual rings were counted under binocular. If the borer have reached the pith, the age was determined with an accuracy of up to one year. In other case error for determining the age of the trees was larger and ranged from a few to several years. In next step the annual rings width were measured using a special equipment for dendrometric measurements with resolution 0,01mm. Then values of the correlation coefficient (CC) between a given sample, and the average of all series were calculated. Dendrochronological curves, which relevant statistics (CC) reached high values were averaged and standardized in order to construct local tree-ring (TR) chronologies for particular species. For statistical procedures computer program COFECHA [Holmes, 1983] was used.

Results and disscusion

Tree-ring chronologies

Altogether 71 wood samples were measured. In the first step, the age of the tree have been obtained. Fig. 2 presents time span of the samples. The trees around 150-years-old were prevailing. Only 7 samples were older then 200 years. The oldest samples came from *Fagus sylvatica,* covering the periods: 1767–2010 and 1785–2010. There were three samples of *Fagus sylvatica* and two *Pinus sylvestris* samples from 18th century.

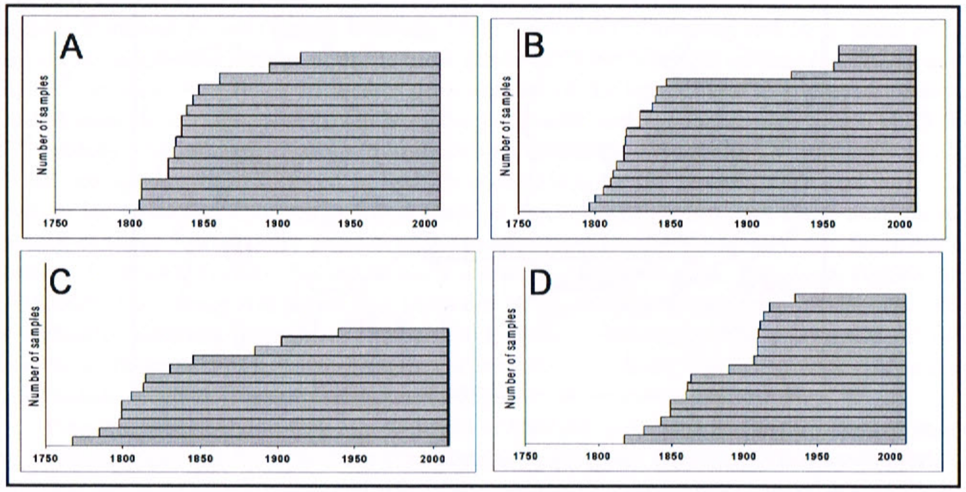

Fig. 2. Replication of the tree-ring sequences forming the sites chronologies:
A – *Larix decidua* from Jaśkowice, B – *Pinus sylvestris* from Jaśkowice, C –*Fagus sylvatica* from Boże Oko, D – *Pinus sylvestris* from Boże Oko

The age of the sampled trees is older then suggested by previous elaborations [Kusza, Strzyszcz, 2005; RDLP – unpublished data]. In the Jaśkowice Nature Reserve the age of the pine woodland is 30–40 years older and *Larix decidua* trees are 20 years older then estimated (with the exception of larches which are found as natural monuments and have not been sampled). Beech forest in Boże Oko Nature Reserve is 40–50 years older then it was

described in literature [Park Krajobrazowy "Góra Św. Anny", 1998]. Investigated woodlands can be classified as ancient forest, which are according to definition [Dzwonko, Loster, 2001; Orczewska, 2003], remains of primeval forests or those which lasts in the landscape longer then 200 years.

The local chronologies for two natural reserves: Boże Oko and Jaśkowice were produced (fig. 3). Comparison of statistical parameters of the chronologies are shown in table 1. From every site 3 – 7 samples have been deleted from the final TR chronology because of low, insignificant correlation coefficient and individual growth trend. Mean sensitivity (mean size of changes between two values in time series), which indicates sensitivity to environmental factors [Fritts, 1976 after Glock, 1937] was highest for *Larix decidua* but similar for other species. Mean ring width were wider for trees (both *Fagus sylvatica* and *Pinus sylvestris*) growing in Boże Oko. *Larix decidua* chronology was characterized by the best agreement between the samples expressed as the highest correlation coefficient within this chronology (0,583).

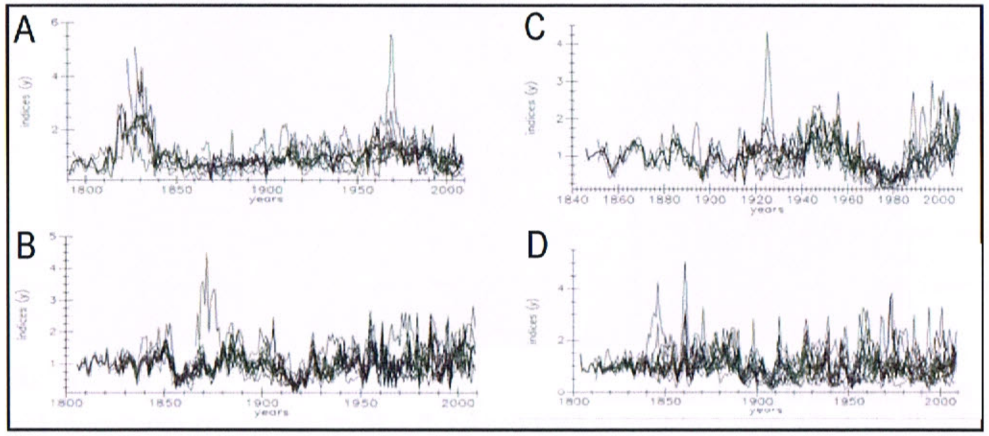

Fig. 3. Standardized ring width chronologies against a background of individual samples from particular sites:
A – *Fagus sylvatica* from Boże Oko, B – *Larix decidua* from Jaśkowice, C – *Pinus sylvestris* from Boże Oko, D – *Pinus sylvestris* from Jaśkowice

Table 1. Statistical data for the tree-ring chronologies

Location	Species	No. of samples	No. of samples in chronology	Age of the oldest tree	Chronology length (> 5 samples)	Mean ring width (mm)	Mean sensitivity	Variance %	Correlation coefficient within master chronology
Boże Oko	*Fagus sylvatica*	14	11	223	1791-2009	1,72	0,24	54	0,478
Boże Oko	*Pinus sylvestris*	17	11	192	1908-2009	1,87	0,28	80	0,388
Jaśkowice	*Larix decidua*	18	13	217	1825-2009	1,38	0,29	75	0,583
Jaśkowice	*Pinus sylvestris*	22	15	215	1813-2009	1,36	0,28	76	0,428

Anthropogenic and natural hazards

Forests of the Opole Voivodship are threatened by biotic, abiotic and anthropogenic factors. Biological hazards are mainly caused by enthomofauna: *Acantholyda posticalis, Lymantria monacha, Tortrix viridana* [Łapiński, 2003]. Such insect outbreaks can be indicated by the dendroecological analysis of wood anatomy [Schweingruber, 1996]. There are growth reductions which last at least 3–4 years (fig. 4), in contrast to extreme climate events indicated usually as only one very narrow ring [Zielski, Krąpiec, 2004]. Insect outbreaks are present in the investigated chronologies in the following years or period: 1947–1950, 1951–1966, 1994–1996, 2005–2006, what corresponds with foresters reports [Łapiński, 2003; unpublished data of RDLP Katowice]. The importance of insect gradation effect on wood is confirmed by weak and not significant correlation with climatic parameters in these periods.

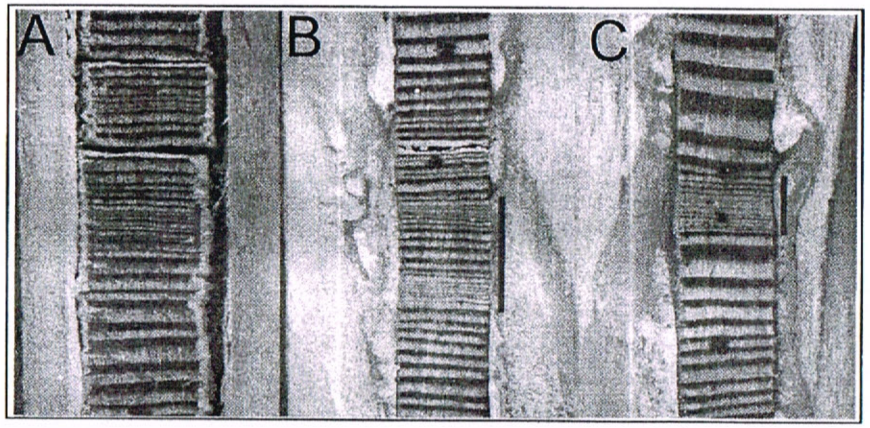

Fig. 4. Examples of growth reductions:
A – 10-yrs cyclic insect reductions in *Larix decidua*, B – 10-yrs cyclic insect reductions in *Pinus sylvestris*, C – ten very narrow rings on 1cm of sample show significant growth depression in the years 1970–1980 at *Pinus sylvestris* stand

However, in 19th century and first half of 20th century rapid growth reductions are caused mainly by meteorological factor like drought. *Pinus sylvestris* and *Larix decidua* from Upper Silesia are sensitive to lack of water in the beginning of vegetation period, thus low amounts of precipitation in spring months causes producing very narrow ring in the given year [Opała, 2010]. In the analyzed growth curves there are periods with annual ring size decrease like 1916–1918, when spring precipitation amounts were much below the average value for tree years constantly. Negative pointer years related to drought in vegetation period are also: 1822, 1842, 1856, 1892, 1922, 1959. This pointer years occur also in the studies from southern Poland [Szychowska-Krąpiec, 2000; Danek, 2009] and other regions of the country [Wilczyński, 1999].

The growth reductions, the strength of relationships between climatic conditions and tree growth and also tree-ring series convergence inform about habitat adaptation, but can also be an indicator of industrial emissions influence [Zielski, 1992; Zielski, Krąpiec, 2004; Szychowska-Krąpiec, 1997; Malik, Danek, Krąpiec, 2009]. Investigated sites were exposed

on industrial pollution since 19th century. Conifers species are more sensitive to emissions, hence there are curve decreases in *Pinus sylvestris* chronology in 1857 (foundation of cement factory in Opole) and in 1897 (foundation of paper mill in Krapkowice) as reaction on increased dust and exhaust gases contamination. Also in the decade 1970–1980 there is a significant growth depression in pine chronology. Simultaneously, *Fagus sylvatica* and *Larix decidua* form the same locations remain intact. The importance of industrial pollution on tree rings requires a broader research as they were only mentioned here.

Conclusions

Although southern part of Opole Voivodeship is primarily deforested with woodland cover only 4%, parts of the primeval forest are still preserved in natural reserves. Investigated woodland were older then suggested in literature estimations, reaching age of 200–230 years. Such age of natural reserves forests proves that investigated specimens have reached its end of life cycle, which is approximately 300 years for *Pinus sylvestris* and *Fagus sylvatica* [Białobok, 1970; Seneta, 1981]. 200 years old trees preserved in natural reserves are good archive of natural and anthropogenic changes in the environment, such as long-term drought, insects gradations or air pollution. The results of the study confirm the effectiveness of dendrochronological method and the desirability of the application on a larger research material.

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Subsidence depressions as anthropogenic wetlands – selected hydrochemical aspects (a case study of central part of the Częstochowa Ore District)

Introduction

Areas under influence of intensive human activity, with special regard to mining, are often characterised by a great degree of the natural environment degradation. Each component of the environment undergoes remodeling, beginning from the interference in geological structure, through changes in relief, climatic conditions, features of hydrographic network and underground waters or soil cover, vegetation mantle and animal world, often resulting from the earlier mentioned transformations. However, one cannot interpret anthropogenic environment transformations as explicitly negative, because in the formerly degraded terrains processes of forming new, specific ecosystems occur. Their origination would not be possible without earlier existing human activity [Jankowski et al., 2008].

In result of mining works carried out in the historical past in the area of the central part of the Częstochowa Ore District, significant transformations of relief and water relations followed many times. They enabled the development of unusually interesting anthropogenic landforms – anthropogenic wetlands [Kołodziejek, 2001; Molenda, Parusel, 2006]. This study focuses on the most important trends in physicochemical properties of waters in objects accepted by the authors.

Study area

The Częstochowa Ore District occupies the area of more than 1200 km^2, including the terrain of iron ore beds occurrence, which are present in a form of clayey iron-bearing layers from the Middle Jurassic period, which is also called the Brown Jurassic (Dogger). This district is divided into 3 main parts – southern, northern and central [Kontkiewicz, 1949]. Objects investigated, accepted by the authors, are located within a central part of the district, which stretches between localities Żarki in the SE, and Krzepice in the NW. The centre of iron ores extraction in this middle part of the Częstochowa Ore District was located in the region of Częstochowa and all investigated objects included within the range of this study are here also located (fig. 1).

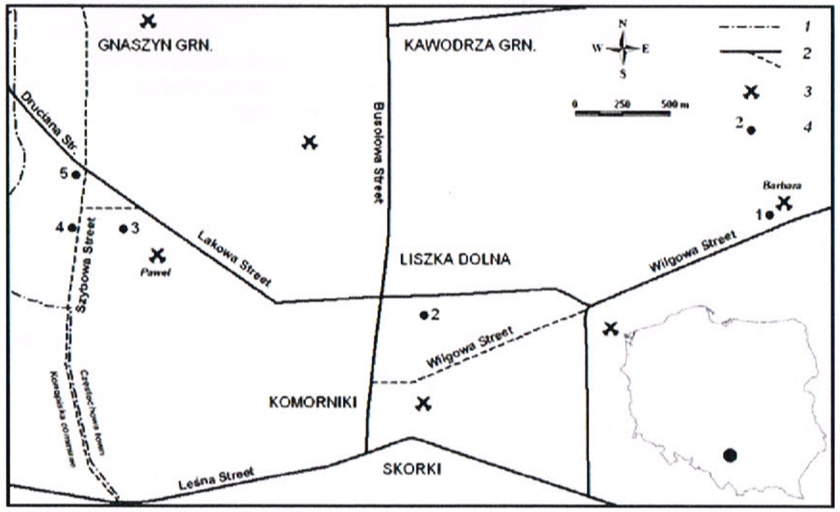

Fig. 1. Study area with the investigated objects:
1 – the border of Częstochowa town, 2 – roads, 3 – inactive iron ore mines, 4 – investigated objects (numbers according with tab. 1)

Terrain relief of the study area is rather significantly diversified, what mostly results from mining of iron ore beds, carried out here as far back as the 14th century. Therefore there is a large richness of anthropogenic convex and concave landforms. Convex landforms are the result of waste rock deposition. The waste rock occurs mainly in a form of clayey siderite with numerous admixtures (quartz, apatite, pyrite, heavy minerals). To convex landforms belong as follows: spoil tips, mounds, bars and indirect form – concave-convex – circular mounds with small shafts of abandoned workings. Among the second type of post-mining landforms are numbered depressions, being the result of vertical movements of rock mass in consequence of underground exploitation. In the area investigated, considering relatively shallow exploitation, small thickness of beds and plastic character of overburden rocks, these movements have slow character [Kołodziejek, 2001]. At the terrain surface their direct effects are visible in rather numerous, although usually relatively shallow subsidence depressions, which existence is not of determining importance in a case of possibilities of wetlands' formation (photo 1).

The climate of area investigated is characterised by relatively significant level of precipitation, which reaches up to 800 mm at elevations and very long vegetation period, amounting to from 210 up to 220 days. The average annual air temperature is shaped within the range of 7–8°C. The net of surface waters, apart from numerous water-logged subsidence depressions, farming ponds and dam reservoirs, includes a dozen or so streams of the Warta river and its left-bank tributary – Liswarta. Underground waters of the area investigated occur within the Quaternary and Middle Jurassic horizons [Kołodziejek, 2001; Kondracki, 2009].

To non-forested plant communities, typical for the area investigated, belong as follows [Kołodziejek, 2001]: natural and semi-natural communities of terophytes at muddy water shores and periodically flooded depressions (class *Isoëto-Nanojuncetea*), nitrophylous communities of felling sites, trampled and ruderal terrains (*Plantaginetea maioris*), communi-

Photo 1. Water reservoir near Szybowa and Druciana Street (phot. by T. Parusel)

ties of rushes and salty meadows (*Phargmitetea*), primary and secondary grassy communities of meadows and grasses at mineral substratum (*Molinio-Arrhenatheretea*), communities of bryophyte-sedge peatbogs and highmoors (*Scheuchzerio-Caricetea fuscae*), and communities of heathlands and poor mat-grasses (*Nardo-Callunetea*). Besides, in the area investigated forest communities also occur, but they are anthropogenically transformed to a great degree and they are characterized by significant pine contribution, which many a time amounts to even more than 75%.

Material and methods

The study presents initial hydrochemical characteristics of 5 selected hydrographic objects included in the investigations (fig. 1), carried out in the hydrological year 2006/2007 together with one-time water sampling in November 2007. Field works included measurements of basic physico-chemical parameters of water (pH-reaction and specific electric conductivity) in the month cycle (tab. 2, minimum, maximum values and medians) with applying terrain models of pH-meter and conductometer [Szczepaniak, 2004]. Water samples were taken for laboratory analyses in a quarterly cycle, with the exception of samples for the analysis of dissolved iron content. They were collected within the one-time evaluation in November 2007. Besides, the precise location of investigated objects by means of GPS receiver was made (tab. 1).

The selection of laboratory analysis sums up in the notion of general hydrochemical analysis [Świetlik, Dojlido, 1999] – general hardness (T_H), content of sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) cations, content of nitrate (NO_3^-), phosphate (PO_4^{3-}), sulphate (SO_4^{2-}) and chloride (Cl^-) anions, and contents of dissolved iron ($Fe_{diss.}$) and hydrogen carbonates (HCO_3^-) were determined. Sulphate content was determined by means of turbidimetric method with a spectrophotometer, chlorides and nitrates at use of a potentiometer with ion-selective electrodes' applying, total hardness, hydrogen carbonates,

Table 1. Coordinates of investigated objects

Object name	No	Coordinates
Inactive iron ore mine „Barbara" – southern part	1	50° 46,49' N 19° 04,15' E
Subsidence depression in Częstochowa Liszka Dolna	2	50° 46,22' N 19° 02,60' E
Effluent from spoil tip in Częstochowa Liszka Dolna	3	50° 46,43' N 19° 01,28' E
Rush community near Szybowa Street	4	50° 46,47' N 19° 01,05' E
Water reservoir near Szybowa and Druciana Street – southern part	5	50° 46,59' N 19° 01,03' E

calcium and magnesium by titration method, sodium and potassium by means of flame photometry, phosphates at use of colorimetric method with ammonium molybdate and spectrophotometer, and dissolved iron by means of phenanthroline with spectrophotometer with applying 2,2-dipyridil as reagent [Hermanowicz et al., 1999; Świetlik, Dojlido, 1999].

Results and discussion

Waters of objects investigated have acid or weakly acid pH-reaction, only in 2 cases the maximum values of pH-reaction are close to neutral – in southern part of „Barbara" mine (No 1) and in subsidence depression in Częstochowa Liszka Dolna (No 2). Besides, the characteristic feature is a rather significant range of water pH-reaction values in each investigated objects. The similar feature is also typical for the proper electrical conductivity (tab. 2).

Table 2. Basic physico-chemical parameters of water

Object number	Physical and chemical parameters							
	pH			conductivity [μS/cm]			T_H [mg $CaCO_3$/l]	mineralization [mg/l]
	max	median	min	max	median	min	mean	
1	7,01	5,73	4,47	1837	1321	1093	727,4	1043,7
2	7,09	6,67	5,74	1729	1445	1074	473,8	913,3
3	6,39	5,64	4,31	3210	2010	1004	1296,3	1707,1
4	6,46	5,53	3,43	1804	615	334	355,6	514,6
5	6,74	6,38	4,73	2150	1123	907	650,7	768,8

Waters of each, except for one (No 4) research objects have large values of conductivity (tab. 2), what is also caused by high level of total mineralization and significant content of particular investigated substances (tab. 3) [Dojlido, 1995]. Different results were obtained by Chmura and Molenda [2007, 2008] in a case of anthropogenic wetlands from the area of the Silesian Upland. A special case of maximum conductivity and maximum average concentration of the majority of remaining substances is the effluent from spoil tip in Częstochowa Liszka Dolna (tab. 2, 3, No 3). Its character – permanent or periodical flow and as a result – limited possibilities of accumulation of pollutants originating from other sources, indicates autogenic origin of investigated substances. Therefore, the predominant source of them in water of the investigated water-logged areas is most likely their leaching from the substratum.

Table 3. Other chemical parameters of water

Object number	Chemical parameters									
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	SO_4^{2-}	NO_3^{-}	Cl^{-}	PO_4^{3-}	$Fe_{diss.}$ [mg/l]
	mean [mg/l]									
1	164,0	77,2	11,1	22,9	81,9	616,7	30,5	36,9	0,039	2,49
2	147,3	25,7	80,9	12,8	199,5	185,0	37,8	222,5	1,267	0,5
3	151,3	223,1	4,9	2,0	73,2	1234,7	8,9	8,6	0,236	0,18
4	93,5	29,7	3,6	1,4	139,8	145,0	98,3	1,6	0,229	1,47
5	171,4	54,1	6,5	2,7	81,2	431,3	15,0	5,6	0,032	0,95

Noted concentrations of dissolved iron are relatively small (tab. 3), even so it is worth focusing here one's attention on the necessity of further investigations in respect of merely signal character of the given report (only one-time evaluation of dissolved iron concentration).

Conclusion

At chosen antropogenic wetlands in the central part of the Częstochowa Ore District chosen physical and chemical parameters were investigated. This parameters indicate that water pollution in described habitats is appreciable. It is the most likely, that investigated parameters are connected with character of the study area base. From remainders of numerous excavations, left after an exploitations of iron ore and accompaning them dumping grounds of post-mining waste, takes place rinsing out. The formation of dissolved iron concentration requires further investigations. The propagation of range investigation regarding of total iron contents, is postulated.

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The development of ecological systems in the area transformed by human impact (settling ponds of „Jan Kanty" black coal mine)

Introduction

Naturalists have always been intrigued by the ability of life sustain conditions inhospitable to humans. Both scientific and popular literature contains numerous descriptions of biota living "on the edge" – in desert, on barren soil of polar islands, under Antarctic ice, in deep waters, and in many other more or less unusual conditions. However, all these habitats exist for millennia, and living beings had sufficient time to evolve biochemical, morphological and behavioural adaptations allowing to live and even flourish in these "extreme environments". More astonishing is the diversity of life persisting in industrial barrens-extreme habitats that appeared as a by-product of human activities only about a century ago [Kozlov, Zvereva, 2007].

The complete destruction of primary vegetation and soil cover in result of human activity is the most drastic example of leading to disturbances of ecosystems functioning as the whole. In relation to it the post-industrial waste management is still the actual problem, and especially in strongly industrialised areas. Binding legal acts impose an obligation on mining entrepreneurs to do improvement of ensuring damage in grounds through their restoring to the state before the loss arising by means of land reclamation (Act on the Protection of Agricultural and Forested Grounds *Ustawa o ochronie gruntów rolnych i leśnych*; Act – Geological and mining Law *Ustawa – Prawo geologiczne i górnicze*). Land reclamation includes processes of purification, protection, shaping and renewa, making terrain surface available and restoring biological productivity to the devastated terrain, at the same time it is the stage of transformations, which precedes the proper management [Gasidło, 1998]. Formerly reclaimed grounds undergo management in different directions [Strzyszcz, Hrabin, 1976; Dwucet, Krajewski, Wach, 1992; Harris, Birch, Palmer, 1996; Krzaklewski, 1999; Tokarska-Guzik, Rostański, 2001]. To improve natural and aesthetic values of post-mining spoil tips numerous attempts of their managing last. They most often consist in introduction of species, which are resistant to difficult habitat conditions [Skawina, Greszta, 1959; Patrzałek, Rostański, 1992 and others].

At fragments, which do not undergo land reclamation processes, the spontaneous ecological succession is observed. The phenomenon of spontaneous succession in post-industrial areas became the research subject of naturalists [Krzaklewski, 1986; Bradshaw, 1989; Balcerkiewicz, Pawlak, 1991; Woźniak, Kompała, 2000, 2001 and others]. These investigations refer to both flora diversity and processes of ecological systems shaping. Many authors [Cabała, Sypień, 1987; Rostański, Woźniak, 2001, Rostański, 2006 and others] point at the floristic richness and diversity and the occurrence of rare and protected species at post-industrial areas as well. Permanent post-industrial wastelands make a secondary habitat for many forming themselves and interesting ecological systems. The example of such terrains is undoubtedly the area deformed by closed down „Jan Kanty" black coal mine in Jaworzno. The aim of the given work is to present vegetation diversity at habitats undergoing land reclamation processes and spontaneous vegetation succession in terrain strongly transformed by post-mining waste deposition.

Materials and methods

Materials referring to vegetation were collected directly during field investigations in 2009 year and 2010 year. Investigations included phytosociological surveys to determinate type of plant communities. At identification of associations the study of Matuszkiewicz [2008] was applied. Names of species were given after Mirek et al. [2002].

Some soil pits were also made and they were characterised in respect of morphology. At particular fragments of the study area (reclaimed or not reclaimed) photographic documentation was made additionally to monitor this terrain in the future.

Study area was presented in the detailed sketch (fig. 1), made on the base of topographic map in the scale of 1:10 000 (sheet M-34-63-A-d-2 *Jaworzno-Os. Stałe*) with applying of GIS methods and software MapInfo Professional 7.5 SCP [Longley et al., 2008].

Study area

The study area is located in the mesoregion of Katowice Upland (341.13) [Kondracki, 2009] within the administrative boundaries of Jaworzno city. In the direct neighbourhood of the investigated complex in the south-eastern direction, terrains of electric power station Jaworzno III occur (fig. 1).

The study object includes degraded terrains after closed down „Jan Kanty" black coal mine in Jaworzno of total area of about 58 ha. It is composed of complex of former settling tanks of mining underwaters of 25 ha in area and centrally located reclaimed post-mining waste disposal site, occupying the area of about 10 ha. In southern part of the study object the lowered terrain is located around the canal carrying waters of yellow-orange colour. This canal flows to the Przemsza River about 1 km to the south of the study terrain. The complex of former settling tanks is composed of chambers: eastern (8,5 ha in area), northern (7,6 ha) and two western ones (6,7 ha and 2,2 ha). Besides, in bank zone of the eastern chamber illegal and permanently used landfill site of rubble, earth and post-mining waste occurs (fig. 1).

Results and discussion

The study area is characterized by significant topo- and microtopographic diversity, caused directly by anthropogenic factors. There numerous concave and convex landforms occur. Features of source material in a form of post-mining waste, have significant impact on processes of vegetation development. The majority of these substances under the influence of rain water and high temperature undergoes strong cementing. It causes the increase in aera-

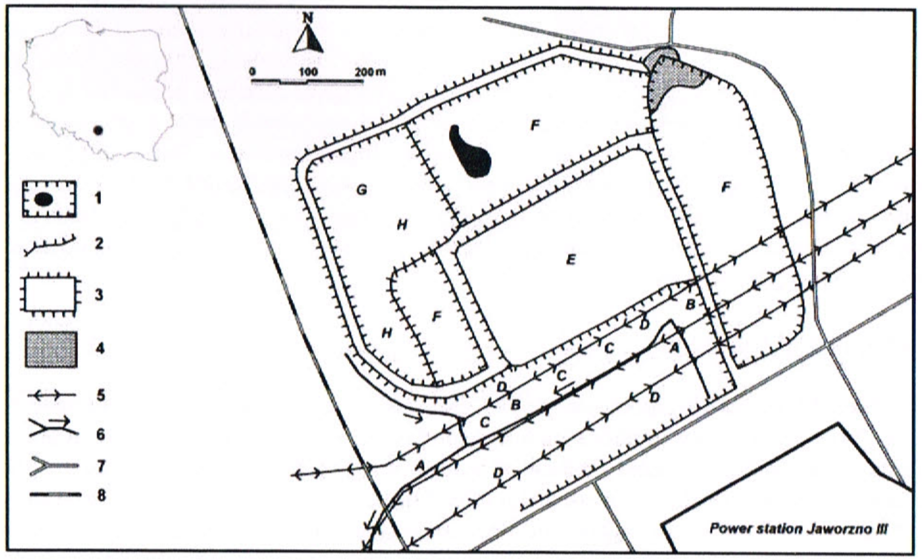


Fig. 1. Settling ponds of „Jan Kanty" black coal mine:
1 – former settling tanks of mining underwaters, open water depts, 2 – dykes, 3 – reclaimed post-mining waste disposal site, 4 – illegal landfill site of rubble, earth and post-mining waste, 5 – high-voltage lines, 6 – canal carrying waters of yellow-orange colour, 7 – roads, 8 – railway, A – alder riparian forest of tree line character, B – artificial plantings with predominance of *Pinus sylvestris*, C – dense turfs of *Calamagrostis epigejos*, D – grasses *Corynephoretum*, E – planting of *Betula pendula*, *Padus serotina* and *Robinia pseudacacia*, F – associations *Phragmitetum australis* and *Typhetum latifoliae*, G – numerous mounds and small mounds of post-mining waste and fine-grained coal material, H – predominance of *Phragmites australis* and *Calamagrostis epigejos*

tion in the substratum, what then makes the development of artificially introduced and spontaneously encroaching vegetation difficult. In the area investigated the following types of habitats were distinguished: water-logged wetlands connected with bank zone of canal running through the study object (water of yellow-orange colour) and fragments connected with settling tanks, levelled surface of post-mining waste disposal site and surfaces, which do not undergo the process of land reclamation.

Along banks of the above-mentioned canal and draining ditches alder riparian forest of tree line character is formed. This community is shaped in a form of 3 zones – specific alder riparian forest and plantings with contribution of *Betula pendula* and *Populus nigra*. The maximum range of alder riparian forest occurrence is about 2 m form canal banks. In the canal bank zone among aquatic and hygrophilous vegetation small concentrations of *Phragmites australis* of low viability occur in a fragmentary way. Within tree line of alder riparian forest herbaceous plants: *Calamagrostis epigejos*, *Solidago virgaurea*, *Cirsium palustre* and *Tussilago farfara* were stated Such species composition betokens extreme character of the habitat – taxons of strategy of ruderal type colonise here.

Depressions along canal with stagnating rain waters are colonised by hygrophilous species: *Juncus conglomeratus* and *J. effusus*. At less humid fragments *Salix rosmarinifolia*, *S. purpurea*, *S. caprea* and *Pinus sylvestris* occur individually. At inter-micro-depression furrows, of maximum depth of about 15 cm, species of eurybiontic character are located besides, and they are as follows: *Holcus mollis*, *Poa annua*, *Achillea millefolium* and *Trifolium*

repens. Each above-mentioned species betokens the existence of substratum of lowered degree of aeration.

Within the study object fragments connected with artificial plantings predominate. There species resistant to toxicity and poorness of the environment, such as: *Pinus nigra*, *P. Sylvestris*, *Robinia pseudacacia*, *Caragana arborescens* were introduced. The tree stand has about 15 years. Moreover, plantings are accompanied by individually broadleaf species: more frequent specimens of *B. pendula*, *Populus tremula*, *Quercus robur*, *Q. rubra* and *Padus serotina*. *Q. rubra* creates dense patches in places. Under them the complete lack of herbaceous species was observed in result of very weak decomposition of plant litter.

Within the range of plantings the undergrowth is not formed practically. These species occur here in dispersion, e.g.: *Pyrola rotundifolia*, *P. chlorantha*, *Orthilia secunda* and *Deschampsia flexuosa*. Among bryophytes the occurrence of *Pleurosium schreberi* and *Climacium dendroides* was stated. These species are typical for pine coniferous forests and betoken coniferous direction of succession in this terrain. Individual specimens of *Pteridium aquilinum*, *Hieracium pilosella*, *Festuca ovina*, *Fragaria vesca*, *F. viridis* were here observed.

Forest litter is composed of fallen conifer pine needles, numerous leaves of *P. tremula* less numerous leaves of *B. pendula*. It is characterised by low degree of decomposition, what univocally betokens weak development of soil microorganism. The character of substratum, built of shale barren rock with insertions of coal substances, red deposits and sand, creates disadvantageous conditions for microorganisms existence. The substratum is fine-grained and impermeable, what is proved by earlier mentioned depressions, periodically filled with rain waters.

At light surfaces on a large scale predominates *C. epigejos*, which creates dense turfs and simply keeps from sprouting and developing of other species. The occurrence of individuals of *S. rosmarinifolia* in a form of clumps is strictly conditioned by the existence of depressions, where periodically rain waters stagnate.

Partial lack of success in land reclamation exertions in the direction of afforestation of the study area by means of plantings of *Pinus nigra* can be explained by the occurrence in substratum mineral substance of red colour (its kind was not determined), most probably of toxic properties. The occurrence of this substance can betoken periodical inundation of this terrain, but in respect of significant distance from the canal bed the authors are inclined to hypothesis of intentional disposal of deposits from canal in this terrain.

Moreover, with deposits of red colour other dependence, stating of their toxic properties, is connected. In terrains, where concentration of deposits is significant, the vegetation is in the state of low variability, and even dying. It is possible to observe the similar dependence in a case of pine plantings with the above-mentioned admixture of some deciduous species. Individuals of *P. sylvestris* rather well develop at the substratum with the content of deposits of red colour, whereas these deposits influence on the deciduous species in a limiting way. They in the predominant majority die. Slightly larger resistance is typical only for *Q. rubra*.

In the zone of ecotone between pine plantings and terrains devoid of arborescent and shrub vegetation, connected with high-voltage lines, the spontaneous vegetation succession was observed with predominant contribution of *Salix acutifolia* and *Corynephorus canescens*. Well shaped grasses *Corynephoretum* with contribution of the most important species for this association, such as: *Hieracium pilosella*, *Cardaminopsis arenosa*, *Rumex acetosella*, *Herniaria glabra*, *Agrostis canina*, *Carex hirta* and psammophylous species of bryophytes *Ceratodon purpurea* and *Polytrichum piliferum* are formed here.

Within flat hilltop of reclaimed post-mining waste disposal site of former „Jan Kanty" black coal mine, significantly elevated over canal „flood terrace", planting of *B. pendula* with contribution of *P. serotina* and *R. pseudacacia* occur. Additionally, in the past, admixtures of *P. nigra* here existed, because numerous dead and cut individuals of them occupy the terrain surface within the whole greenwood. In the undergrowth of characterized forest the occurrence of numerous individuals of *Lycopodium clavatum* was stated, the plant under the strict species protection and – in the area of the Silesian Province – possessing the threat category R – rare species (Parusel et al., 1996; Woźniak, Kompała, 2000). This species well propagates in a vegetative way and thanks to this it occupies significant area. The total area of its occurrence is about 10-15 ares, at the same time the distinct barrier of its spreading is made by dense patches of plantings *R. pseudacacia*, and especially its thick undergrowth.

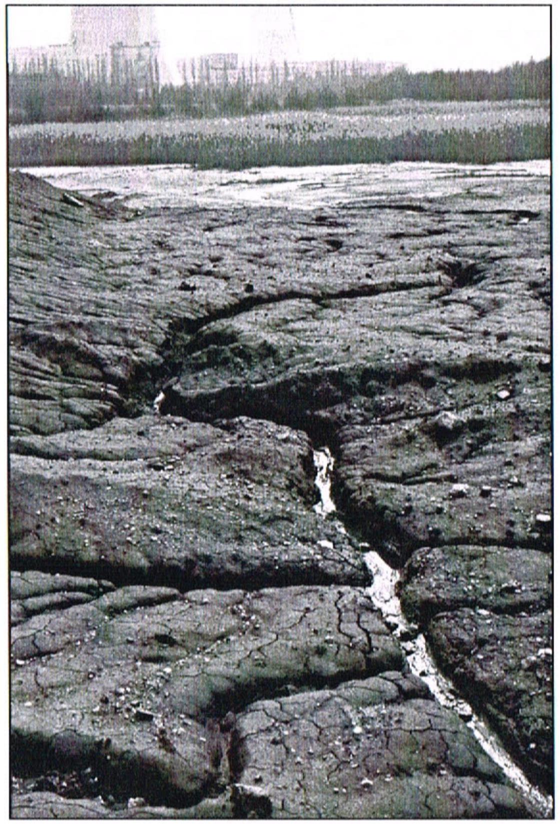
Separate type of vegetation occurs in western, northern and eastern parts of the study object, connected with former settling tanks of mining underwaters. At these habitats in the substantial majority association *Phragmitetum australis* (photo 1) predominates and at small surfaces – *Typhetum latifoliae* prevails.

Photo 1. The association of *Phragmitetum australis* – domination type of vegetation in investigated surfaces

However, in a case of *Typha latifolia* it is only narrow belt up to 4 m to a maximum, directly at open water depths in the central chamber of settling tanks set, where only small permanently water logged area is still kept. At the remaining terrain of settling tanks the reed rush occurs together with dispersed scrub of willow and birch. Maximum height of *Phragmites australis* reaches up to 3 m.

In the northern part of the terrain investigated the area devoid of vegetation occurs. The existence of covers of fine-grained coal and mineral clayey-silty material was stated. Under the influence of atmospheric precipitation within these covers numerous interesting in respect of geomorphology forms and microforms are formed (photo 2).

A



B

Photo 2. A/B – The terrains form formation in anthropogenic surfaces under influence of atmospheric precipitation

In the case of larger from western chambers of settling tank the complete lack of even small permanently flooded fragments or decidedly smaller degree of its covering in comparison to the above mentioned chambers was observed. It is most likely caused by the forming of hard crust at the terrain surface, which significantly makes the colonization of this terrain by vegetation difficult. The surface of this chamber is covered by numerous mounds and small mounds of post-mining waste and fine-grained coal material, which in respect of morphology are similar to takyrs. The predominant species are here *P. australis* and *C. epigejos,* similarly to other chambers of former settling tanks.

Conclusions

Management of degraded terrains in result of activity of black coal mining at the present moment requires rationalization within the range of used forms of land reclamation and renewal and in a case of applied method as well. Ecological systems forming themselves in the study area are poor in every respect. It is conditioned by character of terrain topography and anthropogenic character of material, building the substratum.

Just as in case of other industrial areas, the systematic flora enrichment is here observed, including protected and rare species (*Epipactis atrorubens*, *Lycopodium clavatum*).

Considering the character of complex of degraded terrains after closed down „Jan Kanty" black coal mine in Jaworzno, the authors postulate its use as the excellent research polygon within the range of problem of ecological system's formation in strongly transformed areas.

Industrial barrens are bleak open landscapes evolved due to deposition of airborne pollutants, with only small patches of vegetation surrounded by bare land. These extreme environments appeared as a by-product of human activities about a century ago.

Since vegetation recovery is hampered by soil toxicity caused by extreme contamination by heavy metals, soils remain bare and suffer from erosion enhanced by altered microclimate [Kozlov, Zvereva, 2007]. In spite of general reduction in biodiversity, industrial barrens still support a variety of life, including regionally rare and endangered species, as well as populations that evolved specific adaptations to the harsh and toxic environment. Recently, most industrial barrens show some signs of natural recovery due to emission decline or closure of responsible polluters; some of barrens sites have been or are being successfully revegetated.

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Anthropogenic aspects of landscape transformations	6	Faculty of Earth Sciences, University of Silesia Hall City Office Sosnowiec Landscape Parks Complex of Silesian Voivodeship Polish Geographical Society, Katowice Branch Sosnowiec – Będzin 2010	88–96

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Shores processes occurring within anthropogenic lakes in Upper Silesia (southern Poland)

Introduction

The term Upper Silesian Region refers most often to the area of indefinite limits spreading approximately from Częstochowa Lands in the north up to the Vistula River in the south and from Olkusz and Trzebinia in the east up to the Oder valley in the west. The Upper Silesian Region is equally often identified with the Silesian Upland and its borders as well as with the central part of the Silesian Province (fig. 1). It is the terrain of area – in dependence of minuteness of detail and wideness of territorial divisions – from some to even a dozen or so thousands of km^2 [Machowski et al., 2006]. The terrain described is characterised by the occurrence of important mineral resources: black coal, zinc and lead ores, not exploited iron ores, sands, gravels, dolomites etc. Zinc, lead and iron ores were exploited here as early as the early Middle Ages, and black coal – since the end of the 18th century. Together with these resources extraction the iron and coloured metals metallurgy developed. In result of high degree of urbanisation and industrialisation, the natural environment of the area discussed underwent far-reaching transformation, spectacular example of which is the occurrence of some thousands of artificial water reservoirs, from which fifteen has the capacity larger than 1 hm^3 (tab. 1). The appearance of anthropogenic lakes in the landscape has caused the activating of new qualitatively processes – shore processes.

At shores of artificial water reservoirs in the Silesian Upland shore processes occur. They are characterised by large analogy to shore processes running at seashores, although there have many individuals features. The intensity and range of lacustrine shore processes in the are discussed is conditioned by many factors [Gracia Prieto, 1995; Otvos, 2000; Ostendorp, 2004]. The most important of them are – apart from the size and shape of lake bowl – waving and lithology of direct neighbourhood of the reservoir, very often finding simply correlation with the character of shore shaping and its relative heights. The most spectacular changes in littoral zone are observed within post-exploitation and dam water reservoirs, whereas decidedly less – within the range of shore zones of reservoirs in subsidence depressions. The first ones are open pits of former sand mines, reclaimed in so-called water direction, whereas the second ones have been formed in result of submerging of river valleys in connection with the necessity to provide for needs of the region, characterised by the deficit of pure waters [Czaja, 1999; Jankowski, 1999].

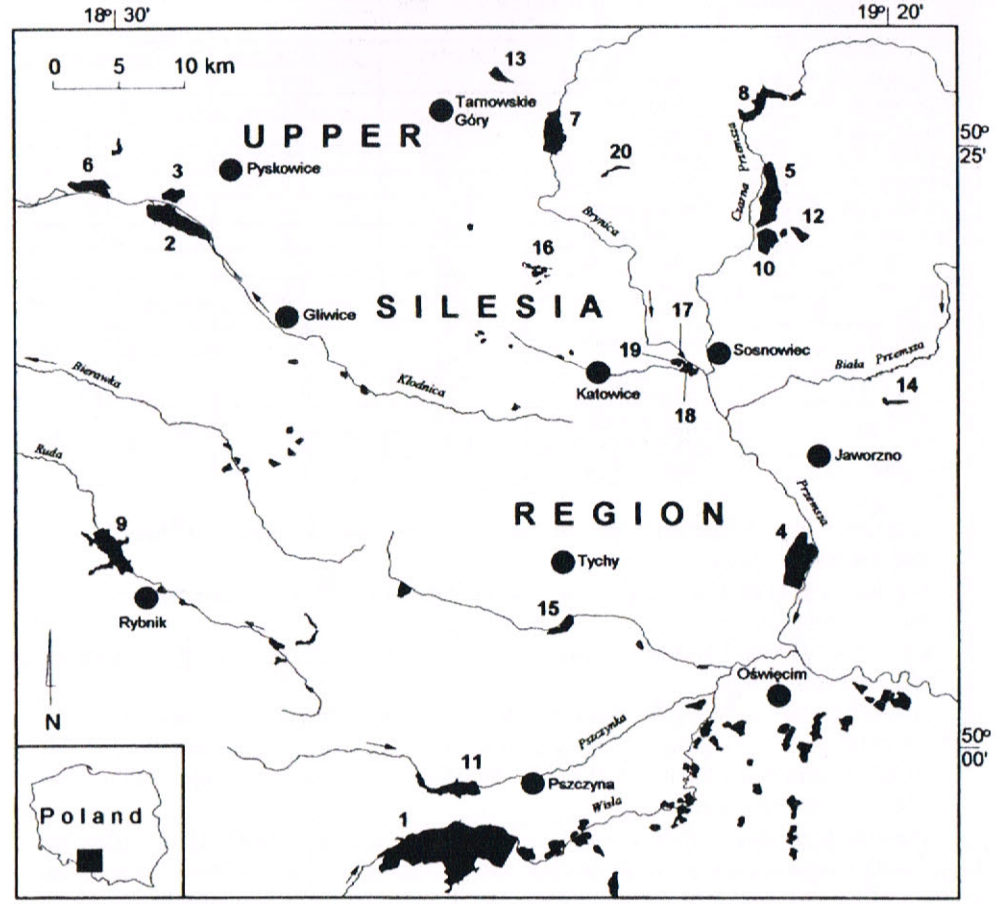

Fig. 1. Location of the research anthropogenic lakes:
1 – Goczałkowice (49° 55' 56'' N, 18° 52' 18'' E), 2 – Dzierżno Duże (50° 22' 24'' N, 18° 33' 25'' E), 3 – Dzierżno Małe (50° 23' 16'' N, 18° 33' 51'' E), 4 – Dziećkowice (50° 08' 07'' N, 19° 14' 07'' E), 5 – Kuźnica Warężyńska (50° 22' 38'' N, 19° 12' 06'' E), 6 – Pławniowice (50° 23' 29'' N, 18° 28' 08'' E), 7 – Świerklaniec (50° 25' 27'' N, 18° 58' 12'' E), 8 – Przeczyce (50° 26' 55'' N, 19° 11' 41'' E), 9 – Rybnicki (50° 08' 25'' N, 18° 29' 58'' E), 10 – Pogoria III (50° 21' 13'' N, 19° 12' 05'' E), 11 – Łąka (49° 58' 24'' N, 18° 52' 34'' E), 12 – Pogoria I (50° 21' 27'' N, 19° 14' 15'' E), 13 – Chechło (50° 28' 04'' N, 18° 54' 49'' E), 14 – Sosina (50° 14' 27'' N, 19° 19' 50'' E), 15 – Paprocany (50° 05' 20'' N, 18° 59' 19'' E), 16 – Żabie Doły (50° 19' 49'' N, 18° 57' 26'' E), 17 – Stawiki (50° 16' 07'' N, 19° 06' 20'' E), 18 – Hubertus (50° 15' 40'' N, 19° 07' 22'' E)., 19 – Morawa (50° 16' 08'' N, 19° 06' 20'' E), 20 – Rogoźnik (50° 24' 13'' N, 19° 02' 35'' E).

Research aims and methods

Identification of research problems, based on initial morphological and limnological recognition, allowed determining the range of study and formulating research aims, which in detail refer to:

Table 1. The largest artificial water reservoirs in upper Silesian region.

Name of water reservoirs	Type of water reservoir	Put into use	Maximum area [km²]	Total capacity [hm³]
Goczałkowice	dam reservoir	1956	32,0	167,0
Dzierżno Duże	post-exploitation	1964	6,2	94,0
Dzierżno Małe	post-exploitation	1938	1,6	12,6
Dziećkowice	post-exploitation	1976	7,1	52,5
Kuźnica Warężyńska	post-exploitation	2005	5,6	51,2
Pławniowice	post-exploitation	1976	2,4	29,1
Kozłowa Góra	dam reservoir	1939	5,9	15,3
Przeczyce	dam reservoir	1963	5,1	20,7
Rybicki	dam reservoir	1972	4,7	22,0
Pogoria III	post-exploitation	1974	2,1	12,0
Łąka	dam reservoir	1986	3,5	11,2
Pogoria I	post-exploitation	1943	0,7	3,6
Chechło	post-exploitation	1965	0,9	1,5
Sosina	post-exploitation	1977	0,5	1,0
Paprocany	dam reservoir	1870	1,2	2,5

- distinguishing of types and presenting of reasons and conditions of shore landforms shaping within water reservoirs;
- evaluation of conditions of shaping and differentiation of bottom deposit covers within water reservoirs;
- influence of varied anthropopression on the course of changes in shore morphology and reservoir bowls;
- evaluation of morphological stage of artificial water reservoirs development;
- the course of morphological changes in bowls of selected water reservoirs in the Silesian Upland and its borders in aspect of similar processes occurring within other artificial water reservoirs.

The course of shore processes was investigated in the years 1992–2000 within the selected anthropogenic lakes. Level circuits, situation-height plans in littoral zone and landscape profiles were made at use of tachymeter „Dahlta 020". Bathymetric recognition was carried out with echo sounder Ultra III 3D, tachymeter and GPS applying. In laboratory grain size distribution was determined by means of sieve and sieve-araeometric method. Basic composition of deposit samples as well as zinc, lead, cooper, cadmium and nickel occurrences were determined by means of ICP method (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, Ba, Sr, Zr, Y, Be and V – sample of mass 0,2 g was fused with lithium metaborate, and next dissolved in 15% HNO_3; Cu, Pb, Zn, Ag, Ni, Cd, Bi – were analysed after total dissolution of sample of mass 0,25 g and decomposition in 10 ml HCl-HNO_3-$HClO_4$-HF in temperature 200°C and diluting up to 10 ml in diluted aqua regia.

Results and discussion

Every reservoir (post-exploitation, dam, in subsidence depressions) is the convenient place to accumulate bed load in the zone of river and lake waters contact. There the change in energetic environment of flowing waters happens and owing to sedimentation of bed load deltas or alluvial fans originate; they are eroded (cut) in periods of low water stages in reservoirs. In later periods the large role is also played by processes of sedentation of organic matter, especially morpho-shaping in periodically dried areas.

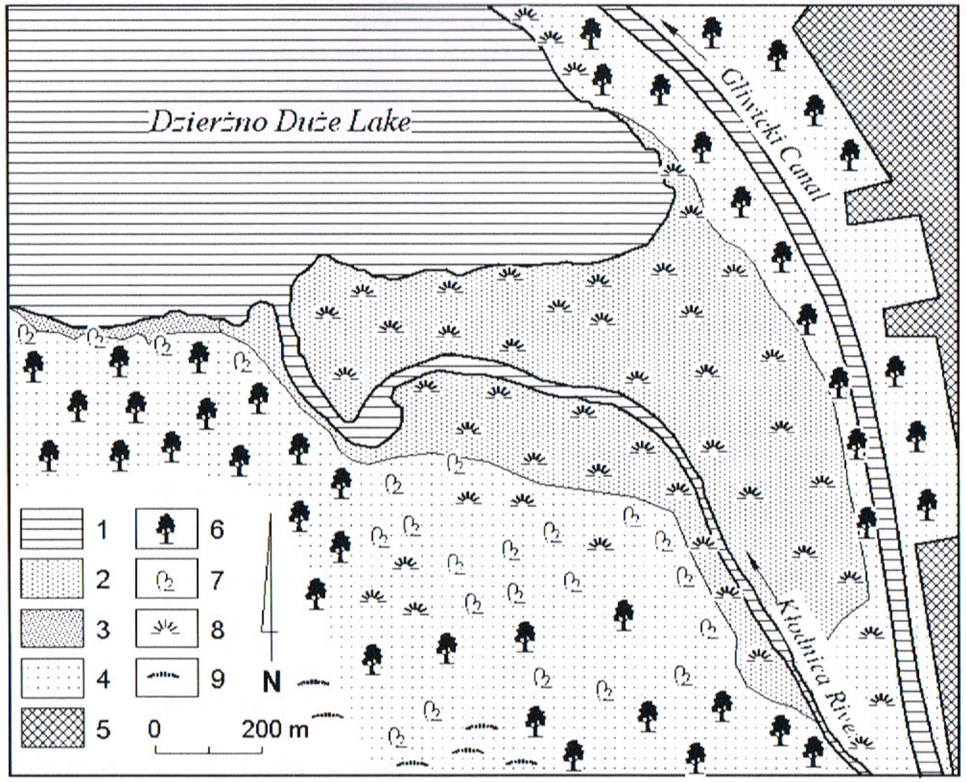

Fig. 2. Kłodnica river delta in Dzierżno Duże anthropogenic lake (Upper Silesia):
1 – water source (rivers, lakes, canals), 2 – delta, 3 – beach, 4 – plains of lower accumulative terraces formed in Quaternary period, 5 – industrial area, 6 – tree vegetation, 7 – shrub vegetation, 8 – grass vegetation, 9 – plough lands

The most spectacular sizes are typical for the Kłodnica delta, originated in the mouth zone of this stream into Dzierżno Duże water reservoir (fig. 2). In consequence of sedimentation and sedentation its increase is so intensive, that periodical dredging is required to make stream of inflow of surface waters into the reservoir permeable; it is carried out within the range of reservoir purification [Rzętała, 2003]. Deposit accumulated by the Kłodnica is to significant degree anthropogenically changed – after data from 1996 year obtained in Regional Head Office of Water Economy in Gliwice, and disposed by GIG in Katowice, in its basic composition occur as follows: SiO_2 (22,21–32,45%), Al_2O_3 (9,51–9,55%), Fe_2O_3 (4,98–6,22%), CaO (3,10–3,18%), MgO (1,25–1,30%), Na_2O (0,45–0,55%), K_2O (1,14–1,28%), SO_3 (1,73–2,50%), TiO_2 (0,40–0,48%), P_2O_5 (0,63–1,05%). With the content of SiO_2 in the deposit correspond roasting losses, which are located within the range of 40,97–54,17%, what seems to be significant for the mixture of material accumulated from mixture of municipal, domestic and industrial sewage, enriched in mineral deposit with coal dust. Urban-industrial use of catchment results in the occurrence of arsenic (51 mg/kg), cadmium (19–29 mg/kg), lead (303–490 mg/kg) and zinc (1261–2232 mg/kg) in amounts significantly straying away from natural contents in every kind of sedimentation rocks mentioned by A.

Kabata-Pendias and H. Pendias (1993). Researches on bottom deposits of this reservoir carried out some years later by M. A. Rzętała [2003] allow similar interpretation although they demonstrated lower average contents of arsenic (22,0 mg/kg), cadmium (9,3 mg/kg), lead (88 mg/kg) and zinc (512,5 mg/kg), and besides they document over and above the average occurrence of among others: antimony (6,7 mg/kg), barium (1230,5 mg/kg), chromium (123 mg/kg), cobalt (22,5 mg/kg) and copper (60,5 mg/kg). Referring to every above-presenting result, although more varied contents of lead, cadmium, chromium and copper in deposits of Dzierżno Duże water reservoir are presented by M. Kostecki (2003), who moreover states very strong or extreme their pollution by polycyclic aromatic hydrocarbons, what is also confirmed by data taken from ODGW in Gliwice, talking of the content of WWA of about 9,2–77,4 mg/kg [Rzętała, 2000, 2007].

Other deltas in the Silesian Upland are decidedly less effective (e.g. deltas of reservoirs Rogoźnik and Pogoria I), but they also document the spontaneous reaction on the process of relief anthropogenisation, and vegetation accompanying them many a time is among others the example of quick regeneration of biocenosis systems after former damages caused by opencast mining of sand deposits. Deltas or alluvial fans often are replaced by widespread zones of accumulation, as it happens in a case of Pogoria III or Pławniowice water reservoirs in the place of Potok Toszecki mouth. In backwater zones of dam reservoirs they are less readable in respect of elemental development of herbaceous and grassy vegetation. This situation occurs in the case of water reservoirs of: Przeczyce, Kozłowa Góra, Goczałkowice, Dzierżno Małe, Poraj. Deltas unusually rarely can be observed within the shores of reservoirs in subsidence and collapse depressions (the continuity of deformation processes of the terrain surface, without outflow character of these reservoirs). The capacity of deltas of water reservoirs in the Upper Silesian Region reaches maximally near 2 million m^3 (Dzierżno Duże water reservoir of catchment area of 530 km^2) most often amounting to from some up to tens, rarely several hundreds of m^3. They can be related only to some water reservoirs, e.g. reservoir Orawa of 32,8 km^2 in area and catchment area of 1181,7 km^2, cubic capacity of delta deposits of which M. Banach [1992] determines at 0,45 million m^3. Whereas deltas of large water reservoirs reach decidedly larger cubic capacities and it is difficult to search for analogies with the Upper Silesian reservoirs, which are characterised by relatively small sizes of these forms in respect of small areas of catchments delivering the bed load and short time of these objects functioning (more often tens of years – rarely more than fifty years).

The signs of intensive morphological changes are relatively not numerous abrasion landforms at shores of dam reservoirs and their abundance within post-exploitation reservoirs. Active cliffs (or only periodically of features of dead cliff) can be most of all met in the place of former scarps of exploitation fields of reservoirs: Dzierżno Duże, Pławniowice, Dziećkowice, Kuźnica Warężyńska, Pogoria III (fig. 3). At shores of Świerklaniec they do not occur at all. At shores of Przeczyce cliffs are present sporadically in the place of contact of lake waters with the foot of valley slopes of features of terrace scarp. The question is similarly presented in relation to Goczałkowice water reservoir on the Vistula and Poraj water reservoir on the Warta. The majority of dam reservoirs is characterised by at the very most, common under conditions of variable damming up, terrace levels. The problem of rate of retreat of rocky walls is similarly presented – it is especially actual in relation to post-exploitation water reservoirs. Although the rate of rocky walls retreat cannot be essential enough (because it is not univocal, linear and half-quantitative measure of dynamics of morphological changes), the hitherto existing amount of material has originated from the cliff abrasion of shore. Regarding even very overstated estimations for the Dzierżno Duże water

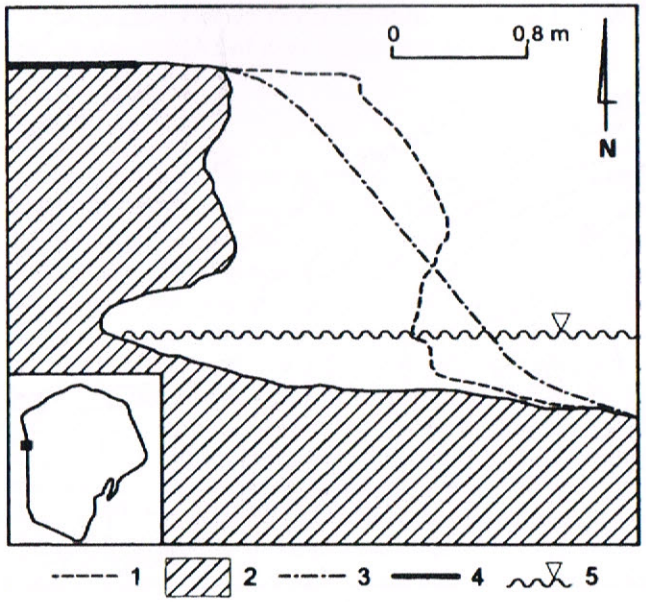

Fig. 3. Scheme of Pogoria III water reservoir western part shore fragment:
1 – extend of cliffed shore in February 1992, 2 – state in October 1993, 3 – shore after strengthening (February 1994), 4 – fragment of road on the rock bed, 5 – water table in lake

reservoir this size can amount to about 60 000 m^3, and for Pogoria III water reservoir only to 3000 m^3. This amount for Przeczyce water reservoir is insignificant, and in relation to Świerklaniec it is difficult to talk about it because of the lack of cliff shores. The part of this material obviously takes part in the building up of accumulative landforms in the same horizon of other part of shore, other one is translocated towards water depths. To confirm the role of denivelation of lakesides in geodynamics of littoral zone it is possible to mention other reservoirs: Żywiec in Tresna [Ziętara, 1995], on the Raba in Dobczyce [Ziętara, 1994] and Czorsztyn. The excellent example on the domestic scale, reflecting the abrasion processes, is Włocławek water reservoir [e.g. Banach, 1994]. Other examples refer to the Siberian dam reservoirs [Ovchinnikov et al., 2002; Kozyreva et al., 2004], and the following to the Volga water reservoir. Similarly, slopes of large gradient are surfaces which are intensively modelled by waters of reservoirs Terlicko and Žermanice in Czech Republic.

With signs of shores degradations of even small Upper Silesian reservoirs are connected threats and damages of elements of hydrotechnical infrastructure. It especially refers to communication lines, running in the neighbourhood of shoreline. Despite of the lack of spectacular threats of calibre of these caused by large Siberian water reservoirs [Ovchinnikov et al., 2002; Kozyreva et al., 2004], because of these existing decisions of artificial strengthening of some sections of shores, e.g. parts of shores of water reservoirs Pogoria III, Rogoźnik, Przeczyce, are made.

Next, the accumulation landforms within water reservoirs in the Silesian Upland and its borders occur within the majority of water reservoirs, especially in these of mature relief of shore. They are relatively often elements of morphology of littoral zones of dam reservoirs – Goczałkowice, Przeczyce, Świerklaniec – and some post-exploitation ones e.g. Po-

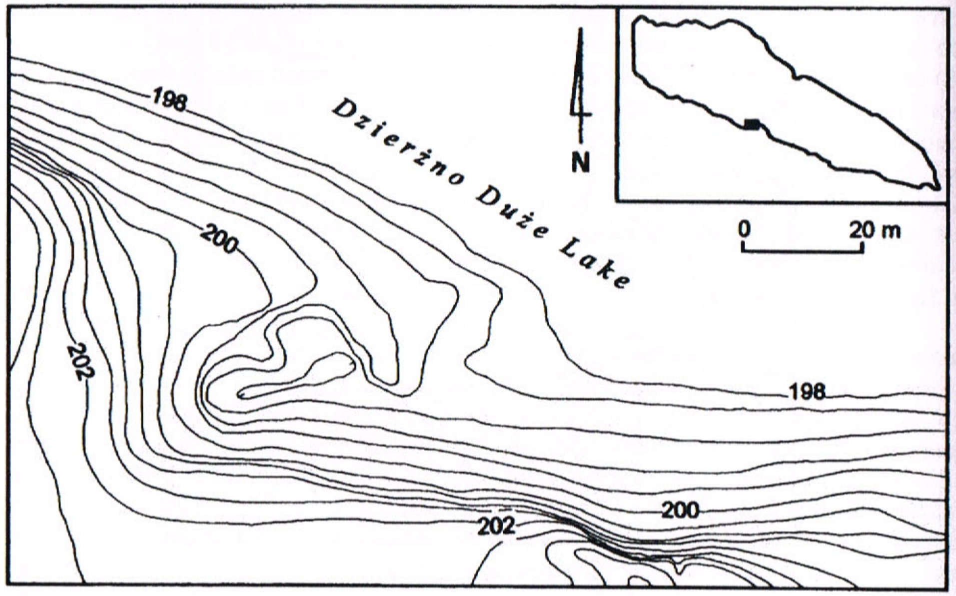

Fig. 4. Beach ridges in southertn part of shore Dzierżno Duże water reservoir

goria III, Dzierżno Duże (fig. 4). There are the landforms (sandy tips, beaches, shore embankments, shallows, zones of material accumulation fixed by vegetation), built of mineral or organic material in dependence on local environmental conditions. Relatively rarely – under conditions of the Upper Silesian reservoirs – accumulative landforms make steady element of shore relief, as in a case of some forms of Dzierżno Duże, Przeczyce, Świerklaniec, Pogoria III water reservoirs. Decidedly larger dynamics of changes is typical for accumulative ephemeral landforms.

Separate discussion is required for reservoirs in subsidence and collapse depressions. As it was above-mentioned, their bowls undergo uneven, but permanent modelling of shape, in result of continuous character of deformation processes of terrain surface. Other feature of them is also small area and relative stability of shores, resulting from fixing influence of turf or reed (e.g. Żabie Doły). They most often occur at wastelands, which usually are terrains along water reservoirs of this genetic group. It all causes that shoreline is devoid of abrasion processes and their symptomatic sign is washing of terrestrial material in the case of poor vegetation cover. In this respect they are characterised by very large similarity to small in area water reservoirs of post-exploitation character (e.g. located at the mouth of Rawa into the Brynica – Stawiki, Morawa, Hubertus) or dam or dike (e.g. ponds in the zone of backwash of Przeczyce water reservoir). Within such objects shore processes occur on a small scale and they are usually connected with processes of accumulation, linked with inshore coastal vegetation.

Accumulation processes and landforms at shores of water reservoirs in the Silesian Upland are less arduous in comparison with abrasion ones, even if they occupy significant areas in littoral zones. Their development is the reason of obstructions in harbours and ports, it causes the silting up and flattening of near-port parts of shore and sections of streams draining water, it also leads to obstruction in water intakes and results in shore overgrowing in the neighbourhood of platforms and watering places etc. These exploitation problems refer to

practically every water reservoir which fulfils the utility function, but the scale and intensity of the given phenomenon decides of their factual arduousness.

Conclusions

Considering the intensively occurring morphometric changes the water reservoirs discussed should be considered to be the objects successively losing their anthropogenic character and distinctly assimilating with the neighbouring geographical environment, what is confirmed by many various natural processes documenting the reaction of the environment on the relief anthropogenisation. Their intensity and range depends on many factors. It is worth emphasising that we deal with unusually dynamical course of processes initiated in a highly anthropogenic way.

Morphological changes happening in the littoral zone of anthropogenic water reservoirs – as opposed to occurring in different stage of development of natural lake bowls – should be numbered among the most intensive. Areas of the most dynamical morphological changes in littoral zones of the majority of artificial water reservoirs are the eastern sectors of their shores. It points at the incomparable role of waving originating at winds from western sectors, in relation to the remaining factors stimulating the development of shore processes.

The largest intensity is typical for shore processes occurring at shores of post-exploitation reservoirs, which are favoured by: irregularity of shoreline, large slope gradient of excavations and particular their basins as well as usually small resistance to damaging of shore material. The rate, range and scale of morphological changes at shores makes the post-exploitation water reservoirs unique not only against a background of floodings originated in subsidence depressions, but also among dam reservoirs, which as a rule are characterised by small intensity of shore processes in respect of flooding of river valley sections, which have small gradients and slightly inclined slopes. Shore processes of dam reservoirs consist most often in translocation of small amount of shore material and building up of shallowly submerged parts of shores by organic matter accumulated in result of necrosis of usually rich inshore vegetation. Similar situation occurs in a case of reservoirs formed in subsidence depressions, but the additional factor limiting the development of shore processes is a small area and capacity of reservoirs. Then, the shore processes of the majority of small post-exploitation water reservoirs are less spectacular, because the influence of factors causing the modelling of their shores (among others earlier levelling of excavation scarps, permanent shore building, small area, disadvantageous localisation and exposure) is usually limited.

Several years' observations on morphological changes in shore zones of water reservoirs in the Silesian Upland, induces to distinguish four stages of development of littoral zone, which are in connection with morphological evolution of reservoirs as geosystems [Jaguś, Rzętała, Rzętała, 1998]: 1) abrasive diversifying of shoreline, 2) abrasive-accumulative smoothing of shoreline, 3) accumulative diversifying of shoreline, 4) biogenic strengthening of shoreline. The first one was finished for the majority of objects investigated, but it is typical for water reservoir Pogoria IV (Kuźnica Warężyńska), formed in 2005 year, the second one refers to the reservoir Dzierżno Duże, the example of the third is Pogoria III and Przeczyce, and the fourth one – Świerklaniec.

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Factors shaping the extent of soil pollution with heavy metals in Upper Silesian Industrial Region

Introduction

The presence of heavy metals in soil can have different origins. These elements can enter the soil as a result of human impact, and may also constitute their natural resource, especially in areas of outcropping of orebearing rocks. The general concentration of trace elements is a result of mutual merging of factors, among which the most destructive are effects of industry, waste dumps and the automotive industry. In case when heavy metals get to the soil, of their availability for plants decides many environmental factors, such as granulation of the soil, its reaction and affluence of humus.

Steady growth of active pool of trace elements may lead to imbalance between their activation and introducing to biological environment, and re-deposition in geological formations. As a result, homeostasis, which is the basis of permanent ecosystems existence in environment, may be disturbed. Potential environmental contamination of heavy metals does not indicate their harmfulness to organisms, because toxicity of trace elements arouses due to biochemical role which they play in metabolic processes of living organisms.

Description of the test area

Upper Silesian Industrial Region (USIR) is one of the most characteristic example of highly human transformed area in Poland. On the whole area of USIR soils distinguish themselves in the highest content of heavy metals in country scale. Average content of lead in ore levels of upper silesian conurbation ranges a few hundred milligrams per one kilogram of soil, with the norm 50 mg/kg. In case of cadmium this norm is exceeded fivefold. In extreme cases these concentrations are even higher.

Current soils condition of USIR is a remain of times when industry, which is now recognised as the main source of trace elements emission to environment, was mostly perceived as a motion wheel for national economy development. Its negative influence was chiefly reduced to such effects as formation of external plant damages or overall decrease of crops. People did not realize then, that limitation or even complete suspension of emitting pollution containing heavy metals, would be a partial solution to the problem – such pollutants have permanent character and after getting to the environment they have influence on it for a long time.

Anthropogenic sources of heavy metals

Industry

Pollutions emitted by the industry cause changes in the environment of quantitative and qualitative character. Compounds carried to the atmosphere settle on a surface of the soil where they get to deeper parts of soil profile. Moreover, during production cycle originate small amounts of wastes containing heavy metal compounds and sewage, which may get to the soil through a leaking system.

In 1997 on the area of former voivodeship of Katowice an inspection of all industrial sources of heavy metal emissions was conducted. Results of the inspection allowed to distinguish a group of 10 factories which were characterized by the highest amounts of harmful elements emission to the atmosphere, and every one of them was located on the area of USIR. These factories are presented along with the amount of emission in table 1.

Table 1. List of factories emitting Zn, Pb, Cd along with the amount of emission (according to data from OBKiŚ – Environmental Research Centre and Control in Katowice, 1997)

Name of factory	Location	Amount of emission mg/year		
		Zn	Pb	Cd
Jaworzno I power plant	Jaworzno	-	0,990	-
Jaworzno II power plant	Jaworzno	-	1,170	-
Jaworzno III power plant	Jaworzno	-	2,200	-
Florian steelworks	Świętochłowice	13,550	2,640	0,060
Jedność steelworks	Siemianowice Śląskie	9,700	2,290	0,400
Katowice steelworks	Dąbrowa Górnicza	-	49,800	0,790
Łabędy steelworks	Gliwice	11,850	0,740	0,015
Łaziska power plant	Łaziska Górne	1,830	1,240	-
Miasteczko Śląskie zink works	Miasteczko Śląskie	10,990	70,980	0,076
Silesia metalworks	Katowice	23,480	-	0,940

Since the inspection, in factories mentioned above several innovations were introduced and modernization of the most harmful sections was made. However, not only the inspection and the results conditioned the intensity of actions taken for environmental protection.

Causes of origin of sudden heavy metal emission decrease ought to be sought in 1990, when contemporary Environment, Natural Resources and Forestry Protection Minister announced "Lista 80" (The 80 List). This list was an additional mechanism of the influence of government services on the group of factories emitting the highest amount of harmful substances and with time it occurred to be an effective tool mobilizing them to take actions for environmental protection. Since the list came into existence, the factories from it reduced: emission of liquids by about 90%, emission of gases by about 60%, amount of sewage by about 33% and amount of wastes stored by about 71% [Banaś, Bronny, 2007]. However, in spite of ecological success achieved, overall emission from industrial plants located on USIR area is still at a very high level comparing to the small amount of space occupied by the district (fig.1).

Waste dumps

In Poland, despite difficulties which appear in finding new areas for dumps, still the most common and the cheapest method is putting wastes to dumps. The size of negative influ-

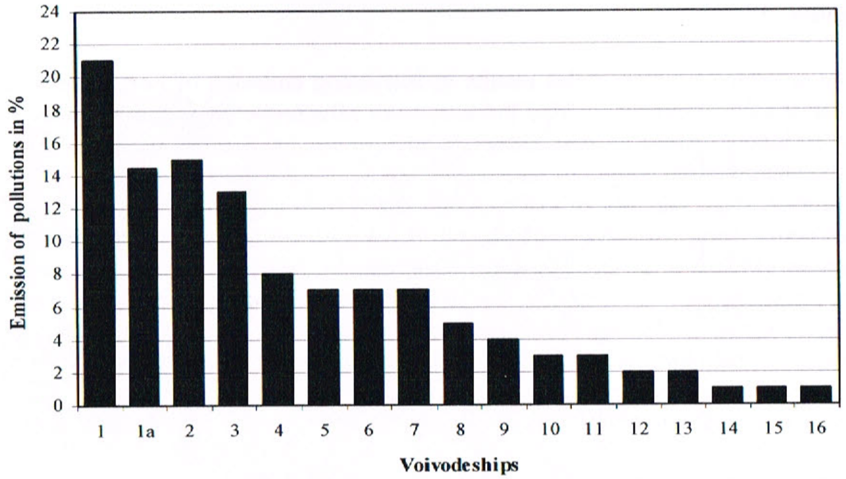

Fig. 1. Emission of pollutions from the most farmful industrial plans according to voivodeships in % (according to data from GUS, 2007):
1 – Silesian voivodeship, 1a – USIR, 2 – Łódź voivodeship, 3 – Masovian voivodeship, 4 – Greater Poland voivodeship, 5 – Lower Silesian voivodeship, 6 – Opole voivodeship, 7 – Lesser Poland voivodeship, 8 – Świętokrzyskie voivodeship, 9 – West Pomeranian voivodeship, 10 – Kuyavian-Pomeranian voivodeship, 11 – Pomeranian voivodeship, 12 – Lublin voivodeship, 13 – Subcarpathian voivodeship, 14 – Lubusz voivodeship, 15 – Podlaskie voivodeship, 16 – Warmian-Masurian voivodeship

ence of the dump over the soil environment depends on the character of dumped material and its harmfulness, and also the way of collecting wastes, location of the object in attitude to underground water and natural resistance of soil to penetration of pollutions from the surface [Kowalczyk, 1995]. In case of waste dumps containing heavy metals, both their sewage and gases and dusts emitted from them contain compounds of these elements.

On the area of USIR the highest amount of industrial wastes is produced by the group of a few factories, among which dominant are steelworks, that are a large threat of emitting heavy metals. In accordance with GUS (Central Statistical Office) data, in 2007 about 3800 tons of wastes were created (excluding municipal wastes) to $1km^2$ of USIR, which puts the analysed area on the first place among areas producing the highest amounts of wastes in Poland. At the end of 2006 on the area of USIR 11 hazardous waste dumps were exhausted, that is 1/3 of all the wastes in the country. Unfortunately, a lot of them were not secured in any way and their location was coincidental and incautious. As a result of the impact of the dumps mentioned above, considerable soils contamination happened. Good example are waste dumps in Chemical Plants "Tarnowskie Góry". Among many years technologies used in this plant were oriented at producing the desired product, but the problem of manufacturing wastes was not taken into consideration. The wastes were carefree put on the area of the plant or in its neighbourhood. Today it is estimated that on the area of 40 ha were deposited more than 1,5 mln m3 of chemical wastes [Kadarowska, Stradowski, 1998] which is to some extent a national record. Results of analyses made on soils located near the dumps show that the acceptable amounts of various elements were highly exceeded: zinc –180 times exceeded, copper – 40 times exceeded, cadmium – 12 times exceeded.

Growing number of auto-mobiles results in increasing emission of heavy metals compounds, and the development of road infrastructure affects the character and specificity of emitted pollutions. Areas located alongside busy routes for decades were and still are exposed to contamination mainly of lead and cadmium. Heavy metals pollution of these areas results mainly from increase of use of liquid fuels, to which petrol and diesel belong. In effect of petrol using, 70–80% of added lead is released with flue gas and goes back to the environment [Matras et al., 2000]. Automotive industry is therefore the main source of this element emission to the atmosphere. Cadmium gets to the atmosphere through rubbing out of car tyres, asphalt and using of car oils. Negative impact of automotive industry does not only come down to harmful emission of pollution to the atmosphere. Negative effect of transport development is also production of huge quantity of waste materials, often containing toxic chemical compounds. Neutralizing of these wastes is mainly done through putting them on the dumps.

Fumes emitted by auto-mobiles spread to about 50 m from the edge of the road, however their most intense effect was determined in the area of 10 m from the edge of the road [Kucharski, Marchwińska, 1994]. The cause of the heavy metals accumulation in such small distance from the roads is due to specific conditions of emission from transport sources, which support diluting of pollutions in the air and in the end they restrict their possibility of migration. In relation to the fact, that USIR has the biggest and the most complex road network, the concentration of trace elements from transport reach to the highest amounts. Confirmation of this thesis is the result of chemism of the soil located along motorways A1 and A4 fragments and around International Airport "Katowice" in Pyrzowice, made in 2002 by WIOŚ (Voivodship Inspectorate for Environmental Protection) in Katowice.

Summary

Heavy metals concentrations in soils of Upper Silesian Industrial Region are higher than the concentration noted in other regions of Poland. Since some time now, however, steady improvement of soils quality in the area can be observed. This improvement is among others a result of introducing already mentioned "Lista 80", alternative fuels used in automotive industry and many law acts regulating the subject of negative impact on environment. Human mentality change has become a widespread phenomenon and it is reflected in overall respect for the value of the environment. In shaping of current soil situation in USIR very important were the reclamation activities carried out on a big scale, undertaken in order to give or restore utility and natural values of degraded soil. The belief that the soil situation in the region is getting worse is therefore wrong.

It was formed in the social consciousness by the mass media supported by all kinds of ecological organizations. Despite the fact that some areas of USIR still have a very high amount of trace elements, this amount is decreasing for years now. This process can be seen on fig. 2 and 3.

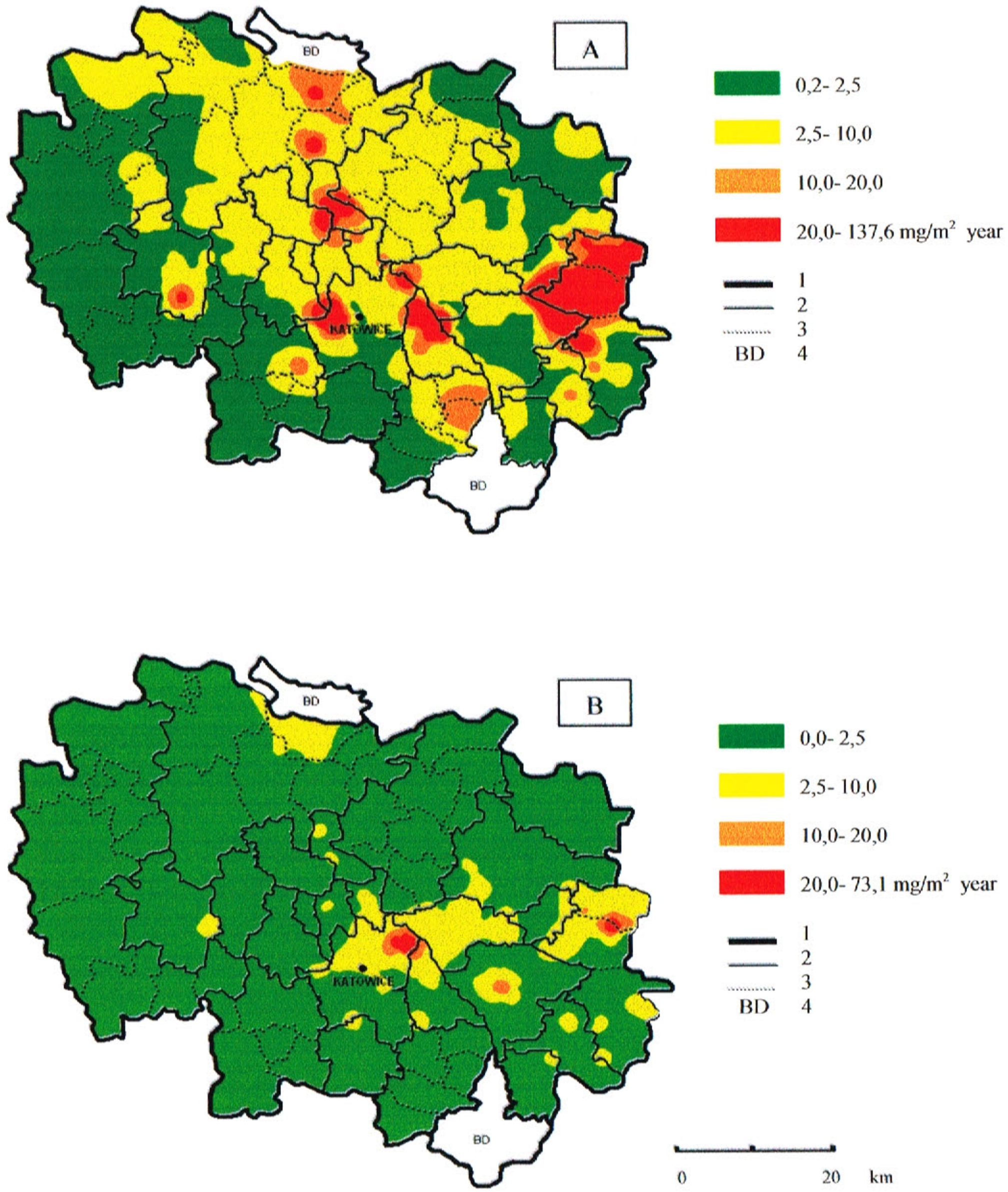

Fig. 2. Cadmium fall in 1986 (A) and 1996 (B) in USIB (according to data from OBiKŚ and IETU- Institute for Ecology of Industrial Areas)- *acceptable amount 10mg/m² year.*

1-border of USIB, 2-powiats (second level of local government administration in Poland), 3-dostricts, 4- no data.

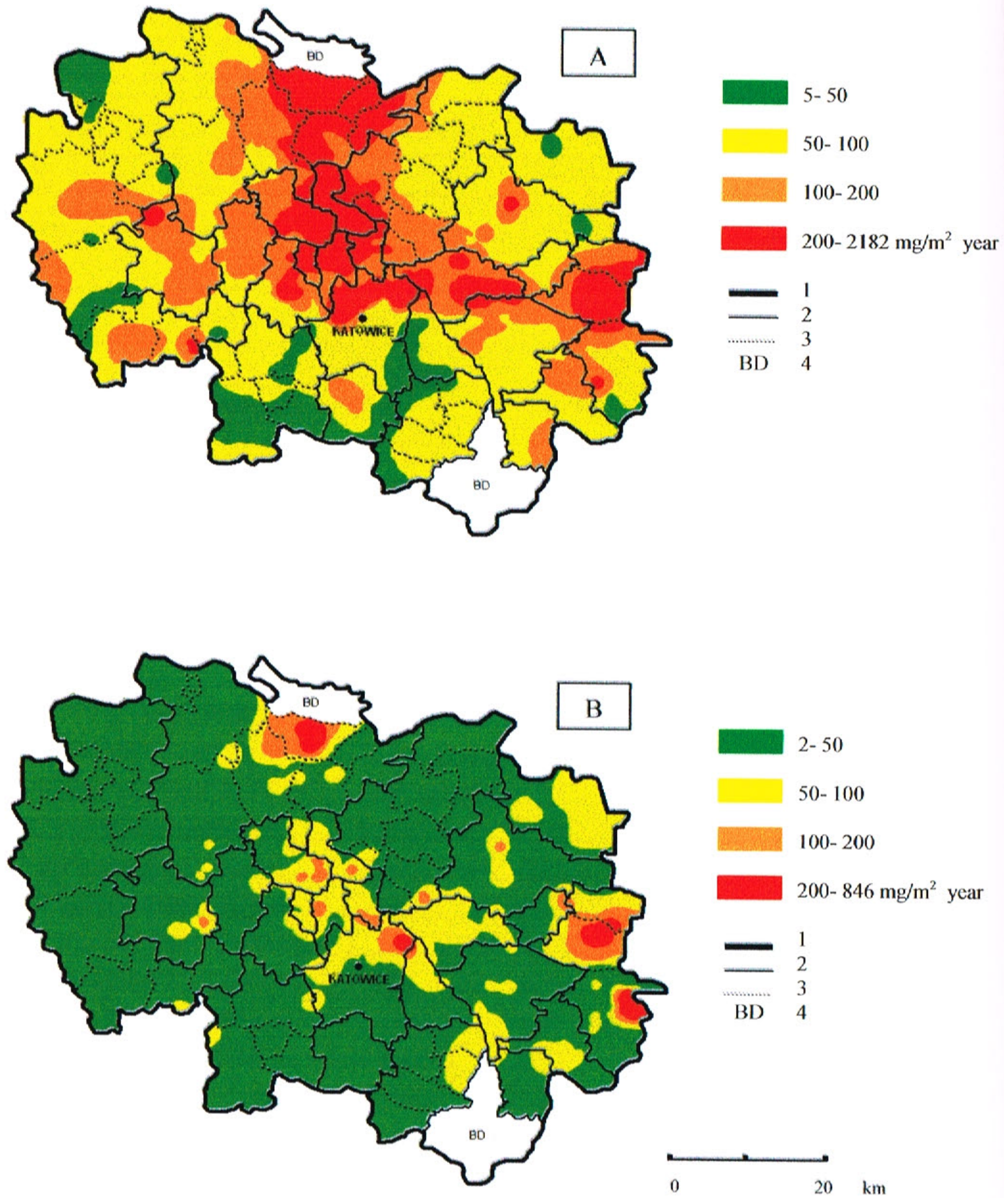

Fig. 3. Lead fall in 1986 (A) and 1996 (B) in USIB (according to data from OBiKŚ and IETU)- *acceptable amount 100mg/m² year.*

1-border of USIB, 2-powiats (second level of local government administration in Poland), 3-dostricts, 4- no data.

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Investigation of island biogeography of Zsolca Mounds

Introduction

Kumanian mound pairs, the Zsolca Mounds maybe the most valuable in Hungary are found in the area of Felsőzsolca in the Sajó-Hernád Plain along the border of the Great Hungarian Plain and the Northern Mountains (figs 1 and 2). They are also often called Onga Mounds. The twin mound covered by ancient grassland, elevating 5.5 m high in average from the agricultural land surrounding in the flood-free terrace of the Sajó is one of the most beautiful mounds in the country regarding landscape. Unfortunately the top of both mounds was strongly disturbed presumably by treasure hunters or amateur archaeologists during past centuries. Places of former excavations are still visible at the foot of the mounds in the form of shallow ditches that could have been 3–3.5 m deep originally (fig. 1). Based on the shape of the mounds and the archaeological findings from the cultivated surrounding area the mounds are tell type mounds from the end of the early or from the middle Bronz Age. Inhabitants of the Bronze Age tell cultures seeking flood-free highs close to rivers carried out intense agriculture and peasant cultivation therefore their presence intensified the transformation of the area into a cultural landscape [Kalicz, 1968].

Among Great Plain dry grasslands loess grasslands once extended in the Great Plain have special nature protectional significance and these have been reduced to only 7.5% of the country by today [Zólyomi, Fekete, 1994]. Remnants found in very small areas (cumanian mounds, earthworks, sortifications, border rands) are very valuable regarding nature protection. Due to their small size certain treatments, abiotic disturbances and biotic interactions may trigger such effects that may result in the significant difference of today's derivative vegetations from each other and from their original state [Barczi, Penksza, Joó, 2004; Vona, Penksza, 2004]. On the Zsolca Mounds very species rich, however, far not characteristic loess grasslands are found due to their mountain foreground location. Numerous floristic data are known from these grasslands [Farkas, 1999; Molnár, 1999].

Material and methods

Plant species list was prepared based on surveys on both mounds in every aspect of the vegetation period during 2006 and 2007. In order to study the edge developed due to intense cultivation transects sized 1 x 6 m were set towards the four main direction of the compass

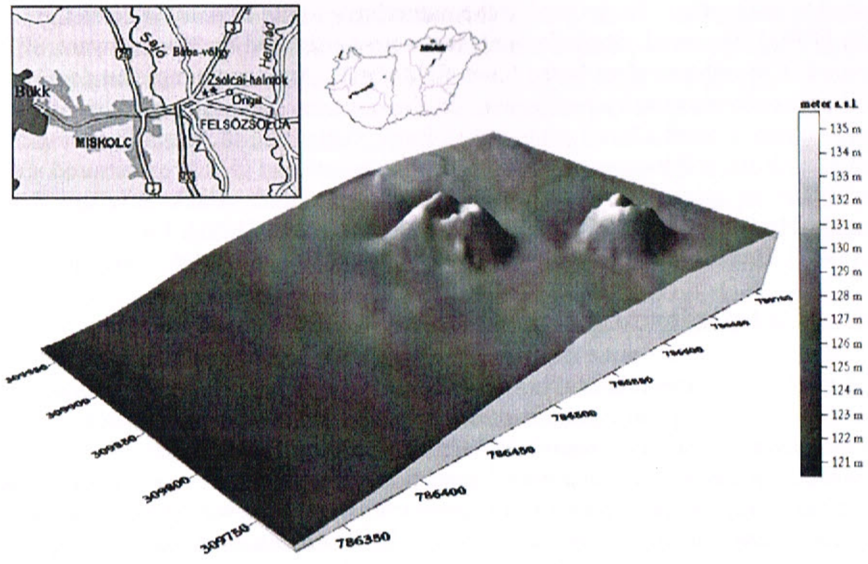

Fig. 1. Geographical position and DEM of the Zsolca Mounds

Fig. 2. Valuable loess grassland covers the Zsolca mounds elevating from the surrounding arable lands

on the eastern mound along lines from the cultivated edge of the mound towards its centre. Transects were analysed separately in 1 x 1 m^2. In the central part of the mound further 4 separate 1 x 1 m^2 were formed. In the quadrats the AD values of the species were registered at the end of May, June and August (2006–2007). In the terminology of species the work of Simon [1992] was followed. In order to detect the edge effect and to determine the width of the edge zone the average values by quadrats of the naturalness values of plant species were compared to each other. To determine the naturalness value of plant species the work of Borhidi [1993] was used. Statistic analyses were performed by the software SPSS for Windows 8.0. In order to identify the fauna field observations and simple random sampling and soil trap collections were performed. On the northern and southern sides of both mounds 10–10 and in total 40 soil traps were placed. Regarding factors influencing the dispersion of animals, soil temperature, natural water content and pH were measured at 5 spots in each habitat. In order to identify the trapped animals and their valid terminology the works of Freunde, Harde, Lohse [1976], Kerney, Cameron, Jungbluth [1983], Lidroth [1985, 1986], Lucht [1987], Heimer & Nentwig [1991], Hurka [1996], Roberts [1996] were applied.

Results of botanic investigations

In the area of the two mounds totalling 0.8 hectares occurrence of 104 plant species has been recorded so far. *Salvio-Festucetum rupicolae* was found on both mounds covered by characteristic species of the association in different ratio from place-to-place.

On southern slopes in smaller extent spots dominated by *Stipa capillata* are found. Besides maidenhair, *Koeleria cristata* and *Carex stenophylla* are forming the grass. At places *Agropyron repens* prevail with scattered *Botriochloa ischemium* and *Bromus erectus*. Advancement of the latter indicates the deterioration of the grassland. Regarding dicotyledons *Teucrium chamaedrys*, *Cytisus albus*, *Salvia nemorosa* and *Inula hirta* are abundant.

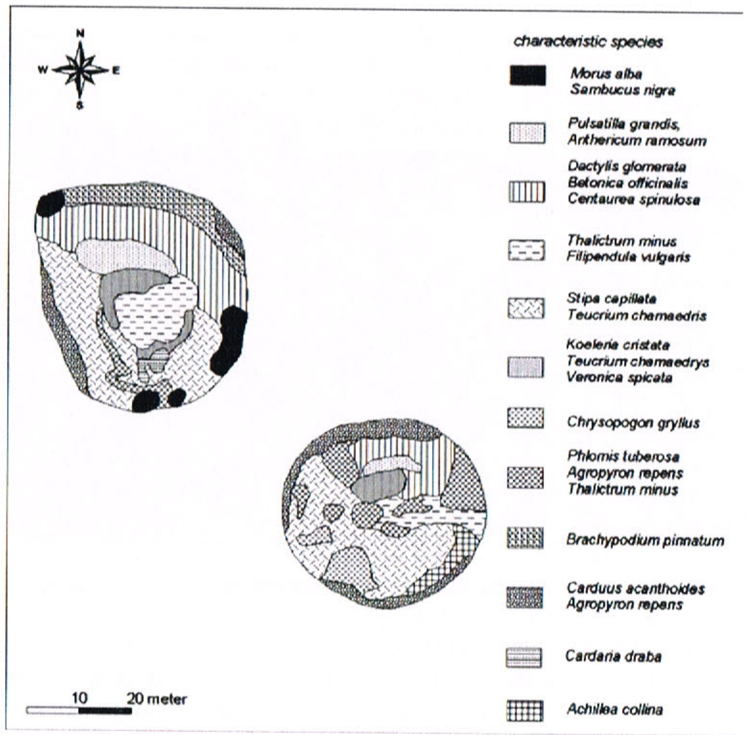

Fig. 3. Distribution of the major vegetation types covering the mounds

In significant areas of both mounds *Festuca rupicola* is the dominant grass forming species, however, scattered spots of *Agropyron repens* and at places dicotyledons – *Thalictrum minus*, *Cytisus albus*, *Phlomis tuberosa*, *Inula hirta* – cover largest areas. Spots of more variable species content are found on the top and the northern and eastern sides of the mounds. From the characteristic species of loess grasslands *Galium verum*, *Veronica spicata*, *Verbascum phoeniceum*, *Salvia nemorosa*, *S. pratensis*, *S. austriaca*, *Thymus glabrescens*, *Filipendula vulgaris*, *Muscari comosum*, *Pulsatilla spp.* and *Aster amellus* are found on great numbers. From rare species *Echium russicum*, *Linum flavum*, *Centaurea triumfettii*, and *Dictamnus albus* can be found (fig. 3).

To study edge effects the naturalness value average of the species observed in the quadrats was applied. Regarding naturalness value averages, significant differences between surveys classified into the given groups were found when the outer 3 quadrats of the 6 m long section of the transects were classed in the edge while the outer 3 quadrats into the inner groups. Distribution of average naturalness values of the quadrats sorted in equal distances from the edge is presented in fig. 4. It is clear from the figure that the averages of the quadrats located within 3 m distance are significantly lower. Significance of the difference was tested by Man-Whitney test. For the difference of the naturalness values of the innermost quadrats of the transects and that of the reference quadrats placed in the central areas of the mound determined by Man-Whitney test, significance of only $p = 0.057$ was obtained. The inner three quadrats of the transects therefore represent adequately the inner area of the mound their naturalness values differ not significantly from values obtained in the central parts of the mound.

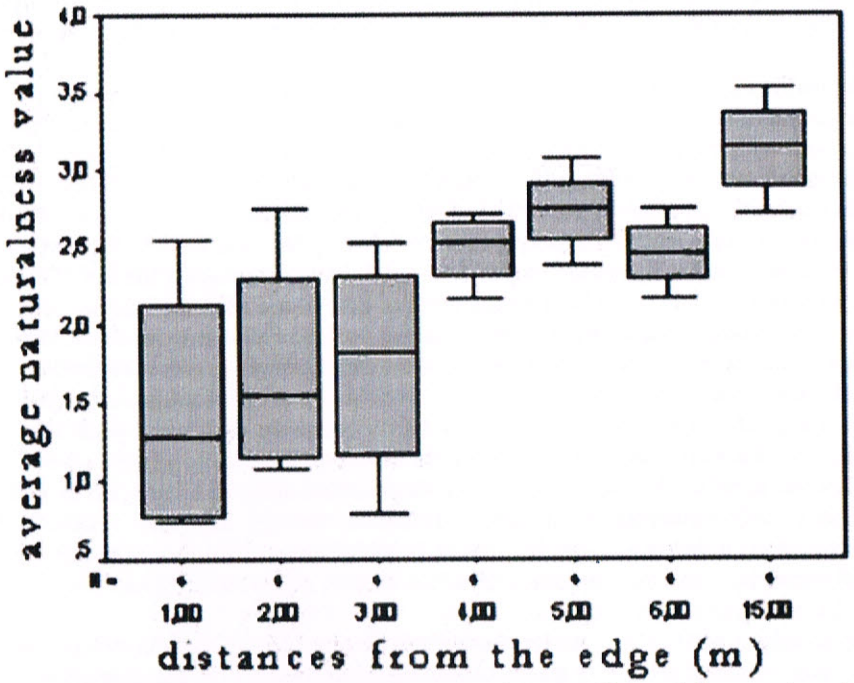

Fig. 4. Distribution of average naturalness values per quadrat sorted in equal distances from the edge

Considering the above, lists of species were compared in relation to find the most frequent species of edge and inner areas of the grassland. For comparison AD values were not applied only the absence and presence were used. Frequent species in the edge involve *Agropyron repens*, *Rubus* and *Cardaria draba* while in the inner areas *Cytisus albus* and *Salvia nemorosa* can be named. *Cardaria* and *Agropyron* are also found among the first five. Characteristic ruderal and arable land weeds are found among the species occurring only in the edge zones, however, crop and dry grassland species as well. Loess grassland specialist species are found among those occurring only in the inner parts together with dry grassland species here as well.

Regarding species missing from the records, adventive weeds occurring in the edge areas and in disturbed patches (ant-hills, vole lines, fox warrens) on the top of the mound include: *Abutilon theophrasti*, *Ambrosia artemisiifolia*, *Xanthium strumarium* és a *Conyza canadensis*. Although these species occur only by threads the advance was notable in the drier year (wet and not too warm spring and early summer in 2006, extreme wet and dry spring and summer in 2007).

Results of zoological investigations

Zoological investigations were started by determining the most important ecological parameters. Near surface soil temperature was measured in a sunny early afternoon weather in June 2007. Measurements near the top of the mound gave similar values. In contrary 7.4–7.9°C difference was detected between the average temperatures of the northern and southern slopes of the mound (northern: 21.5–22.8°C, southern: 29.5–30.2). Soil temperature difference between the two different habitats plays an important role in the dispersion of the fauna.

Following this the pH of the soil samples was measured from the surface down to 10 cm. On the southern side of the eastern mound values of 7.60–7.80 were measured that corresponds well with the pH of the base rock. Similar values are detected on the northern side as well (pH 7.19–7.85). Among the samples of the southern side of the western mound there is one with the value of 6.87. This could be the remnant of the A layer of a former soil. pH values of the rest of the samples varied between 7.65 and 7.70. In the northern edge of the western mound pH was reduced to 6.52–6.71, however, nearing the top of the mound it was increasing (7.16; 7.55; 7.70). In the earth of the mound deposited earlier soil forming processes are going on currently, however, no classic soil layers have been developed.

The natural water content of the topsoil of the Zsolca mounds was measured in order to study the distribution of a factor important from the soil bound animals point of view. Results revealed that the two mounds only partly resemble each other regarding natural water content. Sampling sites were spotted from the top of the mound along 8 metres (5 samples). Lowest water content was measured on the southern slope of the eastern mound (10%) and water content stays surprisingly low until halfway through the northern side. Then water content of the northern slope of both mounds is high (max. 26–27%). Average water content difference between the southern side of the eastern and western mounds is 5.3% while this on the northern side is only 1%.

Up to now a total of 112 species have been detected by soil trap investigations including several protected species (e.g.: *Calosoma auropunctatum, Carabus cancellatus, C. violaceus, Dorcus paralellepipedus, Atypus affinis*). Among snails *Chondrula tridens* and *Helicella obvia* were frequent. Very widespread was *Cydnus aterrimus* on the mounds. In the

soil trap investigations *Carabidae* species (16 species) were dominant regarding the number of both species and individuals. In humus rich soil on the northern side of the western mound with more balanced water content conditions *Stomis pumicatus* can be found. Here the *Pterostichus niger* known from woodland association is found in an open habitat in dense vegetation. Among Tenebrionidae *Blaps lethifera* and *Opatrum sabulosum* are the most frequent. Although *Dorcus paralellepipedus* lives in decaying wood it can be found occasionally on the mounds as well. Considering Chrysomeloidea *Chrysomela limbata* that lives on Plantago is worth mentioning.

Apart from soil trap collecting, simple random sampling and field surveys were also applied to find species: *Decticus verrucivorus* and a protected rare spider, *Atypus affinis*. Large ant-hills were found on the surface of the mound with 4 ant species identified (*Formica cunicularia, F. rufibarbis, F. pratensis, Camponotus piceus*). We have seen the also protected *Lacerta agilis* to hunt for grassland insects. Clearly visible is the fox (*Vulpes vulpes*) warren on the mound. Among small mammals *Microtus arvalis*, *Micromys minutus*, *Crocidura suaveolens* are the most frequent.

Considering fauna, the Zsolca mounds are very small in area (0.8 ha), however, our studies have revealed numerous protected species in its fauna so far. Mounds are surrounded by agricultural lands and their effects are clearly observed in the composition of the fauna. Anthropic mounds present partly very dry, sunny, warm habitats (southern side) for animals while the northern side is densely vegetated and due to its more balanced water budget it has a higher diversity. The two mounds are very vulnerable and characterised by small number of individuals considering fauna due to their small size. Ratio of flying species in the fauna is very high. Most insects prefer the mounds due to their advantageous micro-climatic conditions and associated potential food but they are not constant elements of the grassland association.

Summary

Prehistoric mounds on the Great Hungarian Plain function often as refuges for relic loess steppe vegetation and fauna. The Mound in Felsőzsolca (Felsőzsolca, Borsod-Abaúj-Zemplén County, Northern Hungary) is one representative of them, they are covered by loess grassland fragments in extension of 0.8 ha, surrounded by agricultural areas. They are well documented from floristic point of view. Less studied and analysed are the actual vegetation dynamics as a result of their isolated location, small extension, and numerous and frequent disturbances (pedoturbation caused by mammals, fire and invasive species). With detailed soil, vegetation and faunistic field survey we attempted to describe the most relevant actual processes of these very valuable grassland fragments from conservational point of view. Vegetation was sampled in 28 1 x 1 m quadrats, ordered in transects by distance from the edge. Presence of 104 higher plant species and a significant edge effect in the outlying sections (until 3 m) were established. It could be characterized by a significant lower naturalness value, different plant composition, presence of weed and ruderal species such as *Arctium lappa, Artemisia vulgaris, Atriplex patula* since most specialists (*Salvia pratensis, Pulsatilla sp., Inula hirta, Aster amellus, Dianthus pontederae*) were absent in the edge. The Zsolca Mounds take up a relatively small area as regards the fauna (0.8 h), but according to the research we have done so far, many protected species can be found here. The anthropogene mounds form partly a very dry, sunny and warm habitat for the

fauna (on the southern side) while the northern side of the mounds is of higher biodiversity, due to the dense vegetation and balanced water supplies.

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Studying landscape pattern in Great Hungarian Plain model areas

Introduction

In the last half century landscape ecological researches studied the operation of landscapes from three aspects [Mezősi, Fejes, 2004]. Initial works revealed the structure and performed the classification of landscapes. Analysing thoroughly primary landscape structure gives information on the puffer capacity and resistance of the landscape. From the second half of the 1970s functional landscape analyses gave the basis of meso-scale regional planning and landscape design.

From the 1990s landscape ecological research focused on the processes analysing landscape operation in large-scale based on field survey and mapping applying inductive methods. Demands for making the effects on and changes of landscape systems numerical became strong. For this landscape metrics offers a fine solution.

Landscape metrics is an American landscape ecological method and quantitative research school. Spatial pattern and mosaic character of landscapes are described by the geometric characters and position relative to each other of the landscape forming elements – patches, corridors and the matrix enclosing them [Forman, 1995; Lóczy, 2002; Kerényi, 2007].

Certain landscape metric indexes can be interpreted at patch, class and landscape levels [McGarigal, 2002]. In large-scale, parameters characterize the area, perimeter, shape, etc. of patches. Class level indexes are calculated as simple or weighted average of patch parameters sorted by land-use categories. Landscape level indexes are based on the characters of all of the patches in the landscape. Naturally, not every parameter have versions for all three levels: there are certain parameters that can only be given at patch level or at landscape level.

Majority of the authors of publications in the topic apply landscape metric indexes in order to describe from landscape ecological point of view or to give comparative landscape analysis of areas of different hierarchy (e.g. landscape part, small landscape, catchment area, country) [Szabó, 2007; Csorba, 2007; Kerekes, 2008]. Most of the more than a hundred indexes correlate strongly. Several authors discussed redundancy filtering and the application of certain parameters [Riitters et al., 1995; Szabó, 2009].

Recently, identification of land-use categories and small landscapes based on landscape metric parameters in a deductive way has become widespread [Szabó, Csorba, 2009]. Higher grade indexes involving quality content are suitable for qualitative landscape assessment and may serve as a practical tool for achieving landscape protection, landscape aesthetics and recreation and also for nature conservation aims by understanding landscape ecological processes [Csorba, 2008].

The present paper contributes to the series of comparative landscape ecological analyses the goal of which is to give the exposition and comparison of the spatial pattern of two landscape parts belonging to different landscape types (model area 1: alluvial plain with wind-blown sand, model area 2: flood-plain flat landscape) on the basis of analysing landscape metric parameters.

Description of model areas

Landscape metric measurements were performed in two Great Hungarian Plain landscape parts of similar size but of different morphology (fig. 1).

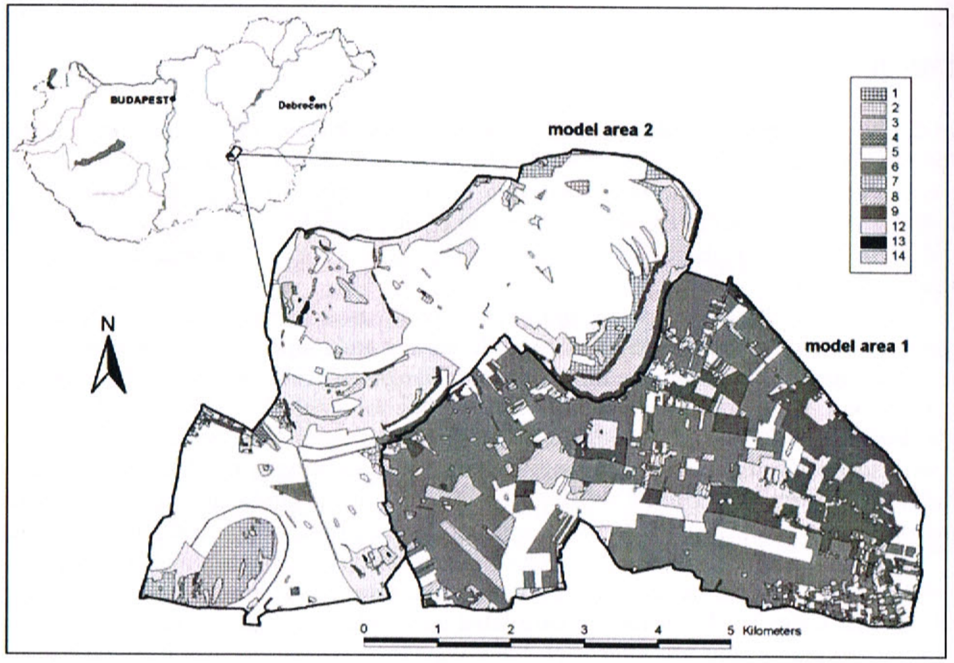

Fig. 1. Land-use in the landscape parts
1 – settlement, 2 – industrial and agricultural establishments, 3 – quarry, depository, 4 – artificial green area, 5 – arable land, 6 – vineyard, fruit garden, 7 – pasture, 8 – mixed agricultural area, 9 – deciduous forest, 12 – meadow, bush, 13 – water, 14 – wetland

The first model area (Tiszakürt-Bogaras sand region) is part of the Pleistocene wind-blown sand area composed of Danube alluvial material enclosed by settlements Cserkeszőlő – Halesz (Szelevény) – Csépa – Tiszasas – Tiszaug – Tiszakürt continuation of the Danube-Tisza Interfluve alluvial fan from which the Tisza only separated it in the late glacial [Aldobolyi Nagy, 1954]. Winds produced sand-dune rows with 2–4 m relative relief and NW–SE orientation [Marosi, Szilárd, 1969]. Forms of blow-out – blow-out dune – yardang – deflation depression characteristic for semi-bond sand areas were transformed several times by running sand in the drier periods of the Holocene and in historical times frequently due to anthropogenic processes [Gábris, Túri, 2008].

In the west a steep erosion edge separates it from the other studied landscape part that belongs to the New Holocene low and high flood-plain terrace series composed of fluvial sand, silt and infusion loess and dissected densely by abandoned beds (Földes marshland, wetland at Tiszasas, Sántaleány creek), point bar and crescent depression [Marosi, Somogyi, 1990]. Its lower situated parts were frequently flooded by the Tisza prior to the river regulation works.

Material and methods

For data preparation and presentation geoinformatic softwares ArcView 3.2 and ArcGIS 9.0 were applied. Landscape mosaics were vectorised in a scale of 1 : 5000 from orthographic photos prepared in the summer of 2005 by visual interpretation. 79 land cover category of the CORINE Land Cover (CLC50) database were merged into 14 land-use groups (settlement; industrial and agricultural establishments; quarry, depository; artificial green area; arable land; vineyard, fruit garden; pasture; mixed agricultural area; deciduous forest; pine forest; mixed forest; meadow, bush; water; wetland) in order to help interpretation.

In former papers we have concluded that when studying landscape metric indexes at micro-level application of large resolution and some kind of vector method is sensible [Túri, Szabó, 2008]. Therefore landscape metric measurements were performed by the IMT (Interactive Metrics Tool) module of ArcView 3.2 and vLATE module of ArcGIS 9.0. For numerical analysis of landscape pattern and for indirect understanding of landscape processes practical index lists are given by softwares developed at the University of Salzburg partly for educational purposes in the framework of the SPIN (Spatial Indicators for European Nature Conservation) project [Lang, Klug, 2006]. Some of the landscape metric indexes were calculated using MS Excel.

As softwares do not differentiate patches, corridors and matrix neither matrix enclosing patches nor landscape ecological corridors (e.g. tree row, canal, road, railway) dissecting landscape parts were studied even though certain land-use types had even spatial distribution and high spatial ratio (model area 1: vineyard, fruit gardens covered 50.12%; model area 2: arable land gave 59.48%). All landscape elements were considered as patches in the course of the analysis.

In this paper some widely used shape, composition and spatial structure parameters were studied at landscape level. International practice was followed regarding units, however, occasionally in text interpretations different units were also used.

Results

Spatial pattern of the landscape parts are dominated by anthropogenic, artificially maintained patches (e.g. arable land, vineyard and fruit garden, planted forest). Their main characteristics are ordered structure and lack of species. Landscape forming activity of man modifies drastically the relationship and connection network of the natural landscape elements [Kerényi, 2007]. Therefore the role of society as a landscape forming element cannot be ignored when studying and quantitatively analysing landscape pattern.

Spatial indexes belong to the simplest metrics. Number, size and frequency of patches (habitats) influence ecological processes, number of species and individuals, species exchange.

Total Area (TA) of the model areas was determined first. Total Area of the first landscape part is 21.63 km^2 while that of the second in 22.41 km^2. Based on the Number of Patches (NP) and Patch Density (PD), the spatial pattern of the first model area is much finer regarding resolution and more mosaic due to the complex cultivation structure (Szelevény-Halesz). This results in that the patch density is three times that of model area 2 while Mean Patch Size (MPS) and Patch Size Standard Deviation (PSSD) are half of that of model area 2 (table 1).

Table 1. Spatial indexes

Landscape metri parameter	model rea 1	model are: 2
TA	2162.5 ha	2241.2 ha
NP	619	216
PD	28.62 patch/km^2	9.64 patch/km^2
MPS	4.8 ha	9.5 ha
PSSD	30.1 ha	56.1 ha

Shape indexes characterize the complexity of the shape of the patches. Their basis is the perimeter/area ratio. In the case of isodiametric patch shape (e.g. circle) edge length is generally smaller than in the case of a complex or elongated shape and as a result disturbing or advantageous effects from neighbouring patches via the edge are less dominant.

Shape index describes patch shape independent from size as it compares the perimeter/area ratio of the patch to the perimeter/area ratio of a reference shape (generally a square). Fractal dimension value is larger if the shape of the patch is more complex.

Total Edge (TE) is around one and a half times longer in model area 1 than in 2 suggesting larger fragmentation of the landscape part. Mean Patch Edge (MPE) is greater in model area 2 that can be the result of larger average patch size and the more complex or more elongated shapes (e.g. landscape elements of abandoned river beds). Smaller Edge Density (ED) value indicates the more compact character of model area 2.

Based on the Mean Perimeter-Area Ratio (MPAR) patches of model area 1 have generally more irregular shapes also indicating greater spatial mosaic character. On the contrary according to the Mean Shape Index (MSI) average difference from the reference shape is greater in the other landscape part thus it is probably dominated by more complex shapes. Value of the Mean Fractal Dimension (MFRACT) is more-or-less similar in the two model areas (table 2).

Table 2. Perimeter based and patch shape indexes

Landscape metric para ieter	model : ea 1	model a ea 2
TE	450260 m	303806 m
MPE	887 m	1188 m
ED	208 m/ha	135 m/ha
MSI	1.521	1.703
MPAR	0.095	0.076
MFRACT	1.4	1.39

Core indexes can be applied to study the stability of the patches on the basis of edge width determined by the researcher. It describes the interactions between the more protected inner part and the more sensitive edge zone of the patch. The size and shape of the

core area and puffer zone influence the occurrence, density and movement of inner and edge species.

In the case of 10 m wide edges regarding the Total Core Area (TCA) and the total area of landscape parts the Core Area Index (CAI) is above 80% which is beneficial for the survival of the inner species. Number of Core Areas (NCA) is 30% greater in the case of both model areas than the number of patches. This can be the result of the fragmentation of the inner parts of complex shaped (narrowing-widening), elongated patches. Occasionally the continuity of the inner zone may be broken as well. Number of Disjunct Core Area (NDCA) is around similar (15%). The inner zone is completely missing in 60 patches and 6 patches of model area 1 and 2 respectively. In these patches only more tolerant edge species live. Cority index value is more preferable in the case of model area 2 (table 3).

Table 3. Core area indexes

Landscape metric paran :ter	model a ea 1.	model a ea 2.
TCA	1750.6 ha	1956.8 ha
NCA	806	277
NDCA	122	43
CAI	80.95%	87.31%
Cority	69.4%	75.8%

Diversity indexes characterize landscape diversity, variance of landscape forming patches and patch types. Richness gives the number of patch types occurring in the landscape. Dominance shows the prevailing patch types in the landscape. Shannon indexes consider the extent and mosaic character of the given land covers and analyse landscape structure from the aspect of quality.

From the 14 land-use categories 8 occur in model area 1 while from the Richness of the other model area only pine forest and mixed forest are missing. Relative Richness reflect this difference clearly. Shannon's Diversity Index (SHDI) is higher in the more fragmented model area 1 and this can be explained by the already mentioned complex cultivation structure and relatively high ratio of remnant and planted forest patches. Value of Shannon's Evenness Index is also higher indicating more even spatial distribution of the occurring patch types. Despite high richness Dominance of the arable land patch type is high in the landscape structure of model area 2, its ratio is almost 60% (table 4).

With its more heterogeneous landscape elements (habitats) and more complex cultivation network, model area 1 has more preferable landscape structure than the other landscape part regarding landscape protection.

Table 4. Diversity indexes, dominance

Landscape metric parame r	model rea 1	model : ea 2
Richness	8	12
Relative Richness	57.1%	85.7%
SHDI	1.38	1.23
Shannon's Evenness Index	0.67	0.49
Dominance	0.70	1.26

Neighbour indexes – based on the results of island biogeography – give information on the spatial distribution and mixing of patches and patch types in relation to the landscape border and to each other. They can be interpreted primarily at patch and class levels, however, applying calculated parameters they may enable the studying of the aggregatedness of landscapes as well. Via the movement of organisms it can be suitable for estimating settlement probability as well for which patches of adequate size are necessary.

On the basis of Average Nearest Neighbour Distance model area 1 is more fragmented, however, values are nearing each other. Similar results are gained for the Standard Deviation of Nearest Neighbour Distance as well. Average nearest neighbour distance in patches with large average size of high element number (e.g. arable land, vineyard-fruit garden, meadow and bush) is around 100 m (table 5).

Table 5. Neighbour indexes

Landscape metric parameter	m del area 1	m del area 2
Average Nearest Neighbour Distance	361.4 m	345.2 m
Standard Deviation of Nearest Neighbour	259.2%	251.8%

Landscape division indexes analyse the role of pattern heterogeneity and that of ecological barriers originating from anthropogenic activity impeding species movement.

Landscape Division Index (DIVISION) studies the chance of 2 animals (two individuals from the same species) meeting at the same time. With increasing division of the landscape the chance of meeting animals is reduced. In model area 2 both the fragmentation of landscape patches and the average distance of similar habitats are greater influencing species movement, species exchange and reproduction populations unfavourably.

Splitting Index (SPLIT) and Effective Mesh Size (MESH) mean the number and size of similar sized areas produced by the splitting of the landscape that enable similar probability for the meeting of animals. This value is more preferable in model area 1 (table 6).

Table 6. Landscape division indexes

Landscape metric parameter	m del area 1	m del area 2
DIVISION	65.17	68.73
SPLIT	6.44	4.3
MESH	72 ha	68.6 ha

Summary

Analysis of the spatial pattern of two landscape parts from the Tiszazug was performed applying almost 30 landscape metric parameter. In the course of the work overlapping of values was experienced in the case of certain index groups and furthermore contradictory results were obtained occasionally when studying the geometric and landscape division characteristics. Thus relationship of all of the landscape metric parameters relative to each other would be important [Szabó, Csorba, 2009].

Based on the measurements, pattern of model area 1 can be characterised by higher landscape diversity, dispersal and fragmentation. Anthropogenic disturbing effects are strongly observed in both of the model areas and these influence the operation of the landscape in a disadvantageous way. Landscape metric analyses may contribute to the preservation of the natural values of protected areas (e.g. Körtvélyes and Bokros in the Tiszazug, Földes-lápos) and to the protection of the landscape.

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A study of floodplain evolution in Bereg-plain

Introduction

River Tisza and its tributary-streams generated remarkable landscape-evolution over a 25 000 km^2 area of the Great Hungarian Plain. River-controls in the XIX. century made significant changes in hydrological characteristics and capacity for landscape-evolution of the river. There were many reasons for river-controls: to curtail duration of floods; to gain arables by decreasing area of floodplains; to shorten sailing-lines. The works begun in 1846, by the modified conceptions of Pál Vásárhelyi and continued to the end of that century. During this period 112 bend cutoffs were made, and the river segment on Great Hungarian Plain was shortened by 37%. Because of this, its gradient also increased – e.g. with 7,8 cm/km between Batár and Szamos-torok [Lászlóffy, 1981]. Because of the levees in a length of 1439 km, the floodplain area decreased down to 1500 km^2. Hence, accumulational area of Tisza decreased down at 5–6% of its former floodplain-area. The examination of sedimentary deposition was very important in the last decade because the four extremely high floods in the turn of the millennium (1998, 1999, 2000, 2001) confirmed the earlier proved tendency that the peaks of flood water-levels are rising. Among the possible reasons – e. g. the increase of the downflow coefficient due to the deforestation or owing to the expansion of the paved surface in the catchment area [Illés, Konecsny, 2000; Konecsny, 2002, 2003] or because of the more and more frequent extreme weather phenomena etc. – the decrease of the cross-section of the active floodplain is arisen. The water experts drawn attention to e. g. the opening of Q-H curves which refers to increasingly higher peak stage beside the same water discharge [Nagy, Schweitzer, Alföldi, 2001]. This can be explained with the diminution of the cross-section of water discharge. Since the width of the active floodplain is stabile, the diminution is the consequence of the alluviation (the rise of the bottom level). The examinations begun towards three directions in order to reveal more correctly the slightly known phenomenon:

1. Manual field measurements: the determination of the thickness of the freshly deposited flood sediment, the sedimentology examinations of the alluviation of the dead beds in the active floodplain, the state survey of the VO. Stones, surveying the cross-sections of the active floodplain and the reclaimed side with a level instrument, comparing their mean altitude [Borsy, 1972; Kiss, Sipos, Fiala, 2002; Schweitzer, Nagy, Alföldi, 2002; Oroszi, Kiss, 2004; Babák, 2006; Oroszi, Sándor, Kiss, 2006; Sándor, Kiss, 2007; Vass, 2007; Vass Szabó, Szabó, 2009].

2. The determination of the heavy metal content of the sediments in the active floodplain: identifying the time (e. g. Chernobyl nuclear catastrophe) of the heavy metal accumulation in every layer of the active floodplain can make the age of the layers deposited onto them definable so the rate of the accumulation can also be determined [Wyżga, 1999; Zhao et al. 1999] Kiss et al., 2000; Kiss, Sipos, 2001; Braun et al., 2003; Szalai et al., 2005; Sándor, Kiss, 2006; Soster et al., 2007; Szabó, Posta, 2008; Dezső, Szabó, Bihari, 2009].
3. Measurements in the third group do not require field observations by all means but using former contour maps with scale as large as possible, the rate of the sedimentary deposition can be determined with the help of the relief map DEM made of the digitalized contour lines [Gábris et al., 2002; Vass Szabó, Szabó, 2009].

In our study we obtained data from sediment-coverings and grain-size distributions (granulometric graphs) to calculate the rate of sedimentary-filling.

Description of the the study-areas

Our study-areas – two dilations on the active-floodplain (where the rate of sedimentation is higher, caused by the slowing and expanding mass of water) – are located on the right bank of the river, in the vicinity of village of Jánd (fig. 1). There were two stages of construction of levees on the right bank of the river: firstly between 1846–1849 for the segment between Borzsa-torok and Tarpa; and secondly between 1855–1856 for the segment between Tarpa and Mátyus [Ihrig, 1973]. In our study-area the active-floodplain evolution took from 1856 (building the levees) up to our samplings in 2008–2009. Levees on the left bank were made later (1926–1928), coeval with the levees of the right bank of river Szamos. Besides building of levees, there were cutoffs (crosscuttings) of matured meanders on both study-areas. As a result of this, active-channels were shifted in long distances.

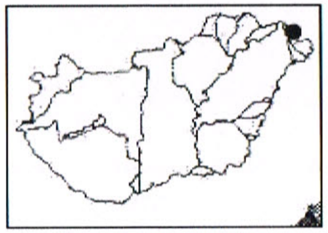
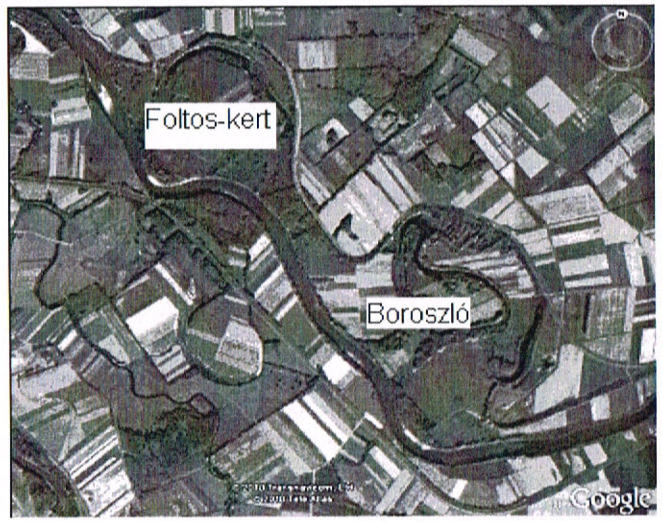


Fig. 1. Two floodplain dilatation in Bereg-plain



Boroszló-kert crosscut (fig. 2) was made before the second military-mapping, supposedly coeval with building of levees. In this case, the beginning of sediment filling of the deadbed is coeval with the forming of active-floodplain. Cutoff of the *Foltoskert-bend* (fig. 3) happened later. As “Tisza Atlasz, 1892” shows, at the end of the 19th century Tisza yet flo-

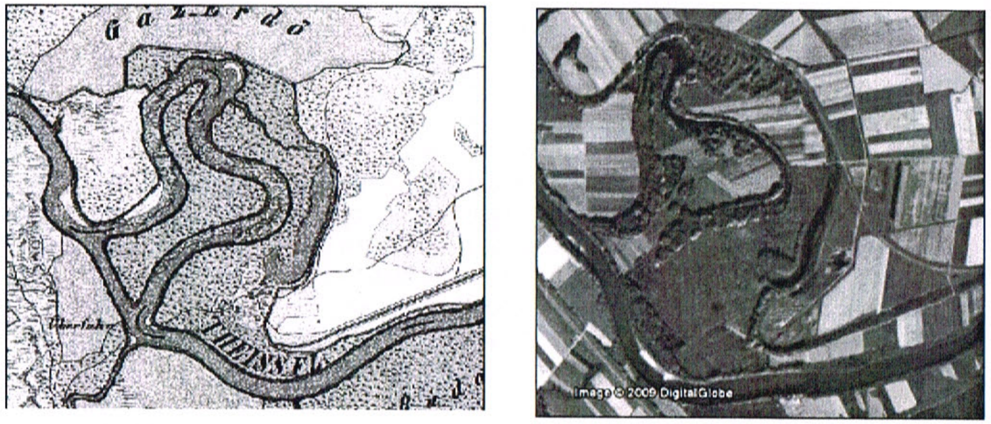


Fig. 2. The area of Boroszló-kert in the second military mapping of the Habsburg Empire and in the GoogleEarth map

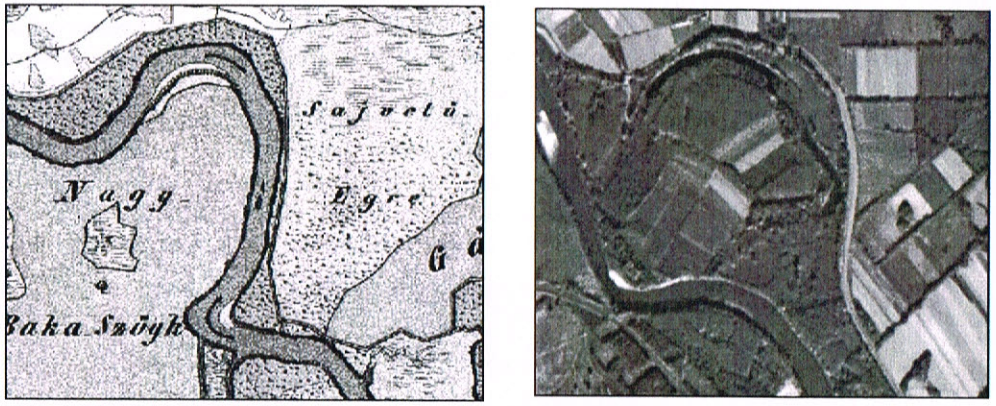


Fig. 3. The active floodplain of *Foltos-kert* in the second military mapping of the Habsburg Empire and in the GoogleEarth map

wed in its original channel (as it also can been seen in the second military-mapping); but as „A Tisza hajdan és most" (1934) („Tisza in olden times and now, 1934") shows, in the early 1930's Tisza already has been flowed in its presently known, artificial channel. Exact date of cutoff is unknown, but based on the experts of FETIKÖVIZIG (Environmental Protection and District Water Authority in the Upper-Tisza) (personal communication; dept. in Vásárosnamény) it must happened before 1914. Therefore, duration of sedimentation of the dead-bed (up to our sampling time) took over a time-period of about 100 years.

Experimental procedure

Because of the remarkable channel-shifts (0,7–1,3 km), it can been supposed that on a given area, e.g. on the late overbank sedimentation processes were ceased rapidly, which mechanisms now works in the vicinity of the new (active) channel, in a distance of about 1 km.

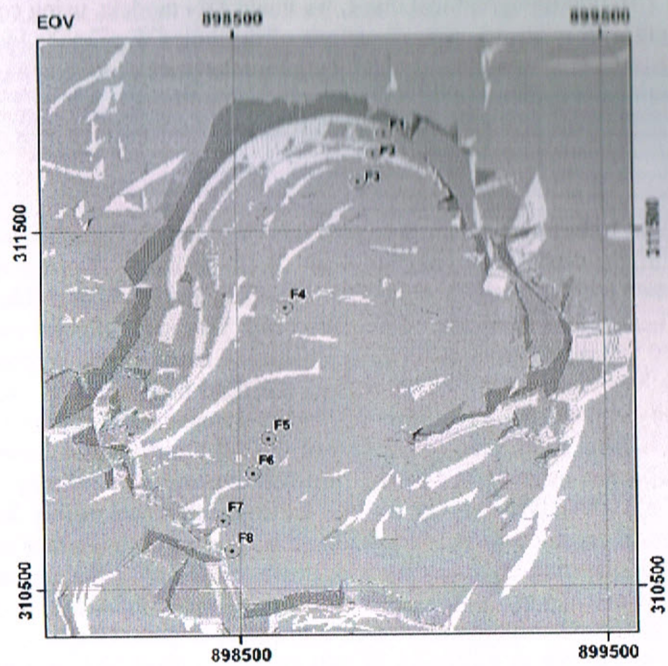


Fig. 4. DEM model of Foltos-kert with drillholes

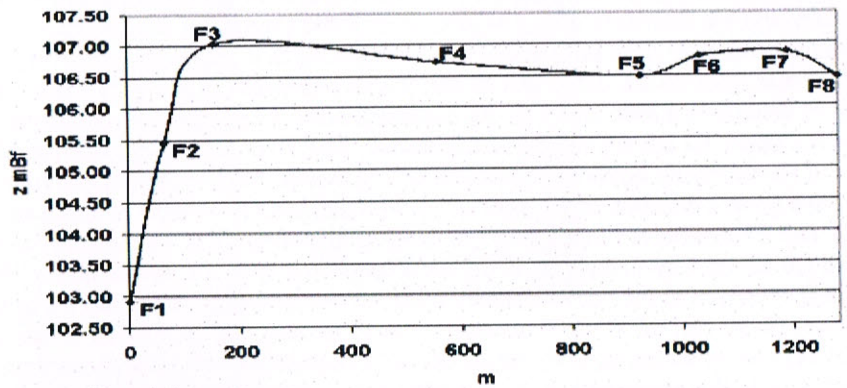


Fig. 5. Cross-section model of Foltos-kert with drillholes

During our studies in *Foltos-kert*, we took a section in a total length of 1250 m, with 8 drillholes (fig. 4, 5) ranging from the dead-bed in its sediment-upfilling stage up to the shifted active (new) channel. For comparsion we also made three drillholes in the dead-bed of *Boroszló-kert* and in its overbank. Depths of these drillholes are between 240 and 580 cm. Resulted drill cores were sampled by 10 cm scaling: mechanical composition was defined by Köhn-pipette decanting method and with sifting. Content of organic matter was defined by Tyurin-method.

Based on 1 : 10 000 topographical maps, we made TIN models, using contour-lines of the map. Sections with relative surface locations of drillholes were made by dumpy level. We fitted two databases to reveal morphological characteristics of the vicinity of drillholes and relative locations of drillholes (fig. 4).

Results

The F1-drillhole in Foltos-kert which is located in a dead-bed has got the lowest absolute-altitude (102,92 m), its depth is 310 cm (figs. 4 and 5). F2-drillhole is located on the late margin of the dead-bed with an absolute altitude of 105,45 m and depth of drillhole is 460 cm. F3-drillhole is located on a overbank of the dead-bend. This is the highest point of the study-area (mBf: 107,03 m, depth of drillhole is 580 cm). Granulometric graphs of grain-size distributions of these three drillholes (alongside the dead-bed) confirms cutoff (crosscutting) of the river-bend (fig. 6). Proportion of sand in the case of F1-drillhole in depths between 310 and 100 cm (with grain diameters of 0,32–0,1 mm) varies between 60–83%, which can be regarded as river-bed sand. Cumulative proportion of clay and silt (with grain-diameters of 0,02–0,001 mm>) from 100 cm in depth up to surface increases up to 64–82%. Content of organic matter in F1-drillhole decreasing from surface down to layer-boundary: in deeper, sanded layers it decreases down to 1/3 part of its original proportion. Similar changes in mechanical composition and organic matter content also can been seen in the case of F2- and F3-drillholes, but with a smoother degree. Graphs of grain-size distrubutions for F4-drillhole in a distance of 580 to the dead-bed, with a depth of 550 cm imply a new mechanism (fig. 6.). The upper layer (80 cm in thickness) consists of sandy-silt, which is underlain by a layer of finer-grained accumulation. Proportion of sand in this sediment accumulation decreases from 12–17% down to 3–6%, while cumulative proportion of clay and silt increases from 56–70% up to 83%. Content of organic matter shows similar tendencies also: from surface down to 80 cm in depth it decreases from 3,54% down to 1,9%, while from 80 cm down to 130 cm, it also increases up to 2,57%. Although the location of drilling is a little closer to the dead-bed, our data implies that sediments in the layer of the upper 80 cm are results of the shifted, new river bed; while fine-grained sediments of the uderlying layers in a thickness of 170 cm are from of the original (previous) channel in a greater distance. In the case of F4-drillhole, sedimentational mechanism of the F1-, F2- and F3-drillholes turns into its reverse, as coarse-grained sediments around the dead-bed are covered by fine-grained sediments originated from the shifted active-channel after cutoff. Towards to the active-channel, traces of this process became more frequently. Upper layer (0–90 cm) of F7-drillhole (mBf.:106,85 m) also can be referred to the shifted new (active) bed, in which layer the upper 20 cm is consists of 38% sand, according to its short distance to the active-bed (less than 100 m) (fig. 6). Under the layer-boundary increasing rate of organic matter content is similar to F4-drillhole. It is interesting that fine-grained layers referred to the older channel (between 90 and 260 cm) is equal to similar depths of F4-drillhole, and their mechanical compositions are almost the same also, but F7-drillcore samples are slightly more fine-grained. The distance between F4- and F7-drillholes is 600 m. On our lowest point we measured accumulation in a thickness of 100 cm. On higher areas accumulation was 80–90 cm, based on F4-, F5-, F6-, F7-drillhole data. Based on these data, rate of accumulation was 0,9–1 cm/year in Foltos-kert during the last one-hundred years, since the cutoff. For comparsion we also drill the crosscutted (which happened in 1860's) *Boroszló-kert* dead-bed (B4-drillhole), which is in its sedimentary-

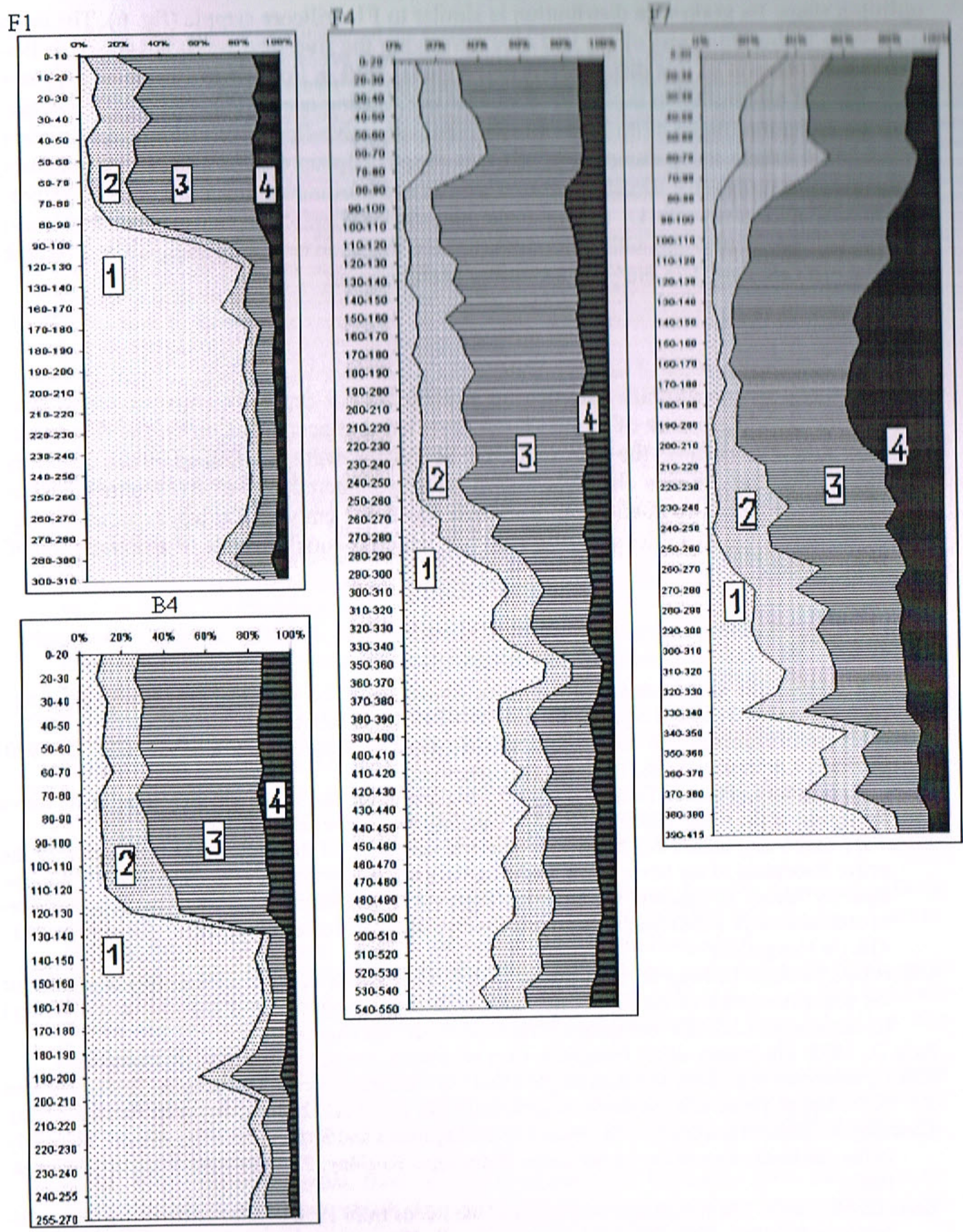


Fig. 6. The granulometric composition of the dead bed in Foltos-kert (F1, F2, F3) and Boroszló-kert (B4):
1 – sand, 2 – loess, 3 – silt, 4 – clay

upfilling stage. Its grain-size distribution is similar to F1-drillcore sample (fig. 6). The main difference is that thickness of silt and clay (overlying the river-bed sand) is 140 cm in Boroszló-kert. Reason of this difference is that channel-shift in Foltos-kert happened 50 years later. Rate of accumulation is similar: 0,93 cm/year. During our previous studies in Szilvás-szeg we compared mean altitudes of floodplains and active-floodplains alongside a section of 2,3 km in length, using dumpy level. Szilvás-szeg floodplain dilation is located 2 km from Boroszló-kert in upward direction. Based on our measurements mean altitudes of active-floodplains are higher with 1,1 m than mean altitudes of floodplains. We suppose that mean altitudes of floodplains and active-floodpalins were the same before building levees. Accept this, we can calculate 0,75 cm/year for rate of accumulation.

Summary

Granulometric graphs of grain-size distributions of shallow-depth drillcores from two dilations of the floodplain-area of Upper-Tisza revealed that accumulation on the floodplain changed after crosscuttings the river-beds. These changes were determined by the distances of the previous and the new channels. Based on approximated date of crosscuttings, accumulation rate of these two dilations in dead-beds was 0,9–1 cm/year. On higher areas we measured accumulation in a thickness of 80–90 cm, which is equal to a rate of accumulation of 0,8–0,9 cm/year.

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