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5

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THE OGINSKI CANAL IN BYELARUSSIAN POLESSYE: ITS HISTORY AND INFLUENCE ON THE ENVIRONMENT

The Oginski Canal (formerly called the Pinsk Canal), situated in the western part of Byelarus Polessye, is a hydrotechnical construction that – however not fully exploited - played significant economic role in the past. It is a part of the former Dnieper-Neman waterway, which connects drainage basins of the Neman and the Pripyat (Fig.1), and further – the drainage basins of the Baltic and the Black Seas through the Shchara and the Yaselda.

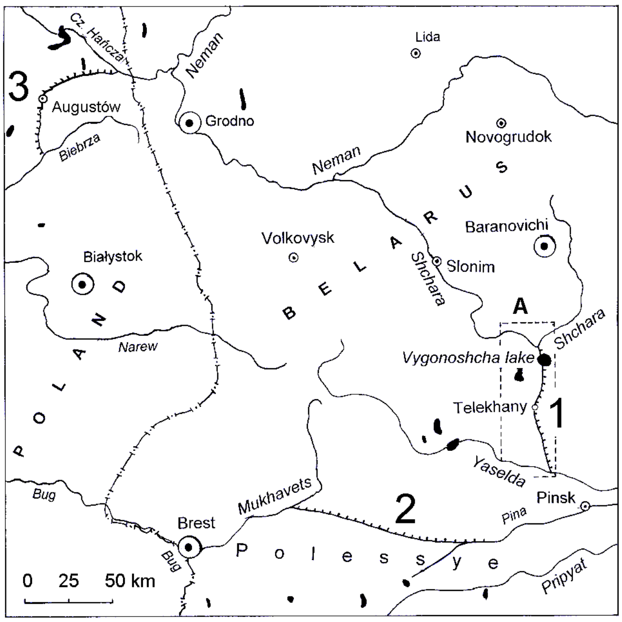

Fig. 1. Location of investigated area (A):
1 – Oginski Canal, 2 – Dnieper-Bug Canal, 3 – Augustów Canal

The idea to build the canal was put forward by Mateusz Butrymowicz – a landowner from Pinsk, but it was Michał Kazimierz Ogiński (1728-

1800) – a magnate and a landowner, the voivode of the Vilnius County, the Great Hetman of Lithuania, but also a poet and a composer, who finally accomplished the plan in 1765–1783. The task was quite easy for the sponsor as it ran through his property in Polesie.

The waterway from the Pripyat drainage basin to the Neman River enabled to transport wood and agricultural products to the Baltic harbours, activised economic development and stimulated land amelioration in the area of the canal influence. The decision to build the canal was approved by the Warsaw Parliament (Sejm Warszawski) in 1768 – that also presented Michał K. Ogiński with the town Loguishin (currently Pinsk Region) and Myshkovtse village including the neighbouring areas. The owner got the right to collect fees since transporting goods through the canal began. In 1775 the Parliament decided to start goods transport along the new waterway, however the canal had not been completed then. After the accession of the area to the Russian Empire, a topographic survey was made and the depth of the canal was measured to determine the transport capability. The canal was finally completed in 1799–1804 and started to be fully exploited as a navigable waterway. At the beginning – there were two bascule bridges over the canal: on the road from Pinsk to Slonim and close to Telekhany.

Photo. 1. Outlet of Ogiński canal from Vygonoshcha Lake (photo by. I. I. Pirozhnik)

Canals made transporting goods easier in those days but such constructions were also very expensive, workers had to use shovels and prospecting tools to drive piles by hand and to build special barriers and branches. Wooden sluice gates 40 m long and 5.25 m wide were opened and closed by hand operated hoists or horse-drawn machines. Along the canals, wooden platforms were built to let horses pull loaded barges and rafts. Despite the fact that wooden platforms were constructed on both sides of the canal the boats passing through were propelled with oars or wooden sticks. The canals made transporting goods easier, activised interregional economical cooperation and geographical division of labour.

The Oginski Canal had one sluice gate between the Shchara River and the Vygonoshcha Lake (which is still in operation) and nine gates – between the lake and the Yaselda River, a tributary of the Pina River. The Vygonoshcha Lake, situated on the Baltic-Black Sea watershed, is one of the bigger natural water reservoirs in Polessye (volume – 32.1 million m^3, the catchment area is equal to 87.1 km^2) and it is situated at the highest elevation within the canal waterway (151.8 m a.s.l.) maintaining proper water level there. The width of the canal was 12–18 m and the depth reached 1.0–1.5m. A 25 m wide belt of land on both sides of the canal, where the previously mentioned „hauling" platforms were built, also belonged to the canal. Dams were built there in places where water level was higher than the surrounding areas. The total width of the canal and the surrounding area belonging to it was approximately 80 m and it is still very well visible along the whole course of the canal (see Photo 2). In the first half of the 19th century mainly wood from Polessye forests, cereals and other agricultural products, as well as raw material for textile industry were transported through the canal. In some years the cargo capacity transported through the Oginski Canal was comparable to the transport through the Royal Canal (currently the Dnieper-Bug Canal – see Fig.1) – the one that connects the drainage basin of the Pripyat and the Bug rivers. The cargo transport through the Oginski Canal was the highest in 1847–1848.

In the second half of 19th century, after building the railway lines: (Brest – Baranovichi – Minsk – Moscow; Brest – Pinsk – Homel – Briansk; Vilnius – Lida – Baranovichi – Luninets – Sarny) the importance of the Oginski Canal as a transport route decreased. It should be mentioned, that the decreasing tendency in transport by water in the area, including the Oginski Canal, had started earlier, already in 1850's. The decrease of rivers importance as transport routes resulted from the general economic recession in western provinces, due to their peripheral and border location far from the main economic regions of the Russian Empire.

During the I World War (1914–1918) and later during the Russian-Polish war (1919–1920) – the area of the Oginski Canal was the place of heavy battles that ruined the hydrotechnical constructions. Ten German concrete fortifications (bunkers) that were built in 1915–1916 along the canal between Telekhany and Vygonoshcha village survived till today. The Russian fortifications from that times have been ruined and do not exist any longer. After general renovation in the interwar period in 1925–1926, navigation through the Oginski Canal was started and in 1928 it became fully navigable again. The Oginski Canal was open till 1941 and it was used mostly to transport wood, however, temporary, small ships and tourist ships were sailing there between Telekhany – Pinsk.

Photo 2. Oginski Canal in the Vygonoshcha village filled with water and covered with vegetation (photo by I. I. Pirozhnik)

Considering the current condition and its hydrotechnical features, the Oginski Canal can be divided into three parts (Fig. 2). In its first (western) part between the Shchara River and the Vygonoshcha lake (the distance of about 3.5 km, the difference of the water level between the Shchara and the lake is equal to 1.0 m), one of the wooden gates is preserved only. The second part – from the Vygonoshcha lake (the water level on its southern bank is at 151.8 m a.s.l.; Photo 1) up to Telekhany runs through a small lake

Vulka (the area 0.51 km^2, the length 1.0 km, maximum width 0.7 km). From the Vygonoshcha lake (the area 26.0 km^2, the length 7.0 km, maximum width 4.8 km, the length of coast line 21.0 km, maximum depth 2.3 m) to Vygonoshcha village (5.0 km) there is sufficient amount of water in the canal, but intensive growth of water plants covers its surface (photo 2). From the Vygonoshcha village to the above mentioned Vulka lake (9.0 km) the canal goes through pine forests with some birches, it is visibly shallowed, and in some parts it dries in summer time (Photo 3).

Photo 3. Shallowed canal in the north of Telekhany village (photo by I. I. Pirozhnik)

Below Telekhany, the third and the longest part of the Oginski Canal runs through the dried marshes and functions as an element of the amelioration system along the interval approximately 30 km long. It collects water from numerous draining canals (e.g., Telekhany and Khvoroshcha canals). Finally the Oginski Canal joins the Yaselda (1 km North-West from the Merchitsy village in the Pinsk district), at the water level of 136.0 m a.s.l. That means, that the water level difference between the Vygonoshcha lake and the Yaselda river is equal to 15.8 m; and the total full length of the discussed waterway (including the Vygonoshcha lake) reaches 54.0 km.

The whole Polessye area, including Byelorussian Polessye area was completely marshy. Therefore, building the above-mentioned hydrotechnical construction contributed to the drainage of the surrounding area. Like during intensive land improvement, at the beginning, it resulted in decrease of both general evaporation and ground water resources. However, at the further stage it resulted in the share of ground water in river charge, which caused that low summer water levels were less significant.

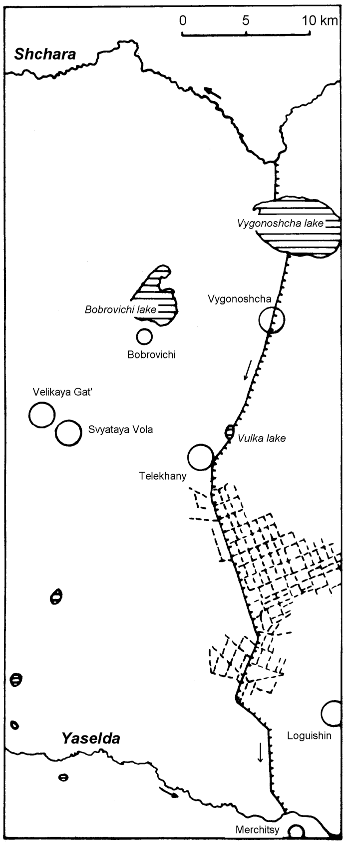

Fig. 2. Course of Oginski Canal

Therefore, the hydrological consequences of the canal construction were positive. However, there is also a negative phenomenon, caused by the lowering of ground water level. It is a multidirectional migration of moisture in the layer supplying water to plant roots. The thickness of the aeration layer reaches 3.0 m and a content of moisture in this layer is much lower then the optimum. Due to deep occurrence of ground waters, the surface layers of soil do not get water by seepage. Moisture concentrates in the lower part of aeration layer – so it cannot be used by plants and it supplies the ground waters.

The canal construction for transport purposes resulted in intensive forest hewing in the closest vicinity, which obviously caused significant changes in the local climate. Decrease of timber resources caused gradual loss of the canal importance. It also influenced changes in land usage.

There are some opinions that the Oginski Canal have saved the Vygonoshcha lake from probable vanishing. The canal runs through the lake charging it with the Shchara river water.

Hence, the closest vicinity as well as more distant areas (including the Bobrovichi lake) are quite marshy (despite land improvements partly carried out) and they remain so unique that a hydrological national natural reserve, covering the area of 430 km^2 was established around both lakes in 1968. Its main task is to protect a unique marshy complex situated on the watershed (the thickness of the peat layer reaches 4.7 m, - the average is equal to 2.1 m), and to regulate water charge to the Shchara, the Grivda, the Tsna and the others. 250 species have been recorded in the flora of the natural reserve, among them 12 rare ones in the regional scale: e.g., *Betula humilis,* *Cephaloziella* sp., *Malaxis* sp., *Najas* sp. There are also many species of water animals, especially birds, which live in low and high peat lands that have significant value for development of ecological tourism.

Original native Polessye culture combined with natural values of the Oginski Canal makes the area a unique historical-cultural and nature complex. It is currently an important factor of regional touristic development, but also implies a demand of proper protection and preservation of the rich cultural and environmental heritage of the region.

According to the Byelorussian internet information reconstruction of the Oginski Canal was started in 2006 (total costs are estimated at 20 mln. USD). It is planned to use it not only for touristic purposes (in the interwar period the canal was used as a canoe trail with picnic sites on the banks) but also to connect it to the renovated Augustów Canal in NE part of Poland. Both of them are important hydrotechnical monuments of the 18th and the 19th century and prove great economical investments of that time.

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CHANGES IN LANDSCAPE IN THE NEIGHBOURHOOD OF ŻABIE DOŁY IN THE SILESIAN UPLAND

In Poland in the last years the special interest of representatives of natural sciences – geologists, geographers, biologists – is taken in mining and post-mining landscapes. In the 1950s–1970s as, a rule values of such terrains were negated, defining them as „lunar landscapes" and numbering them among so-called areas of ecological threat. But more detailed research proved that the post-mining areas are often characterised by high natural values, classifying them to protect by means of different forms of legal protection. Presently these areas are the subject of numerous studies, often of interdisciplinary character. In the Silesian Upland, one of the most known and most often cited examples of post-mining landscape is the complex of water reservoirs called Żabie Doły (Frogs' pits), located at the borderland of Bytom and Chorzów. In the given study the general characteristics of stages of landscape shaping of Żabie Doły are presented, which was based on the analysis of cartographical materials of different age (1825, 1881, 1933, 1960, 1995).

The area investigated is located in the catchment of the Upper Bytomka river, in the river basin of its two left tributaries. The landscape, which has been shaped here during the last 200 years, is strictly connected to the exploitation of different natural resources – black coal, silver, zinc and lead ores, limestones and dolomites, fire-clays, silts and clays.

In the beginning of the 19th century the area described was very weakly managed (Messtischblatter, 1825). Apart from the eastern peripheries of Bytom, only one locality– Łagiewniki and one compact dense forest complex of about 50 ha in area, surrounded all round by plough lands, - was here located. Across this area some old roads run, and at their crossings in the above-mentioned forest a small settlement existed. In the neighbourhood there were not any water reservoirs as well as any essential traces of mining activity, although in the 16-17th centuries the lead-glance (galena) was here exploited on a small scale (Molenda, 1972). In 1791 2 km to the south of the area investigated "Król" mine was established, whereas in 1822 to the south of Łagiewniki „Łagiewniki" mine has originated. But the activity of these mines did not have any influence on the landscape of Żabie

Doły, therefore at the beginning of the 19th century it had a typical agricultural character.

As results from the Topographische Karte from 1881, at the end of the 19th century the landscape underwent noticeable anthropogenic transformation. There is already no trace of forest of 50-hectares in area. To the south at elevations of watershed numerous excavations appear, some of which are rather widespread. They occur in the zone of outcrops of ore-bearing dolomites, almost exactly in the place of fossil karst cones filled with regoliths on a form of clays and fire-clays (Lewandowski, Ciesielczuk, 1997). In these excavations fire-clays as well as ores of zinc, lead and dolomites were exploited. In the north-western part of this area in the neighbourhood of newly originated settlement Neu Beuthen the relief was diversified by innumerable amount of small tips and mounds and some large clay-pits working for the needs of as much as 5 brickworks. To the same end the clay-pit in the northern part of the area investigated was formed in the place of the Miocene clays occurrence (Doktorowicz-Hrebnicki, 1954). The mining of black coal developed – the north-western part of this area was within the range of activity of „Rozbark" and „Łagiewniki" mines, whereas the south-eastern part – in „Król" mine (later "Barbara-Chorzów"). These mines were underground, because in the area investigated the roof of the Carboniferous deposits lies at the depth of at the very least 100 m, what made the opencast mining impossible. About 1860 the mine of zinc and lead ores "Biały Szarlej" (later „Orzeł Biały") started its activity. The development of industry intensified the boom for mineral resources (dolomites, limestones), clayey and gravel aggregates, therefore among anthropogenic landforms the largest areas were occupied by excavations connected with opencast mining (Fig. 1). In the landscape two railway lines, cutting the area from the SE towards NW, are also distinguished. Almost unnoticeable role is played by small water reservoirs (of areas not larger than 0,15 ha) – in the whole area there are about 10 of them. Therefore at the end of the 19th century in the area investigated still agricultural landscape (of plough lands) predominated, although in the western part of this area and at its borders, especially southern, rather large accumulation of mining anthropogenic landforms occurred.

In the last half of the century the following changes in the landscape happened, which are distinctly visible on the topographic map from 1933 year (Fig. 2). They resulted from already intensive mining of ores and hard coal, in the majority carried out by means of method of roof fall. At fields in the region of shallow exploitation of ores (on average to the depth of about 60 m) discontinuous deformations in the form of collapse cones, scarps and

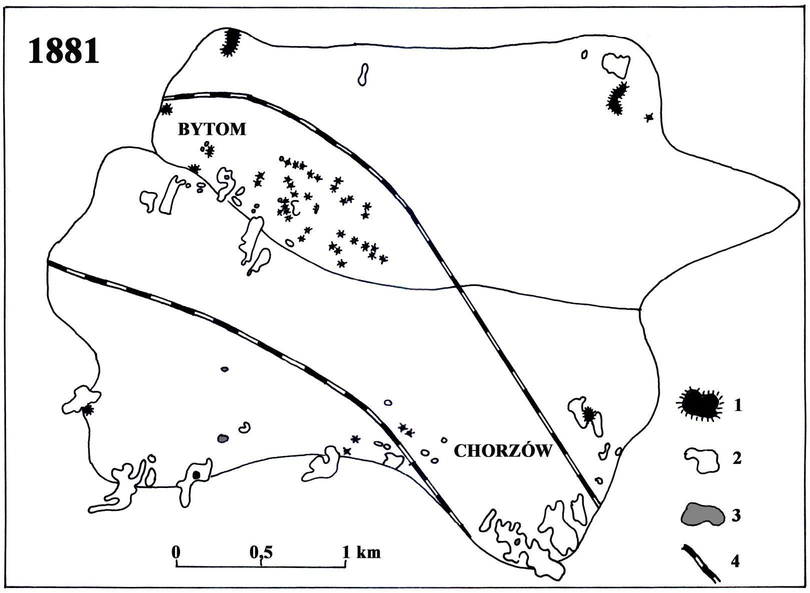

Fig. 1. Distribution of selected anthropogenic landforms in 1881 year (on the base of Topographische Karte 1:25 000, 1881)
1 – dumping grounds, 2 – excavations, 3 – anthropogenic water reservoirs, 4 – railway embankments

fissures have originated. But these landforms were small and referred to sizes of underground workings, the majority of them was levelled during land cultivation and silted up in result of wash. Small water reservoirs periodically functioned in them, whereas in the western part of the area more than 30 water reservoirs appeared – the half of them is made by large and very large reservoirs. Probably more or less this time the name Żabie Doły was started to use to define waterlogged terrains with large amount of amphibians. Water reservoirs in valley bottoms had the character of ponds or floodings connected with terrain subsiding, caused by exploitation of black coal. Four water reservoirs in the southern part of the area most likely have also originated in subsidence depressions, whereas the largest pond was established to store water for the needs of mine of zinc and lead ores. Water taken from it served for flotation of ores and together with waste rock it was flowed to settlement tanks. Large dumping grounds have mainly originated in the north-eastern part of the area. Apart from old anthropogenic landforms new forms have appeared, but the change in function of some landforms is also observed, e.g. in the place of some excavations built-up areas, dumping grounds or water reservoirs have originated.

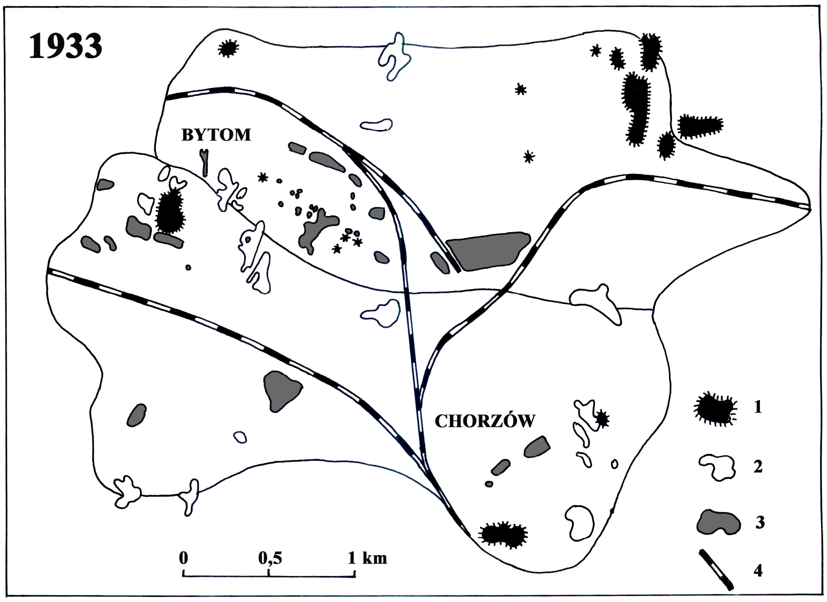

Fig. 2. Distribution of selected anthropogenic landforms in 1933 year (on the base of Topographic map 1:25 000 WIG, 1933)
1 – dumping grounds, 2 – excavations, 3 – anthropogenic water reservoirs, 4 – railway embankments

New railway line running from S towards NE and new branch of central railway line have also been built. The landscape of area investigated in the early part of the 20th century can be determined as mining-agricultural with distinct contribution of water reservoirs, concentrated in the western and central part of the area.

In the latter part of the 20th century the neighbourhood of Żabie Doły is already very strongly transformed owing to economical human activity (Mapa topograficzna, 1960). It is the period of the most intensive mining of both ores and black coal. As the result of coal mining significant terrain surface subsiding happens, therefore in the landscape further water reservoirs in subsidence depressions appear, including also the eastern part of this area, which hitherto were devoid of them. One of the characteristic features of new reservoirs is the reference of shape to railway embankments, which through their permanent heaping increased in their height and became the distinct accent in the landscape. Ponds of Żabie Doły are visible on the topographic map published in 1943 year, so their history numbers almost 70 years. For the analysed time interval the „concentration” of anthropogenic landforms is also characteristic – in the place of former landforms of small and medium sizes large and very large landforms appeared, making landscape dominants, because dumping grounds and settlement tanks reach large sizes and occupy large area (Fig. 3). About 6 million tones of wastes were accumulated on them, whereas numerous old excavations in the south-eastern part of this area were incepted by industrial and housing buildings.

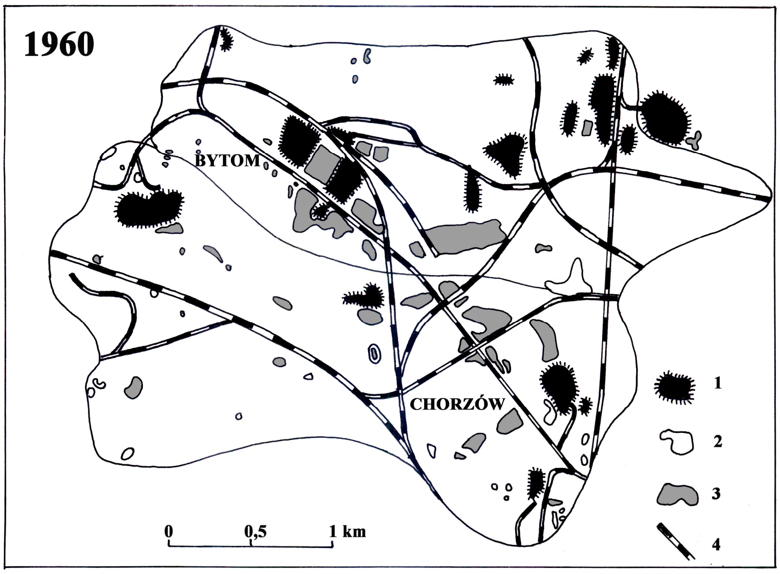

Fig. 3. Distribution of selected anthropogenic landforms in 1960 year (on the base of Topographic map of U.S.I.R. 1:25 000, 1960)
1 – dumping grounds, 2 – excavations, 3 – anthropogenic water reservoirs, 4 – railway embankments

At the end of the 20th century in the area investigated the mining activity of „Orzeł Biały” Mining & Metallurgical Works as well as all mines of black coal was stopped. Thus, the process of mining subsiding was finished, during the last 100–130 years it has caused the lowering in terrain surface of on average 8–10 m. But the hazard of discontinuous deformations still exists, but in difference to continuous deformations it can occur unexpectedly even after the lapse of tens years lat since the mining finishing. In the present-day landscape of Żabie Doły large dumping grounds, large water reservoirs and high railway embankments predominate (Fig. 4). They are the evidence of economic past of this area – during two centuries the typical agricultural landscape was transformed into typical mining landscape.

At the beginning of the 1980s it appeared that more than 120 species of birds, belonging to the water-mud group, found in Żabie Doły good breeding conditions, mainly in respect of existing structure of inshore vegetation – reed, calamus and bulrush.

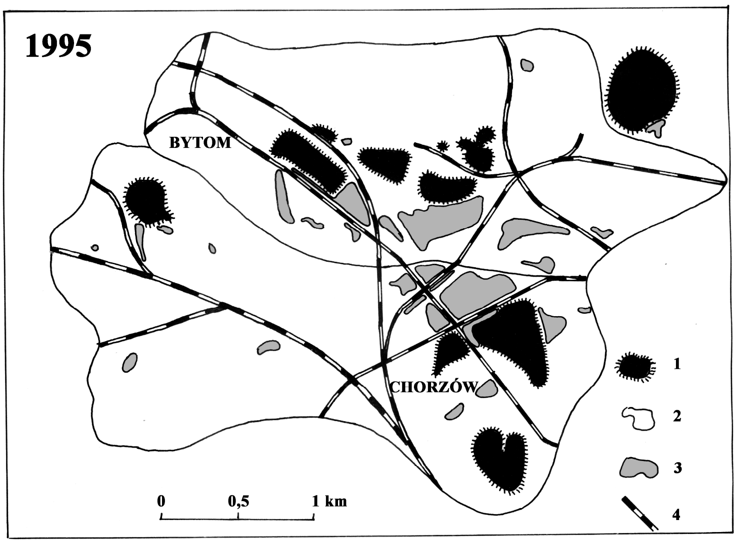

Fig. 4. Distribution of selected anthropogenic landforms in 1995 year (on the base of Topographic map 1:10 000, 1995)
1 – dumping grounds, 2 – excavations, 3 – anthropogenic water reservoirs, 4 – railway embankments

Here among others *Botaurus stellaris*, which was located in the Polish Red Data Book of Animals and threatened by extinction and *Gallinago gallinago*, *Philomachus pugnax*, *Nycticorax nycticorax*, *Ixobrychus minutus* and other species were stated (Piontek, 2001). Among inshore water-marshy vegetation forest-bushy communities of alder-riparian-dry-ground forest character are located. In tree stand light-seed species predominate, they can easily spread, occupying even such disadvantageous places as dumping grounds and settlement tanks. It was determined, that in the area investigated in different biotopes 251 species of vascular flora occur, representing different taxonomic groups. In 1997 the natural-landscape complex "Żabie Doły" of 226,24 ha in area was here established, but ponds occupy about 35 ha. Coming of this terrain within a legal protection finishes the stage of anthropogenic landscape transformation, but most of all it creates conditions for the further spontaneous regeneration of the natural environment.

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NATURAL CONDITIONS OF THE AREA NATURA 2000 „DOLINA GÓRNEJ WISŁY" (THE UPPER VISTULA VALLEY, SOUTHERN POLAND)

Introduction

The Directive on the Conservation of Wild Birds 79/409/EWG obligates countries of the European Union to identify and protect important places for wildly living birds. Together with the habitat directive 92/43/EWG considering the conservation of natural habitats of wild fauna and flora, it makes the base for all- European net of protected areas Natura 2000. In the majority of the Union Countries the terrains of Natura 2000 in total occupy 15–20% of area. In these terrains the protection of unique natural values should be integrated with the economical development. But the law forbids in these terrains to realise large investments of negative influence on the threatened species and habitats.

The area Natura 2000 „Dolina Górnej Wisły" (PLB240001) was established by the terms of instructions of Minister of the Environment from the 21st July of 2004 r., concerning areas of special bird protection Natura 2000 (Dz. U. No 229, position 2313) and on the base of article 28 law. 1 of the Law from 16 April of 2004 on nature protection (Dz. U. Nr 92, poz. 880).

„Dolina Górnej Wisły" occupies the area of 24767,5 ha located in the Silesian Voivodeship in the terrain of municipalities: Jasienica (4172,1 ha), Strumień (4061,0 ha), Skoczów (3960,6 ha), Goczałkowice-Zdrój (3954,3 ha), Czechowice-Dziedzice (3156,9 ha), Chybie (3099,9 ha), Dębowiec (1435,9 ha), Hażlach (557,3 ha) and Pszczyna (369,5 ha), situated in three districts of Cieszyn, Bielsko and Pszczyna (Fig. 1). The State Forests in this area are administrated by two forest inspectorates: Ustroń and Bielsko.

Subjects of protection are there most of all as follows:

- 267 bird species (mentioned in the list of the I Bird Directive widened of the part of species protected in Poland),
- their habitats.

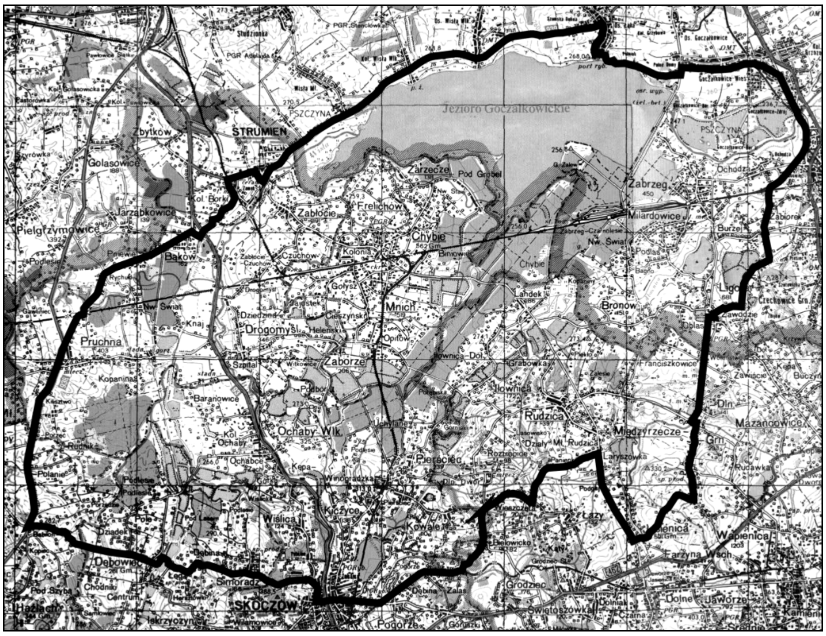

Fig. 1. Location of the area Natura 2000 „Dolina Górnej Wisły”. The boundary of the area was marked by thicker line

Location and physico-geographical description of the area Natura 2000

The area of Natura 2000 „Dolina Górnej Wisły” lies within two physicogeographical sub-provinces distinguished by J. Kondracki (1994). It is the northern part of the Northern Sub-Carpathians and the southern part of the External Western Carpathians. To the first sub-province belongs the Plain of Pszczyna, valley of the Upper Vistula river, Wilamowice Foothills, and also part of macroregion of Ostrava Basin, to the second one respectively - mesoregion of the Silesian Foothills and small fragment of mesoregion of the Silesian Beskidy Mts.

In terrain morphology, to a large degree conditioned by the occurrence of fold structures to the south and disjunctive tectonics to the north (Bukowy, 1974; Książkiewicz, 1972; Nowak, 1973), it is possible to divide zonal (parallel) belts (Fig. 2):

- belt of upland-hilly relief of the Silesian Foothills,
- lower step – the Sub-Carpathians High Plains,
- belt of monotonous relief of the Vistula valley bottom,
- belt of slightly wavy loess relief of the Pszczyna High Plain and Rybnik Plateau.

In Vistula river and its tributaries four river terraces occur. The Quaternary deposits cover the terrain in a form of practically dense mantle of thickness from some to more than 60 metres (Lewandowski, 2003).

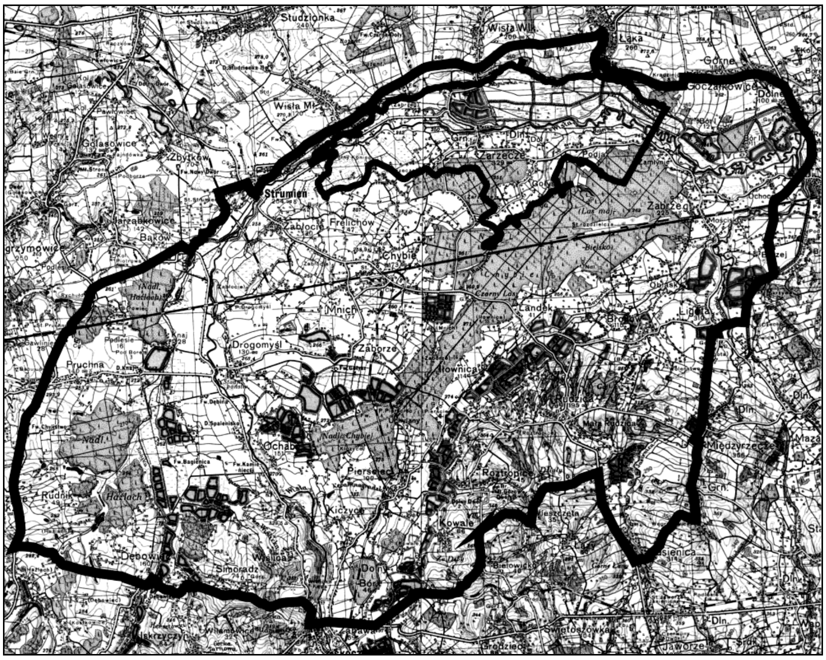

Fig. 2. Terrain management at the beginning of the 1930s in the area of present-day protection of Natura 2000 „Dolina Górnej Wisły". The boundary of the area was marked by means of thicker external line, the range of Goczałkowice water reservoir was marked by internal thicker line

In the area of Natura 2000 „Dolina Górnej Wisły" the largest areas are occupied by brown soils and soils lessivès originated at the substratum built of loess and loess-like deposits (often clayey). Brown soils formed from loess in general are very good and good wheat soils. At the bottoms of larger river valleys alluvial soils characterised by very varied properties occur. With waterlogged terrains the occurrence of small patches of black earth soils is connected. In terrains lying to the south of Goczałkowice water reservoir podzolic soils occur, they were formed from sandy-gravely river deposits building overflood levels within the Pleistocene fan of the Vistula. In respect of poor chemical composition and large permeability the genetic horizons are of large thickness but often weakly marked (Lazar, 1962).

In the neighbourhood of Skoczów at outcrops of Cieszyn limestones patches of rendzinas occur. They are accompanied by pararendzinas originated from marly shales, marls and flysch sandstones. From loess-like deposits underlain by marly rock mantle very good brown soils originated (Komornicki, 1983).

The area of „Dolina Górnej Wisły" climatologically belongs to the transition zone between the influences of continental and oceanic climates. Macroclimate of this terrain shaping is betokened by parallel (zonal) arrangement of physico-geographical units – arc of the Carpathians Mts. and Racibórz-Oświęcim Basin, lying at the extension of the Moravian Gap, steering the inflow of air masses from the south-west (Leśniak, Obrębska-Starklowa, 1983). In the neighbourhood of Goczałkowice water reservoir it is possible to notice the slight increase in wind velocity at the scale of year.

Mean annual temperature ranges from 7,5 to 8,5ºC. The warming influence of Goczałkowice water reservoir, which causes the increase in mean minimal temperature in its neighbourhood, was stated (Atlas klimatu województwa śląskiego).

Goczałkowice water reservoir and numerous neighbouring ponds increase the air humidity, influence on the increase in cloudiness and decrease in 24 hours' air thermal amplitudes. Mean monthly relative humidity of air exceeds there 70–82% in year (Szczęsna-Kozłowska, Krawczyk, Błażejczyk, 1983). With topoclimatic conditions, occurring in the widespread Vistula valley air temperatures inversions and the occurrence of freezes and radiation fogs are often connected. Mean annual precipitation sums amount to 750-900 mm. The vegetation period lasts 200–215 days per year (Hess, Niedźwiedź, Obrębska-Starklowa, 1979).

The prevailing part of the area Natura 2000 „Dolina Górnej Wisły" belongs to the river system of the Vistula river, called in this section Small Vistula. The largest tributary of the Vistula is there right-side Iłownica, collecting waters of Wapienica and Jasienica as well as left-side Knajka. The river net, typical for the Beskidy Mts. Foreland, is characterised by approximate meridional arrangement of beds of rivers flowing from the south (the exception is the section flowing towards east Vistula).

Varied alimentation by underground waters resulting from: different amounts of atmospheric precipitation, differences in shaping and exposure of terrain, varied possibilities of water retention in the catchment, lasting since the Middle Ages transformations of water relations (Fig.1, 2 and 3) is the cause of lability of water stages and discharges in the Vistula and its tributaries. Water stages fluctuate within the range from a dozen or so up to tens of centimetres, and the discharges amount on an average to from some decimal ^{3}/s in small streams to some m^3/s in the case of the Vistula flowing from the Goczałkowice water reservoir.

Fig. 3. Terrain management in the 1730s. in the area of present-day protection of Natura 2000 „Dolina Górnej Wisły” (after the Map of Księstwo Cieszyńskie from 1736 year by I. W. Wieland). The approximate boundary of area was marked by means of thicker external line, the range of Goczałkowice water reservoir by internal thicker line.

The surface hydrographic net of the area is completed with numerous anthropogenic water reservoirs. The largest is the Goczałkowice water reservoir, which fulfils function of water supply and flood control, and the largest complexes of farming ponds – many a time connected with numerous ditches and canals – occur in the south of Chybie town and in the valley of rivers Iłownica and Knajka (Fig. 1). For example – only in the catchment of the Knajka 96 ponds of total area of about 4,5 km^2 occur, it makes about 5,5 % of its catchment area. The total area of ponds situated in the catchment of the Vistula above the dam of water reservoir amounts to about 900 ha.

Goczałkowice water reservoir was built in the years 1950–1955 in result of damming up of the Vistula river by means of earth dam (Siudy, Bilnik, Świercz, Szlęk, 2005). This reservoir is the largest object of such type in southern Poland. The maximum area of the reservoir amounts to 32 km^2, and the capacity - 165,6 hm^3. The flood reserve in the summer period amounts to 45 million m^3, and in the remaining months - 38 million m^3. Many years’ fluctuations of water table level in the reservoir evaluate from

0,5 up to 3,5 meters (Szostak, Zimoch, 2005). It is a shallow reservoir, exchanging the water 2–3 times per year (Kasza, 2005). Mean annual water temperature amounts to about 10,2 °C.

This water reservoir is excessively polluted with biogenic, mineral and bacteriological substances, what is an effect of many years lasting disordered sewage economy in the catchment of the Upper Vistula, as well as agricultural way of land use of significant parts of this area (Szostak, Zimoch, 2005). Therefore it makes water ecosystem rich in biogenic substances, having the influence on the intensive development of phytoplankton in water.

Goczałkowice water reservoir possesses unusually rich flora and fauna. During many years lasting hydrobotanical researches more than 520 species of plankton and periphyt plants as well as 40 species of submerged, emerged or freely flowing plants were here stated. Faunistic researches proved the occurrence of more than 600 animal species, including 350 invertebrates and 250 species of vertebrates. Goczałkowice water reservoir is one of the most important refuges of breeding and migrating birds in southern Poland. The most important places, where birds start hatching, are its western and southern parts. There are widespread, water-logged and humid meadows, brushwood, widespread rushes and water canals, creating numerous habitats (Betleja, 2005).

Birds of the area Natura 2000 "Dolina Górnej Wisły"

On the base of published results of observations (the oldest origin from the 1950s.) as well as unpublished data (stored since the beginning of the 1980s.) it was ascertained, that the total number of bird species in the area of refuge Natura 2000 „Dolina Górnej Wisły" amounts to 270, including 162 breeding species, what makes relatively 61,9% of domestic avifauna and 71,4% of domestic breeding avifauna (Tomiałojć, Stawarczyk, 2003).

Among them one should especially emphasize the presence of species mentioned in the appendix of the I Bird Directive, and they are as follows: *Gavia stellata, Gavia arctica, Gavia immer, Podiceps auritus, Phalacrocorax pygmeus, Botaurus stellaris, Ixobrychus minutus, Nycticorax nycticorax, Ardeola ralloides, Egretta garzetta, Egretta alba, Ardea cinerea, Ardea purpurea, Ciconia nigra, Ciconia ciconia, Plegadis falcinellus, Platalea leucorodia, Cygnus columbianus, Cygnus cygnus, Branta leucopsis, Branta ruficollis, Tadorna ferruginea, Aythya nyroca, Mergus albellus, Pernis apivorus, Milvus migrans, Milvus milvus,* *Haliaeetus albicilla, Circus aeruginosus, Circus cyaneus, Circus pygargus, Aquila pomarina, Aquila chrysaetos, Aquila pennata, Pandion haliaetus, Falco vespertinus, Falco columbarius, Falco subbuteo, Falco eleonorae, Falco cherrug, Falco peregrinus, Porzana porzana, Porzana parva, Crex crex, Grus grus, Himantopus himantopus, Recurvirostra avosetta, Pluvialis apricaria, Philomachus pugnax, Gallinago media, Limosa lapponica, Tringa glareola, Xenus cinereus, Phalaropus lobatus, Larus melanocephalus, Larus minutus, Sterna caspia, Sterna hirundo, Sterna paradisaea, Sterna albifrons, Chlidonias hybrida, Chlidonias niger, Chlidonias leucopterus, Asio flammeus, Caprimulgus europaeus, Alcedo atthis, Picus canus, Dryocopus martius, Dendrocopos syriacus, Dendrocopos medius, Lullula arborea, Anthus campestris, Luscinia svecica, Acrocephalus paludicola, Sylvia nisoria, Ficedula parva, Ficedula albicollis, Lanius collurio, Emberiza hortulana.*

The degree of threat of particular breeding species was determined in the area discussed on the base of criteria of the Polish Red Data Book of Animals and it presents as follows: Endangered – *Aythya nyroca,* Vulnerable – *Ixobrychus minutus, Charadrius hiaticula,* Near Threathened – *Porzana parva, Chlidonias leucopterus, Luscinia svecic,* Least Concern - *Botaurus stellaris, Nycticorax nycticorax, Ardea purpurea, Haliaeetus albicilla, Chlidonias hybrida, Panurus biarmicus.*

Habitats

The valley of the Upper Vistula is the refuge for habitats regarded in the instructions of the Ministry of the Environment from 16 May of 2005 year, concerning types of natural habitats. plant and animal species, requiring protection in the form of areas Natura 2000 designation (Dz. U. No 94, position 795). Z. Wilczek (Betleja et al., 2006) distinguished there the following habitats of the European importance:

- 3130 – shores or dried bottoms of water reservoirs with communities with Littorelletea, *Isoëto-Nanojuncetea*,
- 6510 – lowland and mountainous raw extensively used meadows (*Arrhenatherion elatioris*),
- 7110 – highmoors with peat-forming vegetation (living),
- 7140 – transitional moors and swamps (usually with *Scheuchzerio-Caricetea nigrae*),
- 7150 – depressions at peaty substratum with vegetation from the connection *Rhynchosporion*,

- 7220 – limestone springs with communities of *Cratoneurion*,
- 9130 – fertile beech woods (*Dentario glandulosae-Fagenion*),
- 9170 – sub-continental dry-ground forest (*Tilio-Carpinetum*)
- 91D0 – coniferous forests and swampy forests (*Vaccinio uliginosi-Pinetum*),
- 91E0 – willow, poplar, alder and ash riverside forests (*Populetum albae, Alnenion glutinoso-incanae*).

As Z. Wilczek gives (Betleja et al., 2006) in the area of „Dolina Górnej Wisły" about 800 species of vascular plants were stated, representing the following habitat groups: nitrophilous habitats, mesophilous leafy forests, meadows, periodically flooded meadows, xerophylous grass and brushwood, moors of different type, rushes, coniferous forests, grasses on sands and poor plough lands, forests and swampy brushwood, terophytes of periodically flooded places, heathlands and poor white bent grasses, water. In respect of terrain character and the way of its management the rushes species, e.g.: *Glyceria maxima, Phragmites australis, Typha latifolia* and plants of nitrophilous habitats, for example *Aegopodium podagraria, Cirsium arvense, Plantago major, Tanacetum vulgare* and *Urtica dioica* are represented here in the strongest way. The floristic curiosity of "Dolina Górnej Wisły" is *Marsilea quadrifolia* and *Lindernia dubia*. *Marsilea quadrifolia* is probably already extinct taxon in the free nature, but its reintroduction was attempted to make. *Lindernia dubia* is new species in flora of Poland, discovered on 19.06.2003 (Drobnik, Buchalik, 2004).

In the area of refuge „Dolina Górnej Wisły" 50 plant species undergoing legal protection occur.

STRICTLY PROTECTED SPECIES

Ledum palustre, *Cephalanthera rubra*, *Veratrum lobelianum*, *Hacquetia epipactis*, *Pedicularis palustris*, *Neottia nidus*, *Nymphaea alba* L., *Nymphoides peltata*, *Trapa natans, Epipactis helleborine*, *Dactylorhiza maculata*, *Dactylorhiza*, *Linderia procumbens*, *Marsilea*, *Elatine hydropiper*, *Elatine hexandra*, *Elatine triandra*, *Arum alpinum*, *Matteucia struthiopteris*, *Utricularia minor*, *Utricularia vulgaris*, *Aruncus sylvestris*, *Blechnum spicant*, *Hepatica nobilis*, *Drosera rotundifolia*, *Salvinia natans*, *Equisetum maximum*, *Orchis pallen*, *Galanthus*, *Carex limosa*, *Daphne mezereum*, *Batrachium aquatile*, *Batrachium circinatum*, *Lycopodiella inundata*, *Lycopodium clavatum, Lycopodium annotinum*.

PARTLY PROTECTED SPECIES

Vinca minor, Hedera helix, Menyanthes trifoliata, Allium ursinum, Nupha, Viburnum opulus, Convallaria, Asarum europaeum, Frangula alnus, Primula veris, Primula elatior, Galium odoratum, Ononis arvensis.

The most valuable areas in respect of occurrence of protected plant species are already existed nature reserves „Skarpa Wiślicka" and „Rotuz". Numerously protected species in proposed nature reserves „Grabówka" and „Pióropusznik-Ochaby" also occur.

THREATENED AND RARE SPECIES

In the terrain of bird refuge „Dolina Górnej Wisły" the following threatened and rare species, included in the Polish Red Book of Plants (Kaźmierczakowa, Zarzycki, 2001) were stated: *Nymphoides peltata, Trapa natans, Marsilea quadrifolia, Elatine hydropiper, Elatine hexandra, Elatine triandra, Lindernia procumbens, Schoenoplectus, Orchis pallens, Carex strigosa, Carex limosa.*

Summary

The area Natura 2000 „Dolina Górnej Wisły" was brought into being in the terrain, which was relatively intensively economically used since a long time (Fig.1, 2 and 3). But in result of both the location in the foreland of mountains and in the neighbourhood of Moravian Gap, as well as predispositions of local hydrographical system this terrain for centuries gives the rich environmental offer not only for humans, but also for plants and animals, mostly birds (to the largest degree water ones).

The range of refuge „Dolina Górnej Wisły" exceeds the State boundaries. In the case of some bird species this area is one of the most important breeding sites in the Central Europe. „Dolina Górnej Wisły" simply makes the key element of birds refuge of European range, identified in Oświęcim Basin. Therefore, this whole area is very important for the preservation of species diversity of avifauna not only in Poland, but also in Central Europe.

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SHORE BUILDING OF WATER RESERVOIRS WITHIN THE AREA OF SILESIAN UPLAND

The appearance of artificial water reservoirs within the area of Silesian Upland and its margines contributed to the development of new morphogenic processes which are typical of shores. These processes result in shore transformations leading to the creation of shore forms. They are not only depositional and erosional forms, but neutral shores can also be found. Shore processes taking place within shores do not make any harm to human life and management but their course is not controlled and it is fully subjected to natural development which is initiated only by anthropopression (Michalewicz et al., 1995; Kozyreva et al., 2004).

Abrasional forms are regarded as the most harmful ones because they are results of mechanical degradation of a shore identified with various rates of its recession. Active and dead cliffs, terraces, microbays, cause that a shore is not stable and useless for its management. The recession rate of rock walls within water reservoirs in Silesian Upland reaches annually from some to several centimeters and it is not regarded as dynamic, but it involves taking protective actions in some parts of shores. Depositional forms, such as sand-bars, spits and necks of land are not viewed in terms of infrastructural damages but they demand to undertake specific activities connected with shore building. It is because depositional processes causing them are the reasons of difficulties in the functioning of harbour pools and bays which result in the siltation of usable zones in the reservoirs. From the economical point of view, morphologically neutral parts of shores are the most useful ones as they are mechanically, biologically and even chemically stable (Molenda, 2002).

In case where shore transformation resulting from the development of natural processes shaping a shore starts doing damages or endangers the infrastructure, a man takes up protective actions. These actions include creating protective structures such as embankments, shore walls, etc. Building of the shores of anthropogenic water reservoirs is completed by the components which do not have protective functions (antierosional or antiabrasional) but they are mainly associated with such functions as: transport, tourism, recreation, sport, water supplies for agricultural, industrial and municipal purposes, farming uses of the objects.

Spontaneously progressing shore consolidation through the process of natural vegetation succession is also worth mentioning (Rahmonov et al., 2004a). The processes of shore colonization by vegetation are more and more frequently regarded as an alternative to expensive reclamation processes (Rahmonov et al., 2004b). In this way nataurally valuable zones of above-water surfaces are formed. Moreover, they often become mainstays for nature (ecological lands, natural-landscape complexes).

All components of hydrotechnical building of water reservoir shores together with parts of shore consolidation undergo physical, chemical and biological transformations (Rzętała, 2001). The intensity of these transformations is versatile and it depends on many factors. It also decides on the usage time of these devices and the need for their renovation and technical modifications. However, it seems that the greatest dangers for shore infrastructure are connected with mechanical influence of wave motion and corrosive processes of concrete and metal components – the former is of common character while the latter is limited by the scope as it can only be found in polluted waters.

Apart from classical type of shore building, waste rocks are more and more often used for their consolidation. It is especially connected to the reservoirs which have been created in subsidence basins. The consolidation of shores with waste rocks, from the point of view of their protection against abrasional processes, fulfills its functions. However, using waste rocks in shore consolidation has many negative effects in natural environment. They result from the changes of shoreline character. The shores of hollow reservoirs are featured by mild inclination similar to the natural one, what enables the development of a wide vegetation strip. Intensive vegetation development is also connected with a good type of a substratum, suitable size of land grains and the abundance of nutrients. The substratum of hollow reservoirs constitutes flooded soils of a subsidence basin. When the deposition of water rocks starts, the changes of profile and shore material take place (Fig. 1). In case of rocky, steep shores shore vegetation cannot develop and exist. Besides, waste rocks undergo leaching processes leading to the pollution of these waters.

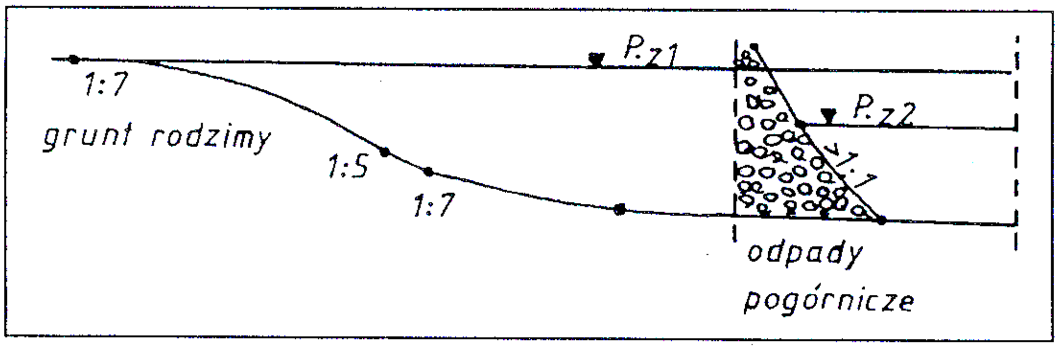

Fig. 1. The changes in transverse profile in the zone of filling up of water reservoir

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PEDOLOGICAL AND SEDIMENTOLOGICAL INVESTIGATION OF TELL MOUNDS (NAGYCSŐSZ AND TEST MOUND)[1]

Introduction, research precedents

In the plains of Hungary, especially in the Great Plain there are numerous heap like features with a height of a few metres that are referred to as mounds both in the everyday language and in the professional earth science literature. The origin of mounds was interpreted differently by geographers, archaeologists and ethnologists. Several authors regarded mounds as natural phenomena prior to archaeologic, pedological and sedimentological investigations. According to Károly Miskolczy "*The position of mounds reveals clearly, … that they were not done, as they are elevating by slopes and flatten again into the plain by slopes. … These mounds are the products of Nature and they were formed when sea covered the plain by the waving of the water*" (Miskolczy 1864).

József Szabó described mounds partly as natural and partly as artificial features: "*wave products formed under the surface of the sea, natural mounds, however, they might have been elevated by wandering people according to their needs.*" (Szabó, 1878). He listed several natural mounds regarded to be reef like features on the right and the left side of the Danube and the Tisza. In contrary, he emphasized the artificial origin of the mounds around Isaszeg and south of Baja following their geomorphological and sedimentological investigation (Szabó, 1868).

At the international congress of palaeoarchaeologists and anthropologists in Budapest in 1876 Flóris Rómer drew attention to the necessity of archaeological research of mounds. The first review of mounds is associated to him (Rómer, 1878). As the result of archaeological expositions started at the end of the 19th century the athropogenic origin of mounds became doubtless. The age and purpose of the mounds was also

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revealed by the exposition of numerous mounds made by local historic researchers and archaeologists.

The scientific research with the first pedological and sedimentological investigations started in the 1960s. According to these, mounds were built mainly onto natural highs from the humus containing A layer (Borsy, 1968) of the surrounding soils. University theses supervised by László Kádár were also performed in this topic displaying the pedological and sedimentological conditions of mounds in the vicinity of Debrecen (Tündik, 1964; Tóth, 1964).

Several mounds (e.g. *Kincses Mound* – Püspökladány; *Árkos Mound* – Hajdúszoboszló) were destroyed by recent constructions (mainly roads), however, their professional archaeological exposition and pedological investigation contributed to the information of mounds (M. Nepper ,1976).

The Act of 1996 No. LIII on the protection of Nature gave ex lege protection to every mound. After this mounds were in the focus of research again with numerous pedological and sedimentological investigations besides their national state survey. These investigations focused on primarily the soil and sedimentological conditions of the surroundings of the mounds and on the examination of the palaeosoils covered by the mounds and the filling material of the trenches (Sümegi et al. 1998; Tóth, 1999; Barczi et al. 2003; Joó et al. 2006). These examinations reveal the technique of mound construction, their function and the palaeo-environmental conditions at the time of mound building. The present publication summarises the most important results of the recent study of the pedology and stratigraphy of two tell mounds (dwelling mounds) in the northern part of the Great Plain.

Methods

Teodolite was used to the determination of the geomorphological conditions of the mounds. From the data of the mapping the topographic map of the mounds was prepared with the help of the software WinSurfer 6.0. In order to describe stratigraphically the mounds mapping drillings were performed along a section with 5-20 metres of drilling distance depending on the size of the mounds. Boreholes reached through the mounds into the "C" layer of the original buried soil that was sampled by 10 cm. In the case of tell mounds encircled by ditches drillings were performed in the ditch as well and in one case a sediment profile was constructed as well. To map the ditch network data of geophysical measurements were also used at the Nagycsősz Mound. Grain size distribution of the samples was determined by Köhn pipette hydrometry and dry sieving. pH values were measured in water and in KCl as well. Carbonate contents were determined by Scheibler-type calcimeter while total organic matter content was determined by the Tyurin method. Pollens of the sediments collected from the ditches were analysed by E. Magyari. Radiocarbon analyses of the charcoal samples were performed in the Light Isotope Laboratory of the Institute of Nuclear Research in Debrecen.

Results

Examining the ditch network of the Nagycsősz Mound (Polgár)

The Nagycsősz Mound is located on a loess plateau that is neighboured by the alluvial plain of the Tisza in the boundary zone of the Nyírség and the Hortobágy (Fig. 1.). In the central highest part of the mound the traces, fireplaces, cultic and personal belongings of several houses built on the ruins of each other were found by archaeologists.

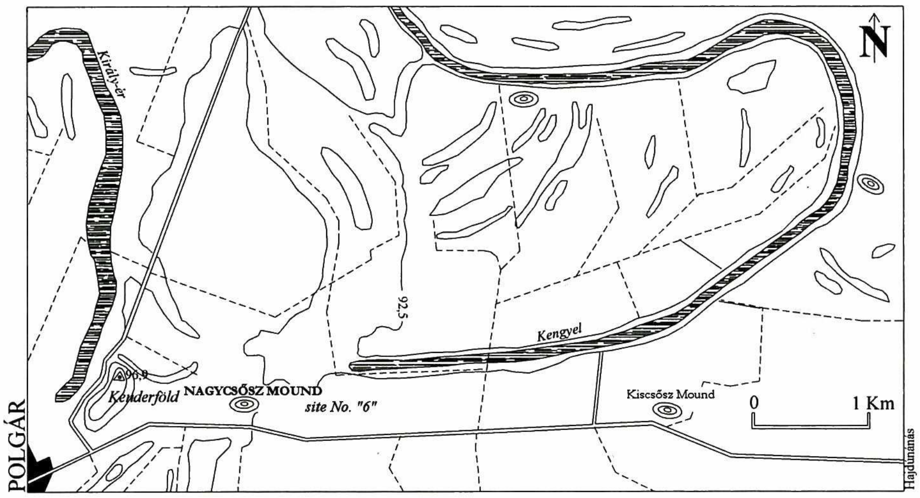

Fig. 1. Geographical position of the Nagycsősz Mound

According to the preliminary geophysical (magnetic) measurements the mound is surrounded by five ditches that are connected by radial ditches (Puszta, 1998). Dark patches on the magnetic image indicated rich archaeological findings (mud-flake, tile fragments) (Fig. 2). These negative forms cannot be seen today due to filling and cultivation. Therefore the stratigraphic conditions of the edge of the mound were exposed by 42 mapping drillings along a section north of the peak of the mound while sedimentological investigations were performed on the material of the third ditch.

The borehole section starts 40 metres to the North from the elevation mark giving information on the location of the ditch (Fig. 3). Boreholes re-

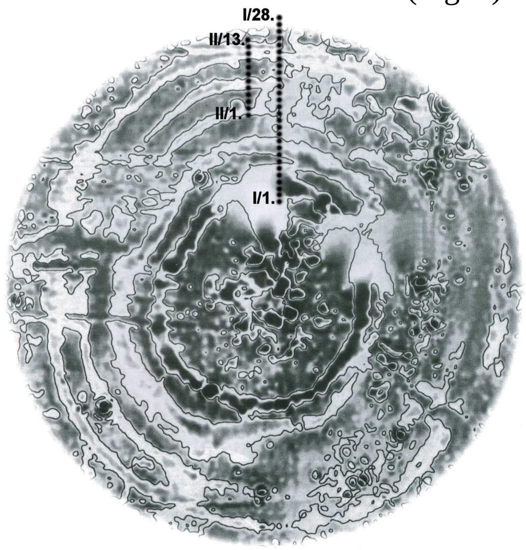

Fig. 2. Magnetic image of the Nagycsősz Mound with the two drilling sections (Puszta 1998)

vealed strongly disturbed soil layers in almost every case down to the undisturbed stratified infusion loess surface or to the floodplain fine sand sediments below it. Deepest was the borehole I/3. In this mixed and in washed anthropogenic strata of mud-flake bones and charcoal were found down to a depth of 3.2 m presenting the innermost and deepest ditch of the network. Furthermore a ditch with similar depth and three shallower ones (1.3-1.5 m) could have been traced. Mapping drillings proved the suggestions of the magnetic measurements of five ditch-like depressions encircling the mound. Based on the archaeological exposition of the centre these ditches were constructed in the Neolithic age. These ditches as small local sediment traps collected the washed soil disturbed by human. In order to reconstruct the environment of the tell settlement, samples were taken from the soil profile of the second ditch and sedimentological investigations were performed on them.

The ditch was built in infusion loess with significant carbonate and clay content. It is filled by washed soil and tell waste in a thickness of 2.9 m. The ditch is filled by washed soil with 55% of clay, 5-6% carbonate and 3% humus down to a depth of 2.2 m. Based on the pollen analysis of the sediments of the Kengyelköz and Király creeks nearby, this washed soil might have been brow forest soil developed in a forest dominated by oak (Sümegi et al. 1998).

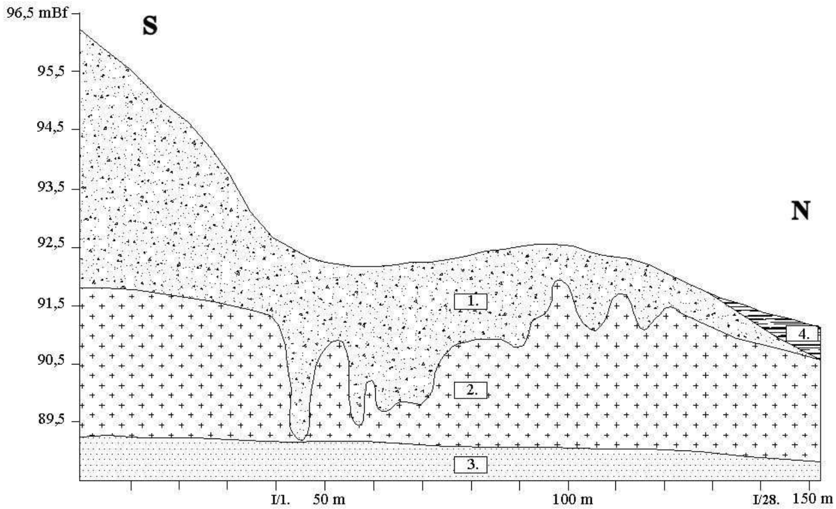

Fig. 3. Stratigraphic conditions of the northern foreground of the Nagycsősz Mound based on drilling section I. 1. disturbed, mixed archaeological strata 2. floodplain loess 3. fine sand 4. floodplain sediment

The analyses of soil thin-section in this horizon indicate high amount of flying-ash suggesting the development of major forest fires at the time of ditch construction, around 4500-5000 years ago. Presumably this was the time when the original woodland vegetation was burnt to give place for cultivation and cattle keeping. The occurrence of iron peas and calcareous fur indicate that groundwater reached the bottom of the ditch and at the time of flooding on the Tisza water cover of 0.5 m may have occurred in this ditch.

There is a soil horizon washed into the ditch between 2.2 and 1.0 m that differs from the above strata in composition. Here the amount of flying-ash was reduced significantly together with the slight decrease of humus. However, clay increased slightly. These alterations reflect the change of structure and composition of the original forest soil towards the development of soil formed by human impact under the effects of a more open vegetation. Both washed soil horizons bear the characteristics of disturbed structure and the in wash of archaeological findings (tile fragments, mud-flakes, bones, etc) from the top of the mound.

The traces of human impact cannot be shown in the top 1 m of the ditch filling. Presumably the area became unpopulated from the end of the Bronze Age, therefore natural soil development started on the in washed urban strata resulting in the formation of cernozem soils. Based on the gained information so far, the ditch network of the Nagycsősz Mound served ritual, cultic functions (Raczky et al. 1994). This is further proved by that there are two exposed archaeological sites of Bronze age in the vicinity of the Nagycsősz Mound (Kenderföld and site No. “6”). The mound is located in an important site between these two settlements. However, the northeastern orientation of the mound is clearly observable in the structure and the magnetic image of the mound. In the field the peak of the Nagy-Kopasz of Tokaj can be seen in this direction. This excellent orientation point might have been important to the ancient people as well.

Studying the water ditch of the Test Mound (Szakáld)

There are several fortified tell like living mounds from the early and middle Bronze Age in the area of the Borsod-Mezőség the majority of which were built by the Hatvan and Füzesabony cultures (Kalicz 1968). One of these tells from the Bronze Age encircled by ditches is the Test Mound (Fig. 4) South of the settlement Szakáld. The investigation of the mound and its ditch was aimed to reconstruct the environment of the tell from the Bronze Age and the former relationship of man and its environment.

The original morphological conditions of the mound strongly denuded by intense cultivation were reconstructed by quantitative determination of the in washed material of the ditch by drillings and mapping. The ditch can be regarded as a half cylinder 3 m deep, 20 m wide and 280 m long in average. Based on volume calculations 26000 m^3 of material was eroded into the ditch mainly from the tell and from the surrounding arable lands in a limited amount.

If the 11000 m^3 of denuded material in the natural depression on the western side of the mound is calculated, the erosion of around 37000 m^3 of tell material took place in total. This means that the elevation of the mound top and steep sides extending over 2 hectares was reduced by 1.8 m in average.

Based on the reconstruction of the original surface, the Test Mound was a living mound at the absolute elevation of 104.5 m, protruding up to 5.5 m from its surroundings and encircled by a semi circular ditch deepened down to the elevation above sea level of 95 m. Thus there was 9.5 metres of height difference between the bottom of the 4 metres deep ditch and the top of the mound. The northwestern and the southwestern end of the ditch leads to the former Sajó bed named Keringő therefore the mound surrounded by water filled depressions from every side elevates as an island presenting complete protection (Fig. 4).

On the basis of the exposition established in the 4.6 m deep ditch encircling the mound, the ditch was constructed by the Bronze Age people in the floodplain loess like sediment constituting the surface of the alluvial fan (Fig 4). Between the bottom of the ditch and the gravel of the alluvial fan the constructors left a 1–1.5 m thick greenish grey clay impermeable layer. This is indicated by the 1.5 m thick "lacustrine" sediments accumulated in the bottom of the ditch suggesting a static or slowly moving stable water environment eutrophic bentonicly.

The lowermost 18 cm of the lacustrine sediments are composed of clayey silt with high humus content holding tiny charcoal and soil fragments that might have been washed in by rainstorms. This stratum is overlain by a blackish grey eutrophic lacustrine sediment stratum containing bones, tile fragments and mollusc shells covered by a stratum rich in charcoal between the depths of 2.4 and 2.6 m.

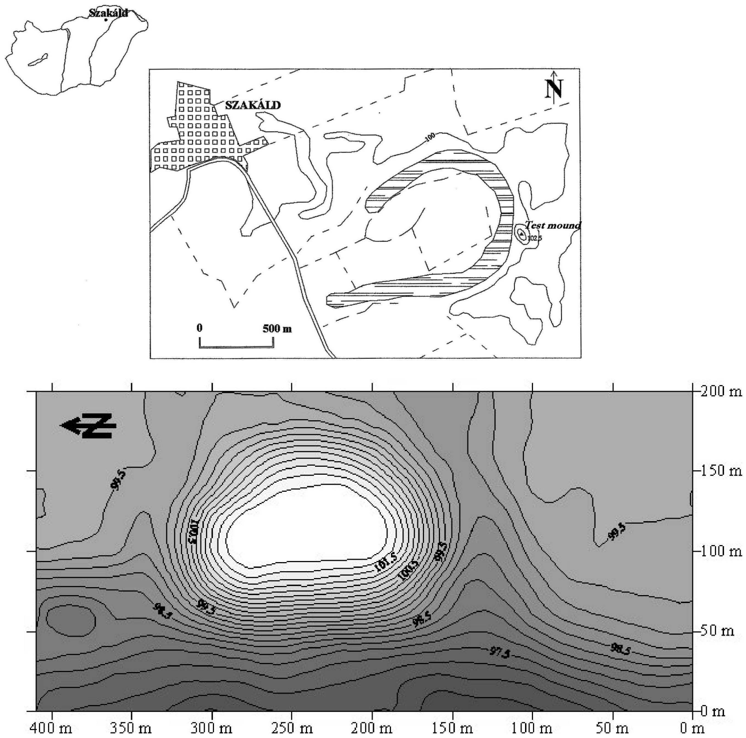

Fig. 4. Topographic map of the Test Mound (Szakáld)

Radiocarbon measurements were performed on the charcoal of this layer. The age of the stratum is 3260 years BP. This in washed charcoal containing stratum indicates that the settlement was burnt and was not rebuilt later, it became unpopulated. Above the charcoal stratum the ditch was filled by sediments eroded from the tell either naturally or due to cultivation and mixed by anthopogenic impact (Fig. 5).

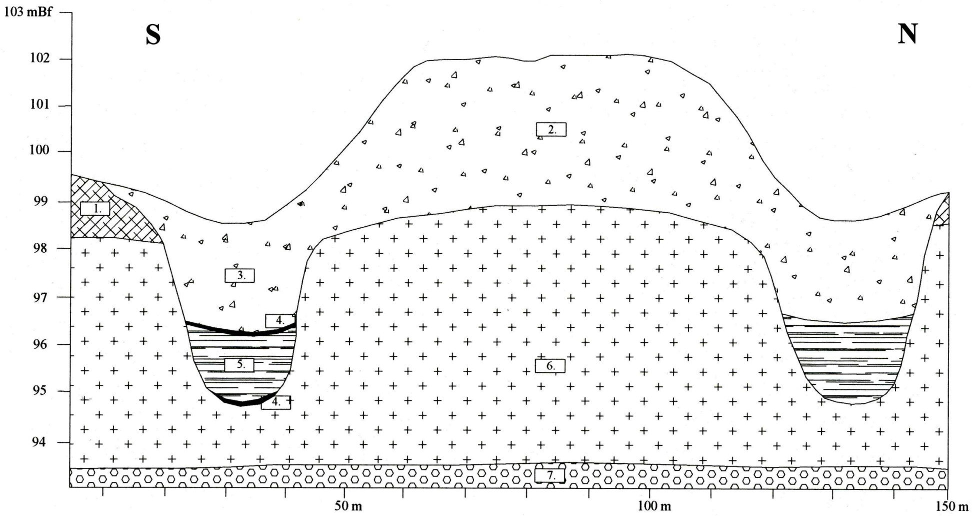

Fig. 5. Stratigraphic outline of the Test Mound 1. recent cultivated soil 2. disturbed tell material with archaeological findings 3. tell material eroded into the ditch encircling the mound 4. stratum rich in charcoal 5. lacustrine sediment (with mud-flakes and bone fragments in its upper level)

The section contained pollen in assessable quantity only between the depths of 262 – 316 cm. Strata above 262 cm were completely dry and disturbed. The examined eight samples contained 58 taxons in total (Table 1).

There are few trend like changes in the percentage pollen content of the samples. This can be the result of either the disturbance of the lacustrine sediments or the rapid sediment accumulation representing a few hundred years. A sharp changing, however, can be seen in the data. In the lowermost strata the rate of the wood pollens is 30% and its species composition indicates the mixing of the bottom of the ditch to the Pleistocene strata (*Pinus sylvestris, Picea abies, Betula sp.*). In contrary the rate of arbor pollens reduces to 14 % in the samples from upper strata indicating gradual deforestation. Here the in mix of the pollens of older strata cannot be detected. The low rate of individual tree species (2-4 %) indicates that there was no continuous woodland vegetation on the shores of the ditch. On the shores of the abandoned bed near the mound soft gallery wood species may have grown (*Salix sp., Alnus glutinosa*). While more distant from the bed scattered hard gallery wood together with oak species may gave occurred individually or in smaller groups (*Quercus sp., Corylus avellana, Tilia sp., Acer sp.*). The greater quantity of Carpinus betulus and Fagus sulvatica pollens can be explained by presumably not only the nearness of the Bükk Mountaines but they may have been present in the area individually.

Table 1. List of ecological indicator species referring to anthropogenic impact and their percentage distribution in the various layers (Analysed by E. Magyari)

	316 cm	**308 cm**	**300 cm**	**294 cm**	**286 cm**	**278 cm**	**270 cm**	**262 cm**
Species signing treading:								
Graminea	4.1%	13.9%	8.4%	4.2%	9.5%	4.8%	9.1%	14.8%
Compositae lig.	2.78	1.47	9.78	10.56	7.31	4.85	10.14	8.55
Plantago lanceolata	0	2.21	5.78	0	0	0	2.42	0
Plantago media	0	0.74	4.00	0	0	0	2.42	0
Polygonum aviculare	1.39	2.21	3.56	3.87	2.28	5.29	2.9	2.97
Charyophyllaceae	0	0	0	0	0	0	0.97	0
Chenopodiaceae	1.39	18.38	8	22.18	22.83	18.06	14.98	10.78
Grown crops:								
Triticum sp. and Avena sp.	0.9	0	1.78	1.41	0.46	0	2.42	0
Segetal weeds:								
Centaurea cyanus	0	0	0.44	0	0	0	0.48	0.37
Polygonum aviculare	1.39	2.21	3.56	3.87	2.28	5.29	2.90	2.97
Polygonum persicaria	0	0.74	0	0	0.46	0.88	0	0.37
Cruciferae	0	1.47	0.44	1.76	0.91	0	0.97	0.37
Spergula arvensis	0	3.68	0.89	0	0	0	0.48	0
Labiateae	0	0.74	1.78	0	0	0	0.97	0.37
Weeds along the arable land:								
Solanum sp.	1.39	0	0.44	0	0	0	0	0
Artemisia sp.	2.78	2.21	4	1.41	4.57	1.32	0.97	2.97
Species signing grazing:								
Filipendula vulgaris	0	0	0	2.11	0	6.61	0	0.37
Graminea	4.17	13.97	8.44	4.23	9.59	4.85	9.18	14.87
Compositae lig.	2.78	1.47	9.78	10.56	7.31	4.85	10.41	8.55
Potentilla sp.	0	0	0.44	0	0	0	0	0
Juniperus communis	0	0	0	0	0.46	0.44	0	0

Based on the composition of the pollens wet meadows and marshlands can be reconstructed on the shores of the ditch and the oxbow lake with species of *Cyperaceae, Mentha sp., Valeriana dioica, Filipendula vulgaris* és *Umbelliferae*.

The species of *Myriophillum sp., Sparganium sp., Nymphaea alba* és *Alisma plantago-aquatica* lived formerely in the water of the ditch suggest lake environment and a minimum water depth of 2 m. The presence of

Phragmittes sp., Typha sp., Cyperaceae species indicate reedy developed in the rim of the ditch.

The vegetation cover of the more distant dray areas were strongly disturbed as species indicating trampling are dominant (*Chenopodiaceae, Plantago sp., Taraxacum sp., Compositae, Polygonum aviculare*). On the basis of all these the image of a poorly vegetated settlement environment crossed by paths can be outlined around the ditch and on the top of the mound where only a few species enduring trampling and drought lived. Cattle grazing on the meadows around the settlement is suggested by the frequent appearance of species indicating grazing (*Filipendula vulgaris, Potentilla sp., Gramineae*). The low rate (1-2 %) of the pollens of grown corn (*Triticum sp.*) and several weed associated to arable lands (*Centaurea cyanus, Solanum sp., Spergula arvensis*) indicating abandoned arable lands in the direct vicinity of the mound while the presence of extended corn fields more distant from the former settlement is probable.

Summary

Pedological and stratigraphic examination of the mounds may clear successfully the conditions of their building. Tell like mounds were elevated by the deposition of several culture and transported soil strata. Transported soil strata separating the culture strata originate from the ditches established in the foreground of the mounds. These ditches served not only as excavation areas but may have strengthened the cultic role of the central mounds as well. The five concentric ditches of the Nagycsősz Mound at Polgár may have served this role. Water may have filled the ditches located near the floodplain of the Tisza giving water ditch function to the trenches. Ditches are not visible on the surface but magnetic measurements and stratigraphic drillings revealed their presence. The mound was doubtless populated from the Neolithic to the Bronze Age. Studying the sediments washed into the ditches from the mounds and from its surroundings, the anthropogenic impact on the environment between 4500 and 5000 years BP involving the burning and transition of forests into pastoral lands were revealed indicating the settlement of cultivating and cattle keeping people.

The Test Mound Bronze Age tell located in the elevated part of the Sajó floodplain in the area of the Borsod Mezőség also have a large ditch visible on the surface and might have been 3.5 m deep originally. From the completely cultivated mound 37000 m^3 of tell material was eroded into the bed nearby and the artificial ditch through the past centuries. Based on the investigation of the sediment section established in the ditch it can be stated that permanent water cover might have been in the ditch resulting in the deposition of lacustrine sediments. On the basis of the age determination of the burnt, charcoal containing in washed strata it seems that the mound was burnt at 3260 BP and it was not rebuilt after and it became unpopulated. Following this there was no permanent water filling in the ditch and large quantity of mixed material was eroded into the ditch from the tell and from its surroundings. The environment of the mound at the time when it was populated was reconstructed by pollen analysis of the lacustrine material of the ditch. There were no continuous forests in the area in the Bronze Age trees formed only smaller groups. The pollen spectra revealed wetland meadows in the floodplain and settlement with disturbed, trampled environment together with arable lands.

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Gábor DEMETER[1] – Botond BURÓ[1] – Dóra KOVÁCS[1]

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THE THREATS OF UNSUCCESSFUL RECULTIVATION AND MISUSE OF A COAL MINING PIT-HEAP

This contribution aims to demonstrate the risks of the usuccessful recultivation of a waste tip resulting accelerated erosion and increased runoff enhanced further by human carelessness and misuse.

The heap was deposited during the coal mining periods in Oroszlány between 1970-1990 and consists of mainly carboniferous or calcareous shales, unproductive lignite seams, removed soil, claymarl and other unproductive layers considered as non-contaminants. The bottom circumference of the heap is 530 m, its area reaches 1,75 hectares, while the planed upper part reaches 0,11 hectares, its circumference is 150 meters. The height is 15 meters measured from eastwards (from the creek) and 7 meters westwards (ploughlands) (Fig.1). Erosional processes, runoff, infiltration and water storage capacity of the soil were monitored and measured between 2006-2007.

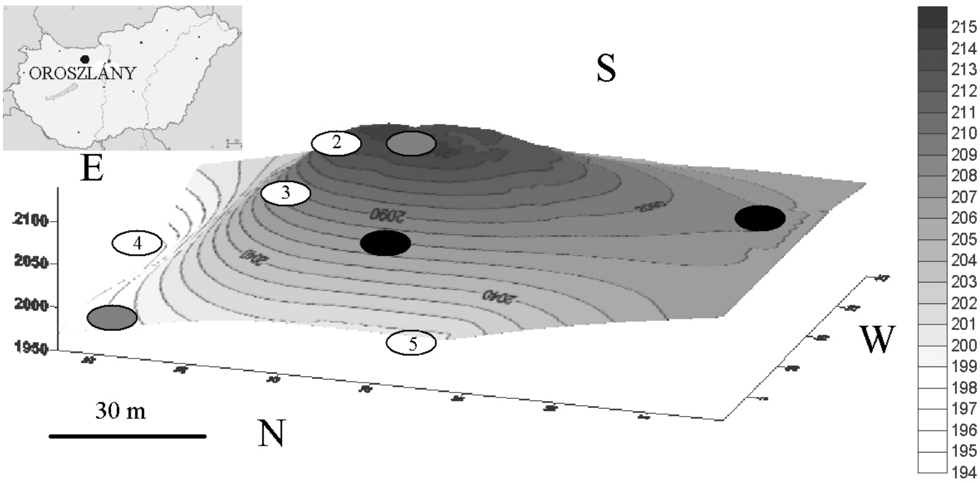


Fig 1. Sketch map of the heap (height above sea level in meters). Black ellipsoids show the positions of sediment traps, the gray ones the position of the two drillings (8 m and 4 m), the light ellipsoids show the position of soil samples (0-70 cms)

The drilling and sampling of boreholes proved that the structure of the heap is layered. The deposited layers show the dynamics of the growth in coal production, also proving that the main mass of the heap remained undisturbed. The deposition met the minimum requirements of environmental protection since lignite layers alternate with clayey layers isolating the contaminants from each other, preventing the wash-out and the infiltration into the ground water. Contrary to the positive measures, this feature resulted unfavourable effects enhanced by human impact.

It must be pointed out that the geological conditions are not optimal and the location of the waste tip is problematic. The nearby mountainous region (Vértes Mts.) consists of highly tectonised mesozoic limestones with great porosity, carstic phenomena are abundant in the horst-graben type fault-dominated mountains. The waste heap is located in a graben, where the limestone sank below the surface and is overlain by palaeogene-neogeneous coal bearing seams. Unfortunately these layers are mainly composed of sandy, unconsolidated molasse sediments with high porosity and due to the low pH-values, low buffering capacity and high infiltration velocity (see Fig. 2-3) these cannot prevent the infiltration of contaminants into the carstic subsurface or surface waters.

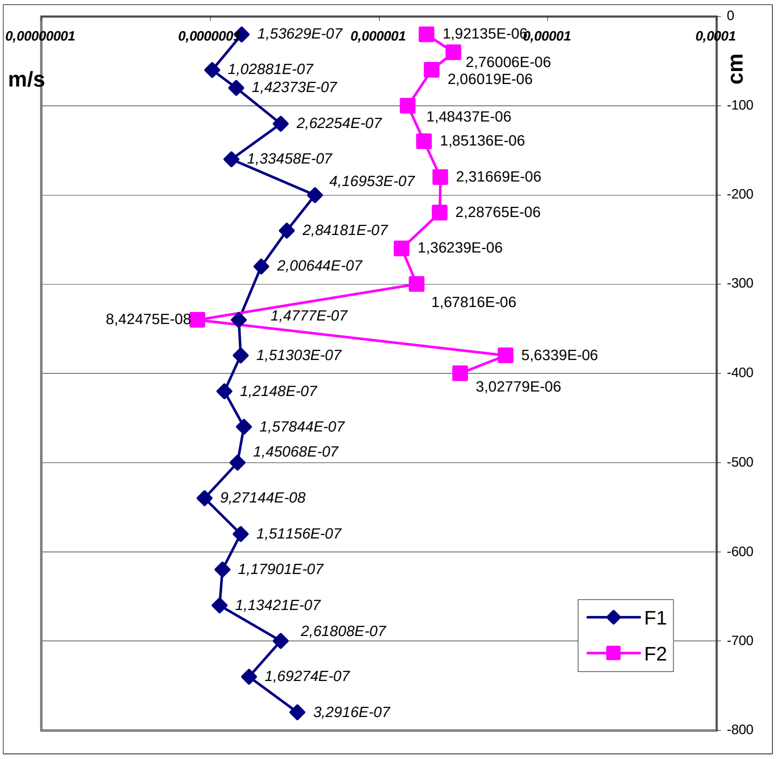


Fig. 2. The „k" infiltration velocity at different depth.
F1: the waste heap (measured from the top), F2: the background area.
Note the infiltration velocity is much greater in the sandy background area

The heap is located close (20 meters) to a creek which is considered the water base of the nearby landscape protection area (Vértes Landscape Protection Area). The limits of the protected area are not farther then 100 meters. Insulation (geotextiles or bentonitic clays) is missing under the heap, above the ground water table (located at 3.2 meters depth).

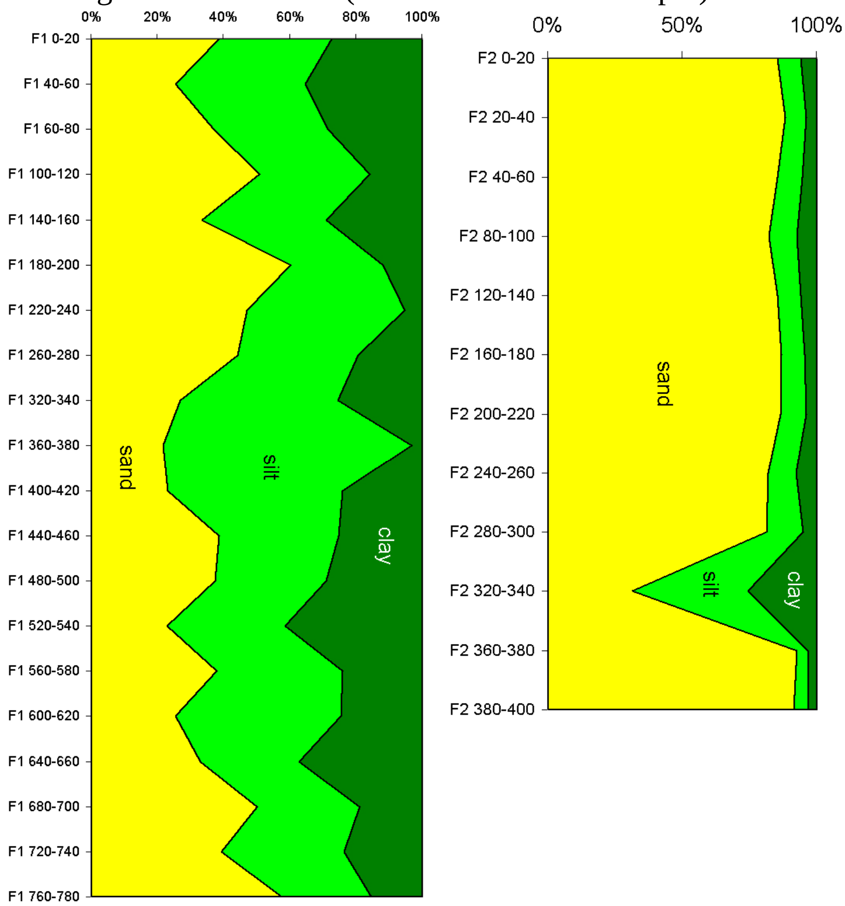


Fig 3. The sedimentological composition of the heap (left) and of the background area (right) (*depth in cm*). Note the rythmic occurance of clayey sediments composing the layered structure of the waste heap and the dominance of the sand in the base. (Ground-water table below the clayey layer at 320-340 cms from surface)

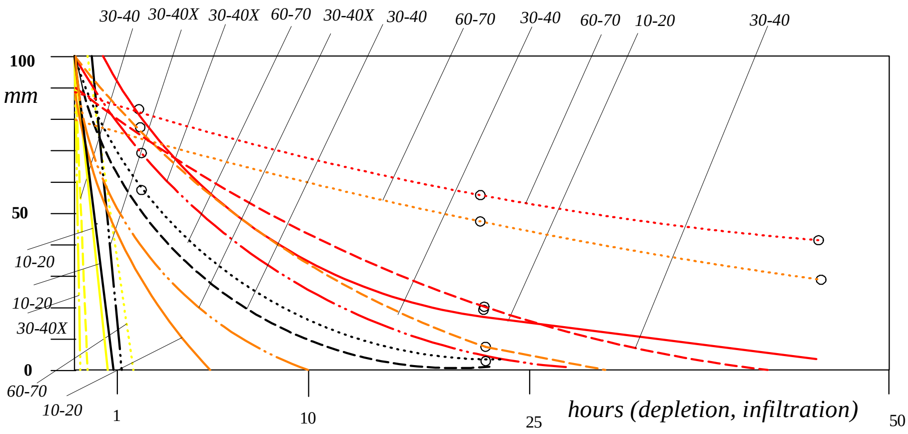
After the collapse of the communist regime the mines were closed in the region, the main building was reorganized as a museum, just few hundred meters from the heap. Being the highest point, the heap gives an excellent outlook to the protected area and to Majkpuszta where the ruins of a huge monastery, some watermills and little ponds can be found. These lakes were originally planned to supply industrial water or cooling water for the nearby factories, like the Tatabánya powerplant, or functioned as sediment traps decreasing the concentration of contaminans resulting from mining activities. Now they are valuable ecological corridors enhancing the diversity of the landscape, used for recreation purposes, like fishing and equestrian.

The role of the waste heap in dominating the landscape was recognised early and after the collapse of the mining industry a wide-scale recultivation took place – but only on papers. Some measures were implemented like decreasing the slope gradient in order to avoid erosion and mass movements, but other rehabilitation processes, like creating a soil layer and establishing viable plant assotiations were condemned to fail due to the lack of interest of the entrepreneur.

By the time our investigations started, the soil layer had already completely disappeared if ever existed (according to the documentation, millions were paid for this purpose), and the waste heap was rarely covered by plants of pioneer assotiations, indicating that the process was rather natural, and not as a result of human intervention. The southern part of the heap now functions as a track for cyclists and motocross-racers. This activity enhanced the erosional processes.

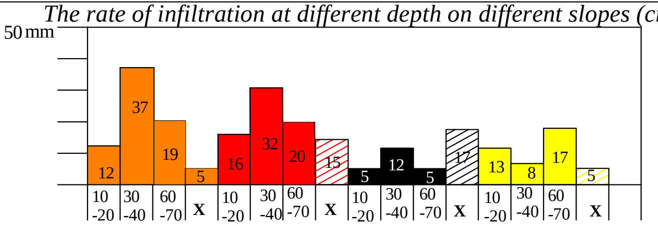
The structure of the heap was originally planned to prevent the infiltration into these sandy layers, thus to protect the ground water and the nearby creek. Our investigations confirmed that the specific structure of the heap prevented the vertical infiltration of the precipitation, thus it lowered the wash-out, but unfortunately increased the runoff (Fig. 4, 5, 8). The lowered wash-out prevented the (re)concentration of contaminants in the evapo-transpiration zone, and the leaching of contaminants into the ground water. Since the centre of the heap remained dry, thus the speed of reductive, anaerobic reactions was limited, and it resulted reduced secondary (sulphuric) mineralisation, although the lignite seams were characterised by high sulphur-concentration. The heap is not burnt out (the drilling produced no signs of ignition), secondary minerals were not mobilized and did not reach the ground water table.

This positive effect had some serious drawbacks: the decreased wash-out induced increased runoff, that quickly removed the deposited soil from the covering layers. The steep slope gradient, the lack of infiltration, the soil loss and the poorly developed vegetation caused a vicious circle: it reduced the spread of assotiations that could have hindered the soil loss. This feedback (soil loss–low vegetation cover–increasing soil loss) lasts until the slope gradient reaches an equilibrium that reduces the soil loss.



	3. section/convex slope	4. section/concave	2. section/top	5. section/background
10-20	3. slow	13. quick	10. quick	14. quick
30-40	4. slow	8. medium	5. medium	15. quick
60-70	*1. very slow*	*7. medium*	*2. very slow*	*11. medium*
30-40+	**6. quick**	**12. quick**	**9. quick**	**16. quick**

The rate of infiltration at different depth on different slopes (cm)



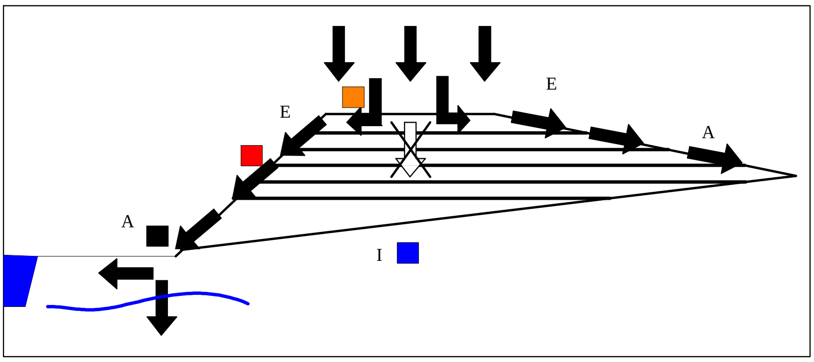


Fig. 4. Water balance of the heap measured at different depths (cm, using 10 cms thick samples, + means horizontal orientation the others show vertical orientation) on different slopes. The first chart shows the depletion dependig from elapsed time in case of 100 mm precipitation. The second chart shows the velocity of depletion on different slopes. The third presents the water storage capacity of the different samples (ml), and the last one the movement of the water.

The surface water running off from the heap containing contaminants can reach the background area lacking insulation and infiltrate into the ground water and into the creek. Since the buffer capacity of the background area is low (Table 1), the carried metallic ions are not captured. Fortunately, the upper part of the heap does not contain extreme metal concentrations.

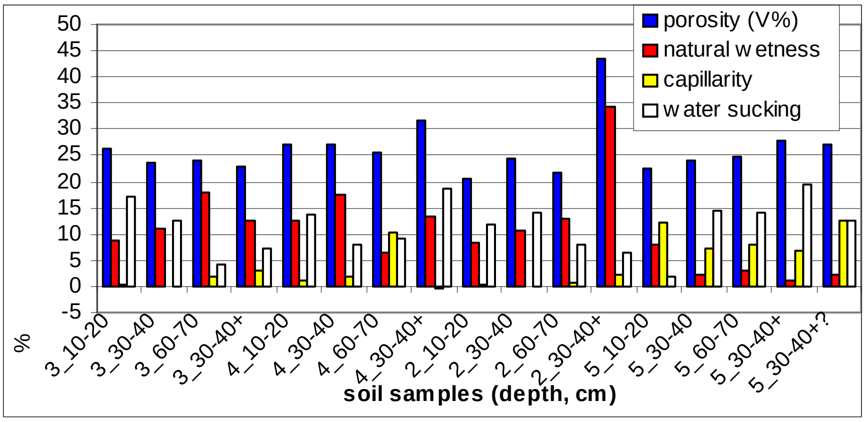


Fig 5. The hidrologic parameters of soil samples from the heap

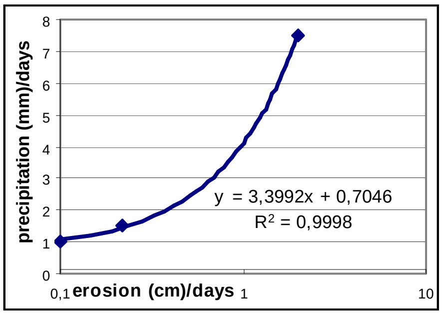


Fig 6. The rate of erosion at 35° slope angle

The present soil loss rate was measured by Gerlach sediment traps on the undisturbed sides. In 2006, after 4 days of constant raining 8 cm upfilling was measured on the northern steep slope with 35 degree slope gradient, eroded from a 10 meter long slope, meaning 0,08 m overall denudation. Between June-November, 2006, further 13 cm upfilling was measured, meaning 0,13 m denudation. The western, gentler slopes showed 0,04 m denudation within the same period (8 cm upfilling in a 20 meter long slope with 15 degree steepness). Between 2006 November and 2007 March further 22 cm fill was measured in the northern slope (0,22 m height decrease).

The seasonal deepening/widening of gullys was also investigated (Fig. 7).

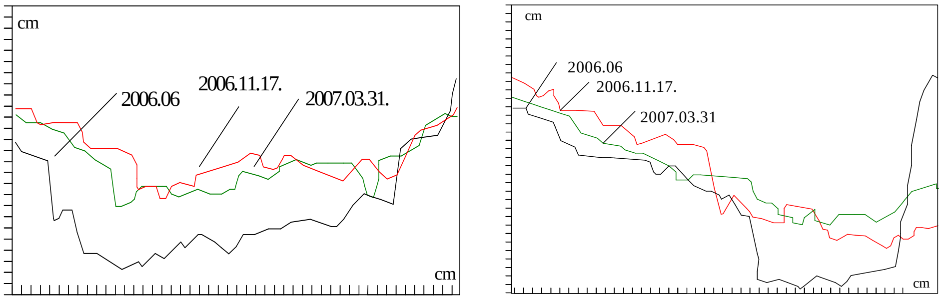


Fig. 7. The seasonal changes of upfilling and sediment transport. Summers are characterised by deepening of gullies, the autumn and spring is characterised by widening, upfilling

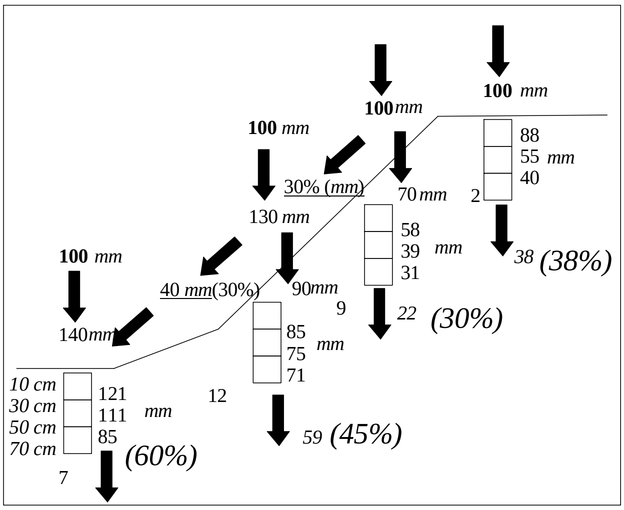


Fig 8. Potential runoff and infiltration on the heap-slope supposing equal (100 mm) precipitation. Infiltration rate increases reaching the backround area, exceeding runoff rate. (Evapotranspiration is not measured.)

The flora of the heap is mixed, feeds from 3 sources. The young trees spread from the protected woodland (*Quercus petraea, Populus alba, Betula pendula*) or from the bank of the creek. Some plants came from the nearby ploughlands and meadows or disturbed areas (*Trifolium sp., Plantango media, Cirsium arvense, Lolium perenne, Achillea millefolium, Lotus corniculatus*), and many species can be considered pioneer associations (*Tanacetum corymbosum, Rumex acetosa, Sedum sp., Melilotus sp., Daucus carota, Calystegia sepium, Echium vulgare, Cichorium intybus, Equisteum arvense, Crataegus monogyna*). Without human intervention it would take some 30 years for the vegetation to establish stable assotiations (succession). For recultivation among other recommended species we can find Eleagnus angustifolia, Crataegus sp., Robinia pseudoacacia. These are not elements of the natural vegetation, but it is not necessary if the main purpose is to hinder erosion. But, since the area is near the protected landscape, these species should be avoided. Trifolium and Medicago are strongly recommended, since they are optimal for recreating soil structures.

Since the heap itself is dry, it is not consolidated by the reworking activity of the water only by its own weight. The owners committed several mistakes when they decided to recultivate the heap again. First, without any permission they initiated landscaping fieldworks. Using heavy engines they accidentally cut through eletric wires leaving the part of Oroszlány town without electricity. They cut down forests near the creek and tried to plane the surroundings of the heap illegally, ruining the vegetation and modifying the runoff and the condition of stabilised slopes. The optimal cost-effective recultivation plan for the heap can be seen on Fig. 9-10.

Fig. 9**.** *Upper row* (from the left to the right: the „soil" of the heap; erosional gully with vegetation cover; renewal of erosional gullies after the illegal planation works
Bottom row (from the left to the right): the heap, the woodland and the Vértes Mts.; illegal planation works near the protected area

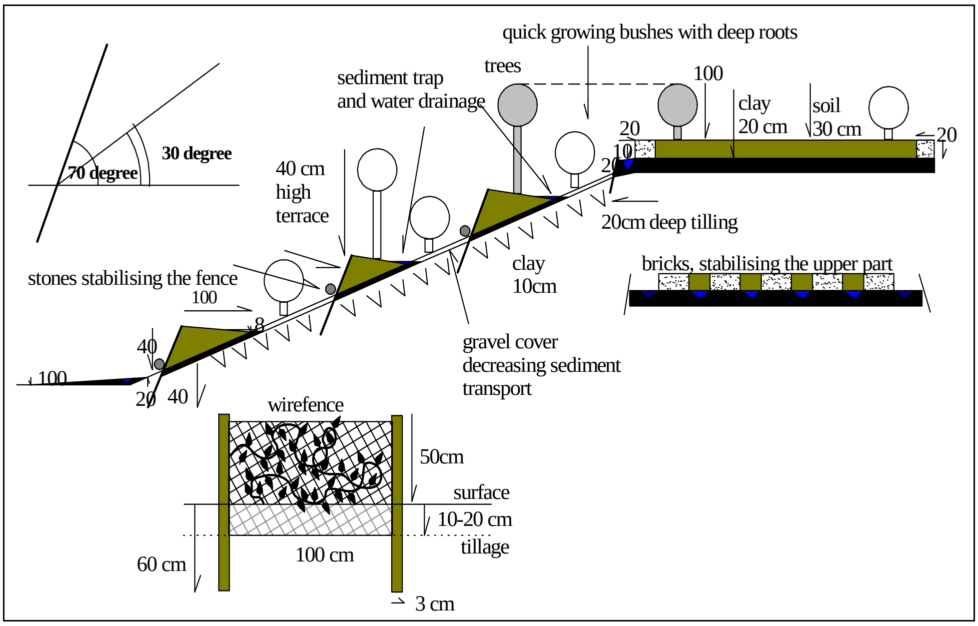


Fig. 10. A proposal for the recultivation of the heap using minimum soil surplus reaching minimum erosion. The tilling before adding the soil decreases the soil erosion. The terraces minimize the amount and costs of soil deposition. The wirefences tilled under surface and the Hedera helix decrease the soil wash-out, the plants with long roots consolidate and stabilize the heap, increase interception. The bricks hinder the soil loss from the top. Terraces are open-drained to collect and control the runoff.

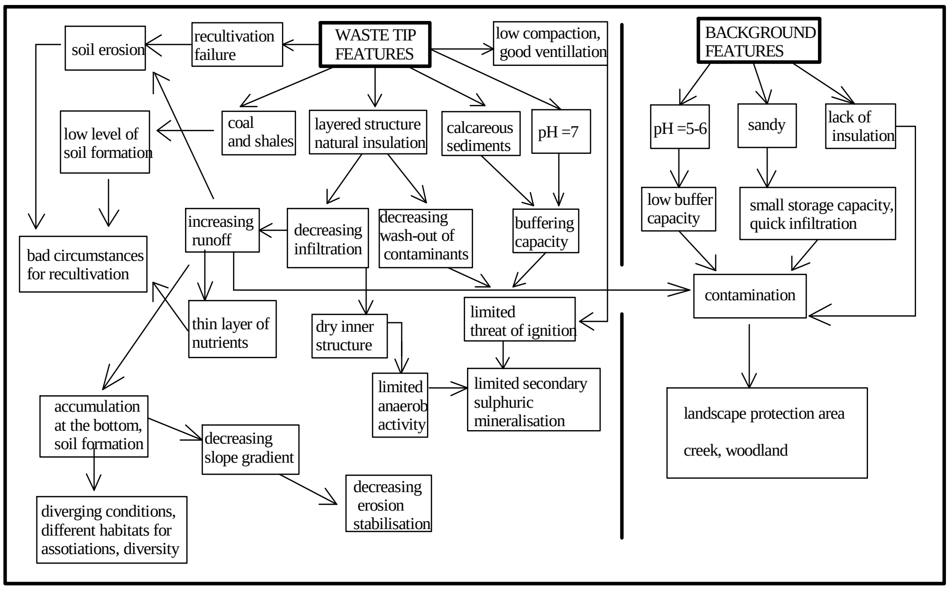


Fig. 11. Effect-mechanism of processes on the waste tip

Table 1. Clustered structure (Ward's method) of the heap based on sedimentology, pH, organic material, and carbonate content

Depth (cm)	Geology (Drilling 1: HEAP)	pH (H_2O, KCl)	Organic material (%)	$CaCO_3$ (%)	CLUSTER5	CLUSTER8
-20-0	dry, grayish, carboniferous humic layer					
0-20	yellow sand with signs of soilification	6,98:6,68	30,9%	**14,50**%	**1**	**1**
20-40	greenish grey silty sand with coal stripe	7,06:6,85	11,98%	11,62%	2	2
40-60	greasy yellowish gray clayey silt	7,16:7,01	**3,4%**	21,1%	2	2
60-80	black, clayey soil, calcareous	7,43:6,99	12,3%	34%	3	3
80-100	sandy clayey silt with coal, clayey-calc. shale clasts	7,01:6,88	27,7%	47,7%	4	4
100-120	sandy clayey silt with coal, clayey-calc. shale clasts	6,96:6,86	20%	39,5%	4	4
120-140	sandy clayey silt with coal, clayey-calc.shale clasts	6,94:6,82	21,6%	47,3%	4	4
140-160	sandy clayey silt with coal, clayey-calc. shale clasts	7,00:6,77	14,6%	23,2%	4	4
160-180	160-170 green clay, 170-180 sandy clay with organic material, consolidated	7,36:6,94	16,1%	29,2%	2	5
180-200	loamy sand with coal and organic material	7,34:6,91	12,3%	39,7%	2	2
200-220	**green dark gray silty clay**	7,06:7,14	**4,7%**	43,7%	**2**	**5**
220-240	**clay, aquitard**	7,19:6,98	14,2%	52,8%	**4**	**6**
240-260	same, brown	7,66:7,10	**8%**	43,9%	4	6
260-280	same, black, organic	7,76:7,17	**6,7%**	47,2%	2	5
280-300	same, organic green	7,60:7,10	**6,1%**	50,7%	2	5
300-320	**grayish green silty clay**	7,18:7,07	10,66%	54,6%	**2**	**5**
320-340	grayish green sandy clay	7,83:7,25	11,9%	55,4%	2	5
340-360	grayish green sandy clay	7,55:7,36	**2,3%**	45%	2	5
360-380	same. from 370brownish red sandy silt	7,63:7,09	**2,6%**	27,5%	2	5
380-400	brownish black organic sandy silt	6,86:6,54	12,9%	6,3%	3	7
400-420	upper part: black organic (coaly), bottom: limonitic green silty clay	7,17:6,74	12,87	**6,5%**	3	3
420-440	**blue-gray clay reductive, unvented, aquitard**	7,53:7,00	12,5%	**18%**	**4**	**6**
440-460	black coal, organic material sandy clay	6,86:6,66	27,4%	**3,8%**	3	7
460-480	black coal, organic material sandy clay	6,97:6,76	24,4%	26,5%	3	7
480-500	black coal, organic material sandy clay	6,92:6,76	13,7%	17,2%	3	7
500-520	black coal, organic material sandy clay, humid	7,09:6,87	13,89%	25,48%	3	7
520-540	**same, but greasy, wet plastic, like plasticine dark gray clay**	**7,18:6,94**	**20,11**%	**25,88**%	**4**	**6**
540-560	dry, sandy material with claymarl and organic clasts	7,17:6,95	19,50%	36,03%	2	2
560-580	dry, sandy material with claymarl and organic clasts	7,39:7,17	12,03%	34,78%	2	2
580-600	dry, sandy material with claymarl and organic clasts, greenish gray	7,53:7,22	6,20	37,55	5	8
600-620	dry, sandy material with claymarl and organic clasts, greenish gray	7,43:6,88	9,52%	30,93%	2	2
620-640	**red, greenish clay, shale, wet, anaerobic**	**7,31:7,04**	**9,07**%	**28,70**%	**2**	**5**
640-660	calcareous dark gray organic material	7,12:6,86	20,05%	15,64%	4	4
660-680	calcareous dark gray clay with organic material	7,10:6,85	23,37%	31,15%	4	4
680-700	calcareous dark gray clay with organic material	7,08:6,86	17,76%	30,9%	4	4
700-720	**greasy, wet, plastic, dark gray clay**	**7,02:6,86**	**13,47**%	**39,58**%	**4**	**6**
720-740	greenish gray organic material	7,83:6,83	12,55%	36,34%	4	4
740-760	dry, calcareous sandy material with organic content	7,27:6,76	11,73%	50,26%	2	2
760-780	gray sandy-silty material	7,34:7,22	7,13%	61,65%	2	5
780-800	**dark gray plastic, dark gray clay**	**7,15:6,94**	**11,58**%	**31,38**%	**4**	**6**

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LAND-USE CHANGES IN TRANSCARPATHIA REFLECTING ANTHROPOGENIC EFFECTS, WITH SPECIAL REGARD TO THE CATCHMENT AREA OF THE FEKETE AND FEHÉR TISZA

Introduction

Land-use is an important issue today, it determines the everyday life. Land-use is determined by natural conditions together with man who alters it with his activity. As a first step anthropogenic effects have to be defined. Anthropogenic effects are human activities or processes induced and influenced by human activities that influence the operation of landscape directly or indirectly.

As generally everywhere anthropogenic effects can be measured best in the types of landscape. Different landscapes are developed as the result of different human activities. Human effects influencing the landscape can be determined by studying these. Studying the effect of human activities is important as they are the only way of understanding the landscape and to create optimal land-use in the future. In the case of the present study area there are a few factors that have to be calculated in the course of the analysis. For example the area is important in the water level undulation of the river Tisza as its forest cover influences significantly the quantity of run-off water flowing into the river. Therefore this problem having numerous indirect reasons has to be investigated. It can be stated that the direct reason of the is the change in land-use, i.e. human activity.

The development of the embankment of the Tisza and the problems related to the flooding of the Tisza have been key-issues for years. Land-use conditions in the study area influence fundamentally the water level of the Tisza as rivers of this area determine the water level of the upper section of the Tisza. If the relationship between forest coverage and water levels are to be studied this area is the best choice.

The Tisza is regarded as having variable water levels and producing great floods and occasionally flooding a part of the Carpathian Basin. Some think the undeveloped state of the embankments along the Upper Tisza as the main reason for flooding while others point the presence of embankments at all as the source of the problem. It is difficult to answer the question due to the complexity of the problem; however, this is not the aim of the present publication. Doubtless the Tisza produces flooding nowadays as well and water level undulation, i.e. rapid variation of the precipitation and melt water flowing into the Tisza in the catchment area is regarded to be one of its reasons. Thus studying the changes in forest cover and land-use that are regarded to be key factors in water level fluctuations might be useful. The water level fluctuation of the Tisza is extreme with incalculable floodings that, according to the literature, might have numerous reasons. Doubtless one of the most referenced reasons is the reduction in forest cover as bare hill slopes cannot withhold rapidly falling large amount of precipitation and melt water. Therefore it is important to know the rate and variation of forest cover together with the associated changing of land-use through the past centuries that are involved in the present publication. For this the landscape types of the area are studied according to the available data and maps analysing the land-use characteristic for given historical periods. Several researchers aimed the same in recent years. Their results are reviewed in the followings in order to give as complete image on the question as possible.

Study area

Transcarpathia is located between the Carpathian ranges and the Great Hungarian Plain in Central Eastern Europe. Its borders are given by the Ung valley in northwest, the 250 km long ranges of the Beskides and the Máramaros Mountains in northeast and East and along the line of Tiszaújlak (Vilok)-, Mezőkaszony (Koszini)-, Csap (Csop) and Ungvár (Uzsgorod), marked by longitudes of E22°10’ – 24°06’ and latitudes of N47°54’ – 49°06’.

The total area of the county is 12800 km^2 and can be separated into two landscape units:

- mountain (Carpathians)
- plain (Great Plain of Transcarpathia)

The majority of the area of the county (86%) is covered by mountains and headland. The mountains consist of three ranges: the former border and watershed is marked by the Beskids and the Gorgans. Parallel to these a more dissected mountain range is found that was separated as an individual mountain by geographers only recently and it was named Polonina Mountains after the mountain meadows so characteristic to the landscape. The third range is the volcanic Vihorlát-Gutin. The Máramaros Mountains, in other words the Hucul Alps can be found in the southeastern part of

Transcarpathia near the boundary with Romania. In the southwest lies the Transcarpathian Plain or the Tiszahát.

45% of the woodlands of Transcarpathia can be found in the mountains and mountain alps cover 40 thousand hectares (Bulla et all., 1999)

The rivers of Transcarpathia belong to the water system of the Upper Tisza basin and their rich springs can be found in the sandstone belt of the Northeastern Carpathians. The main river is the Tisza that is originated from the joining of the Fekete- (Black) and Fehér-(White) Tisza in the Máramaros Mountains. Its tributaries are Borzsa, Talabor, Tarac, Latorca, Ung, Nagyág.

49.7% of the area of Transcarpathia is covered by woodlands. 59.2% of the forests are beech, 29% are spruce, 7.8% oak and 2.2% other.

Transcarpathia is too big and colourful to show anthropogenic effects satisfactory. Its borders are subjective; therefore the publication aims to give a sample on the changing of land-use by analysing a smaller area that is suitable to model similar landscape units. The choice for the study area is the catchment area of the Fekete- and Fehér-Tisza. (Fig. 1)

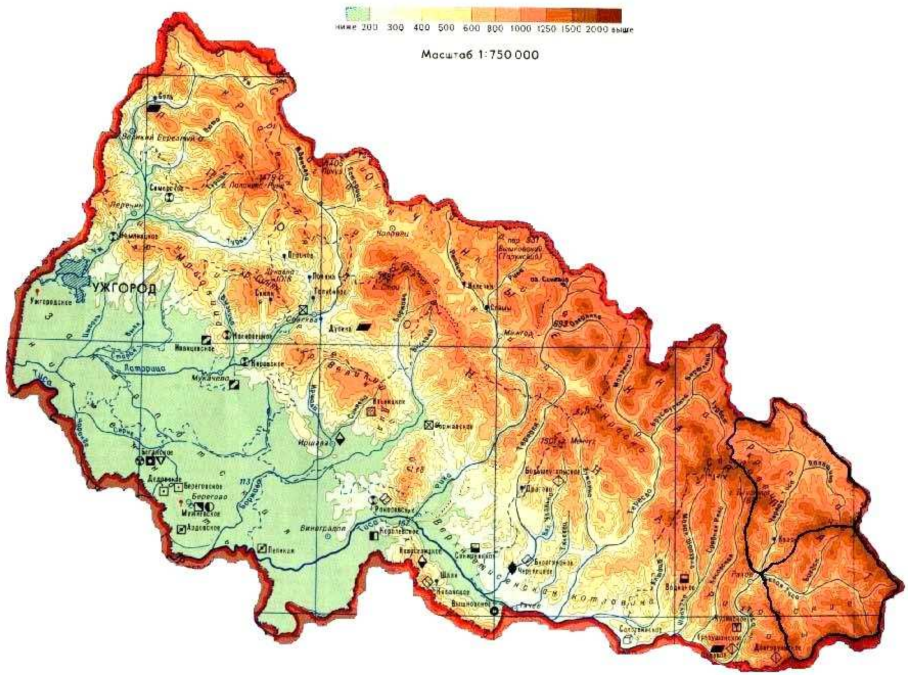

Fig. 1. Transcarpathia (Sablij, 1991)

— Study area

The 59.2 km long Fekete-Tisza, also named Csorna-Tisza originates in the alp called Okola (Sheep-fold) northwest from Körösmező (Jaszinya) at an elevation of 1,229 m (Várady, 1900). The area of its total catchment is 569.2 km^2, its major tributary is the Mezőhát, named Lazescsina stream in Ukrainian. The river joins the Fehér-Tisza at Rahó at an elevation of 480 m and here the river Tisza is born. The Fekete-Tisza covers 50 km from its source to the joining of the Fehér-Tisza and it covers height difference of 780 m, i.e. its fall is 15.8‰.

The Fehér-Tisza, Bila-Tisza as called in Ukrainian enters the surface at an elevation of 1480 m in the Kurbul polonina. Its catchment area with the values of 489.4 km^2 is somewhat smaller than that of the Fekete-Tisza. The fall of the river along the 32.6 km from the source to the joining of the Fekete-Tisza is 30.6‰. The Fehér-Tisza runs in a narrow V shaped valley with steep sides so characteristic for rivers of high grade. The valley widens at Láposmező (Luhi) to 200 m, elsewhere its width is around 40-50m. Its most important tributary is the Saul. The river together with its tributaries runs on the impermeable surface of the Máramaros Massive (Lászlóffy, 1982).

The annual precipitation in the peaks of the Hoverla-Szvidovec is 1600-2000 mm the majority of which especially in the higher regions is snow. Snow melting usually takes place in April. It is frequent that early Spring precipitation warmer than the environment melt the snow cover resulting in catastrophic flooding. Natural vegetation cover is usually forest, beech covers the smaller peaks (above 400-500 m) and pine trees are found on the higher ridges, above 1100-1200 m except for the peaks. The border of forests runs in 1800 m while subalpine meadows and grazing lands are characteristic above this elevation (Tímár et al., 2005).

Review of the literature

According to the survey of Nagy et al. (2002) the rate of cleared forests in the Upper Tisza region in the last eight years is 3.7%. The investigations of Molnár and Gönczy 2006 did not support the assumptions of significant deforestation and associated increase of run-off co-efficient either. Definitely

The results of the research carried out by Tímár et al. 2005 are the following: the rote of forest cover in the catchment area of the Upper Tisza was reduced from 52% in 1896 to 48% by 2002. The same rate was reduced from 73% to 66% in the catchment area of the Fekete- and Fehér-Tisza. This means that 8 nad 9.6% of the forest cover of 1896 vanished. (The

4%/7% /absolute reduction/ is around 8%/9.6% of the 52%/73% /original state/.) This reduction of forests may seem to be great, however, it is not so significant neither in the higher areas of the catchment area nor on the steep slopes (Tímár et al., 2005).

Dezso Zs. and his fellow colleagues made further investigations in the Ukrainian and Romanian sections of the Upper Tisza and they studied land-use changes in the catchment area of the Borzsa, Latorca, Ung, Laborc and Ondava in the periods of 1992/1993 and 2000/2001. They pointed out that the reduction of the rate of forest cover was 3-4% in the parts of the Upper Tisza that are found outside Hungary. The reduction of the rate of forest cover was 18% in the Upper Tisza region in Romania, 5% in the Upper Tisza region in the Ukraine and 12% in the catchment area of the Borzsa. The rate remained unchanged in the catchment area of the Latorca, Ung and the Ondava. The area of the arable lands decreased while the area of non-forest natural vegetation and that of cropland/natural vegetation increased. Built-up area did not change significantly in this short period (Dezso et al., 2004).

Methods, results

Three data sources were applied in the course of the research: the military topographic map with the scale of 1:100000 published by the Cartographic Company of the Ukraine, the maps of the Habsburg Monarchy with the scale of 1:28800 constructed in the course of the second military mapping and the SRTM digital database made by the NASA for free use.

By digitising the landscape types of the two maps applying the software GeoMedia 5.1 the digital map database of the Fekete- and the Fehér-Tisza were completed. In the case of the 1:100000 scale military topographic map issued by the Cartographic Company of the Ukraine the projection system of the digitising was the 35 zone of the 1942 Gauss projection that was later, due to compatibility problems, calculated into UTM 35 with the base surface of WGS 1984. The projection of digitising in the case of the second military mapping was the projection UTM 35. Obtained databases were exported into shape file using which the two land-use maps of the area were constructed (Fig. 2, 4) with the help of the software of ArcView 3.2. After this the intersection of the two maps were performed (Fig. 6).

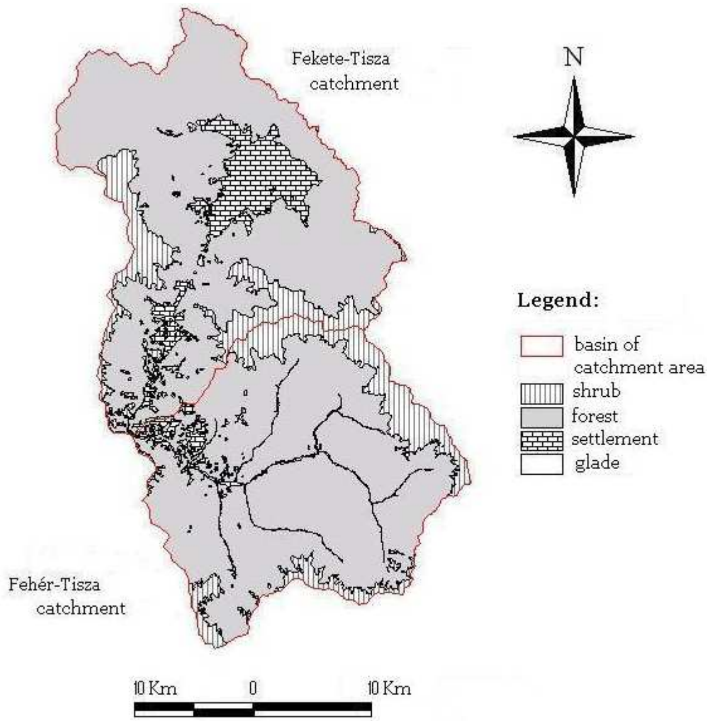

Fig. 2. Land-use in the catchment area of the Fekete- and Fehér-Tisza in the 1860s

According to my calculations in the Fekete- and Fehér-Tisza catchment area the rate of forests, shrubs and settlements were 79%, 14% and 7% respectively from the total area in the 1860s (Fig. 3). Low rate of settlements can be explained by relief conditions, scarce population and by the fact that the area was the periphery of Hungary at that time. Considering land-use it is important that at that time, due to its periphery position the area was poorly industrialised with the domination of raw-material exploitation like mining and logging. Regarding agriculture, apart from the limited households woodcutting already mentioned and associated game management were important.

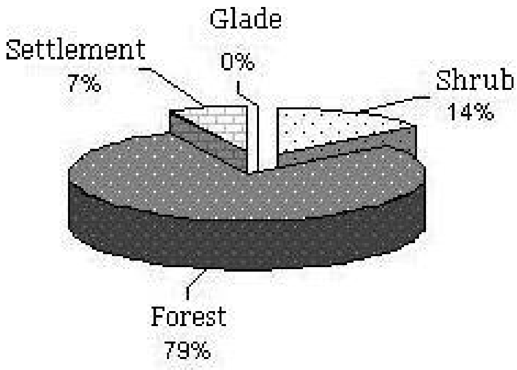

Fig. 3. Land-use distribution in the 1860s

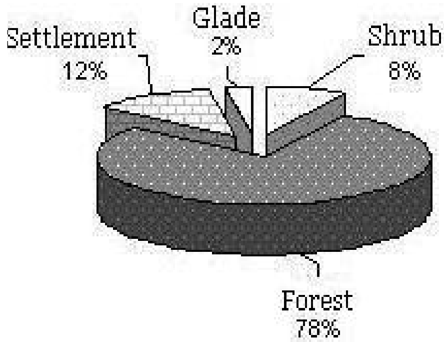

Fig. 5. Land-use distribution in the 1990s

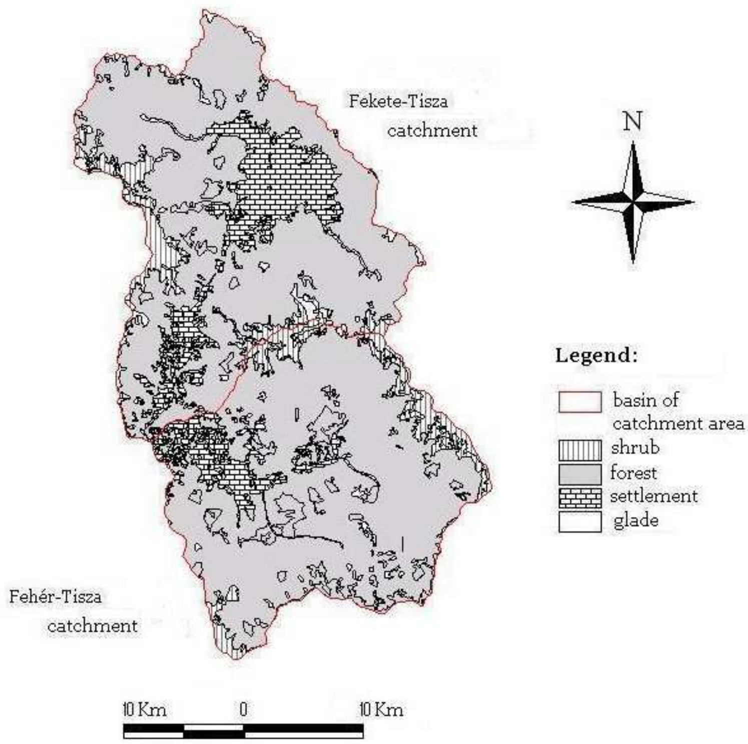

Fig. 4. Land-use in the catchment area of the Fekete- and Fehér-Tisza in the 1990s

It has to be noted that surveys at that time fulfilled the local demands but they were rather inaccurate for today's tasks especially regarding map displays. Many characteristics can be only estimated considering available information and recent tendencies.

The rate of landscape types in the study area in the 1990s were as follows: from the total area 78% were forest, 8% bush, 12% settlement, 2% glade that represented ignorable rates 140 years before (Fig. 5).

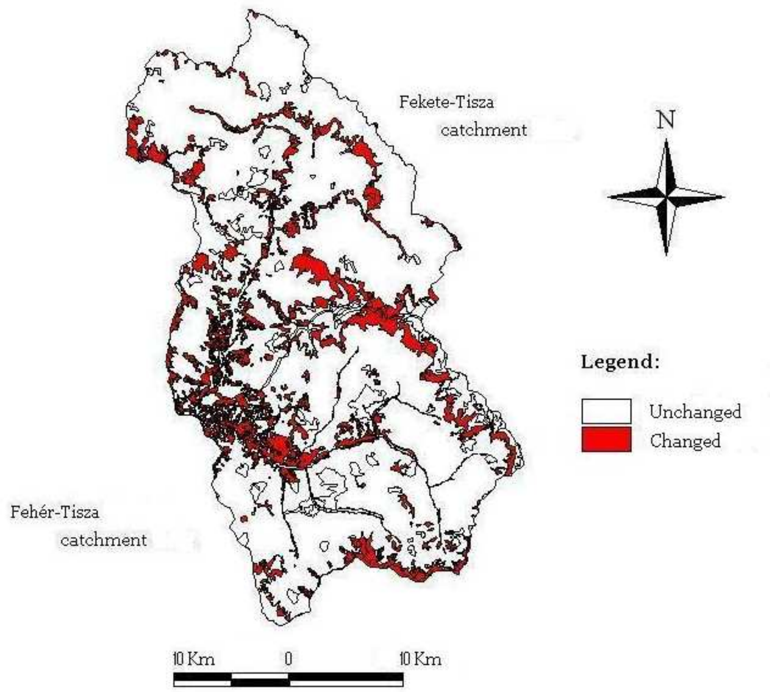

Fig. 6. Changing of land-use in the period between 1860 and 1990

Changes during the 140 years were summarised in Table 1. It is clear that the area of shrubs was reduced by 6%, that of forests was reduced by 1% while the area of glades and settlements was increased by 2% and 5% respectively. Therefore it can be stated that the increase of the area of settlements took place at the expense of shrubs and not forests.

According to the calculations made by the software ArcView, changes affected 16.4% (170.45 km^2) of the area from the 1860s till the 1990s while 83.6% of the area (865.38 km^2) remained unchanged.

Table 1. Land-use changes in the catchment area of the Fekete- and Fehér-Tisza between 1860 and 1990

Type	1860s (%)	1990es (%)	Changed (%)
Shrub	14	8	-6
Forest	79	78	-1
Glade	0	2	+2
Settlement	7	12	+5

Following the construction of the intersection of the maps from the two different times some analyses were performed regarding landscape types (Fig. 7-8).

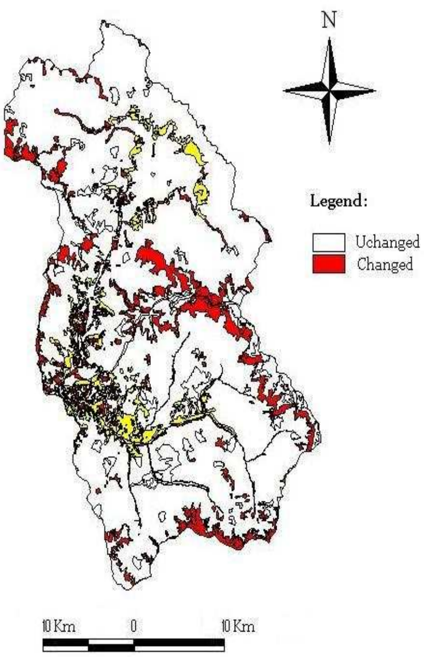

Fig. 7. Yellow areas were forests turned to settlements

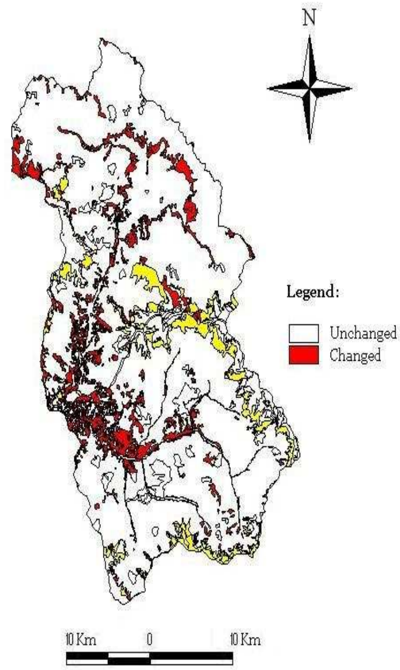

Fig. 8. Yellow areas were shrubs turned to forests

These are summarised in the *table* and in the diagram of Fig. 9. The results are the following: 71% of forests changed into settlements, 19% of them turned into glades and 10% of them became shrubs (Fig. 10). The 85% of the area of shrubs that were changed turned into forests, 9% of them became glades and 6% of them were occupied by settlements (Fig. 12). 71%

of changed glades turned into settlements and 29% of them became forests (Fig. 11). This resulted the surprising fact that 10 km^2 of settlements turned into forests. This is might be explained by that the built-up area of settlements was not separated from gardens when digitising the maps of the second military mapping and the cultivation of gardens might have been abandoned in recent or earlier years.

In total 170 km^2 were changed. From this, changes occurred on 80 km^2 of forest, 79 km^2 of shrub, 0.05 km^2 of glade and 10 km^2 of settlement. Furthermore forest gained 78 km^2, shrub 7 km^2, glade 23 km^2 and settlement 61 km^2 of area.

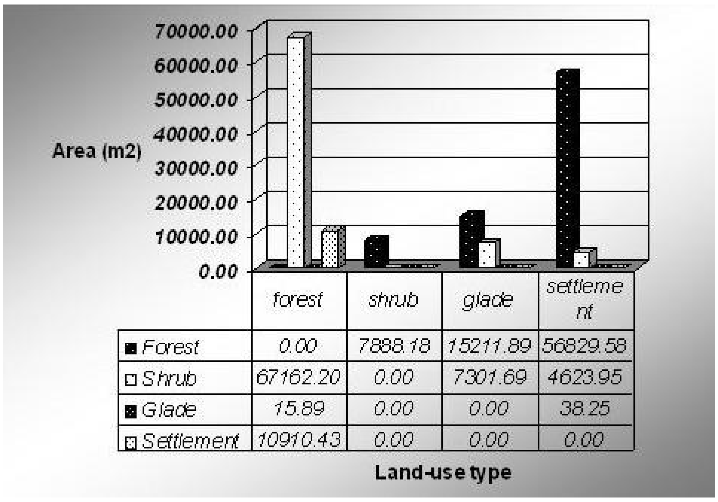

Fig. 9. Area changing

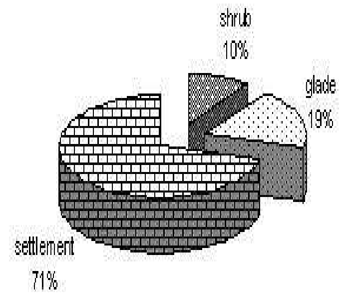

Fig. 10. Forest changing

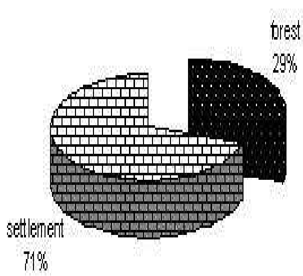

Fig. 11. Glade changing

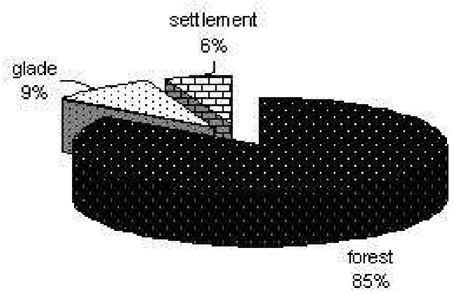

Fig. 12. Shrub changing

Conclusions

These changes cannot be regarded as significant considering the land-use changes and forest cover of the Carpathians and the Carpathian Basin. These changes occurred partly because the area similar to the 1860s was a periphery in the 20th century as well. Regarding the history of the 20th century the area changed supremacy at least three times resulting in the lack of economic investments. The border-side politics of the former Czechoslovakia and the Soviet Union did not favoured investments and economic development. The politics of isolation closed the developed economic relations, and provided no alternative perspectives and relationships. Associated to this as the area was a border-side region with numerous ethnics no significant investments were planted. The natural isolation of the mountainous parts can be mentioned as well. Hard relief conditions favour no industrial investment. These were disadvantageous for humans but were ideal for nature conservation. Regarding agriculture some significant changes can be traced. Rate of arable lands were reduced significantly between 1992 and 2001 following the Soviet-Ukrainian regime change (Dezso et al., 2004). One of the major reasons for this was the elimination of the Soviet type large scale agriculture. Numerous cultivated poorer arable lands were not cultivated later. It is promising that at the beginning of the 21st century the Ukrainian State starts to explore the possibilities in the natural areas. Tourism slowly advances in the county. Presently the poor conditions of infrastructure impede significant tourism investments in the area.

Overall land-use did not change much as forestry is still dominating in agriculture and the area still cannot be regarded as industrialised. Similar to the above mentioned researchers my results also indicate that land-use changes in the area were not enough to influence significantly the variation of the water quantity of the Tisza as it was supposed by some. Knowing the changes in land-use we can gain information on future processes and influence the future ways of land-use. Doubtless the rate of the number of settlements and together with this the population of the settlements have been increased. Land-use of the inhabitants is virtually the same as in the 1860s thus it presents no threat for the natural areas so far. It is preferable that there were no declines in the majority of the area in the past hundred years and the majority of the area remained in close-to-natural conditions.

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STUDYING THE WIND EROSION REDUCING EFFECT OF IRRIGATION ON SOILS OF THE HAJDÚHÁT[2]

Introduction

Wind erosion causes serious damage in many places on the Earth as well as in Hungary regarding vegetation, built-in environment and via transported chemicals (together with dust and pollen) it is dangerous for health as well by resulting in allergy diseases. Initially researches in Hungary concentrated on sand areas of poorer productivity. Later from the 1980s danger of wind erosion was revealed in areas of more bound soils with better agricultural utilisation.

One of the important factors influencing deflation activity of wind is the moisture content of the soil. Increasing moisture content reduces or even eliminates wind erosion. Studying the explanation of this defensive effect it can be stated that cohesion is greater in wetter soils than in dry ones. Surface stress resulted by water coating developed on the surface of the particles due to the moisture content of the soil gives cohesion. Wind can erode the surface only if cohesion between soil particles is exceeded by energy. Another effect is that wet soil particles have greater volume weight than that of dry ones therefore wind can move this particles harder.

Moisture content of soils can be originated from three sources: precipitation, groundwater and irrigation. In the case of precipitation its quantity, distribution and intensity are important. In Hungary extreme distribution of precipitation is the primary source of problems as a part of the intense precipitation cannot infiltrate into the soil, it remains on the surface as inland water where it evaporates or runs off sideways producing loss in the water budget of the area. In long periods without precipitation the soil dries in great depth resulting in the deterioration of the soil structure. This is particularly dangerous due to the great drop energy of intense precipitation that causes the disintegration of the surface particles increasing the intent of the soil to crust formation. Inland water remaining on the

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surface mentioned above also contributes to the formation of surface crust on the soil. The harmful result of this is the delayed shooting of plants as they have to cut themselves through the crust distracting significant amount of energy from their future development. This crust also prevents the entering of air into the soil together with the movement of water in the soil (Blaskó et all., 1998). All these result in the reduction of production averages together with a general soil quality deterioration. On the other hand, the crust has beneficial effect as well as it protects for a time the soil against wind erosion.

Storms producing large quantity of precipitation in a short period of time arrive with strong wind. If there was no rain for a longer time period and the soil surface was dried the wind of the storm would cause serious damage. At such occasions dust storms are also frequent.

Soil moisture is supplied from the groundwater through capillary water elevation. Groundwater can have either harmful or beneficial effect on soil moisture. When it is situated too high limiting the growth of plant roots or its salt (sodic) content results in sodification, it is harmful. These conditions deteriorate soil structure as well. It is beneficial when it is situated deep enough to have positive effects on the water uptake of roots. Of course, too deep groundwater may also considered harmful as capillary water elevation cannot produce water for roots. Groundwater can be supplied from either precipitation or irrigation. However, over irrigation may result in the elevation of the groundwater table near the surface. Examples for this can be observed in the former rice producing areas.

Relationship between irrigation and soil is similar to relationship between precipitation and soil. A significant difference is that the amount and distribution of irrigation water can be controlled, therefore it is important to note the followings (Filep, 1999):

- In the relationship of soil and irrigation the role of the quantity and quality of irrigation water, movement, chemical composition and distance from the surface of groundwater; standard of irrigation management together with the method and frequency of irrigation are important.
- Regular irrigation influences the water budget, physical and chemical properties of the soil. The effect of regular irrigation on soil physical conditions can be observed primarily in the changing of the structure, porosity and water conductivity of the soil.

- Cultivation when the soil is too wet also results in the deterioration of soil structure. However, structure deterioration can be eliminated by applying appropriate agricultural technique together with appropriate irrigation technique, timing and water releasing velocity.
- Not appropriate composition of irrigation water (e.g. containing large quantity of sodium salt) also results in soil degradation.

Wind tunnel experiments with wet soils were performed to study the wind erosion reducing effect of different amount of precipitation and irrigation on different soil types. For these a drought land cultivated basically by ploughing was chosen as study area where water was supplied by irrigation.

General description of study area

The study area is located at the connection of three landscapes (Hortobágy, Hajdúhát, Nyírség) in the region of Hajdúnánás-Hajdúdorog. The site was picked due to the varied geological-geomorphological conditions of the neighbouring areas ensuring widespread types of factors influencing wind erosion regarding soils, drainage and land-use as well.

The area is a transition zone from West to East considering both geological and geomorphological conditions. From the completely flat area of the Hortobágy the landscape becomes undulating towards the Nyírség and relief increases as well (of course in lowland terms). This transitional character appears in the case of soils as well. Bound partly underwater soils with high clay mineral content (solonec meadow and meadow soils) are substituted by less bound, looser soils with higher sand content more suitable for cultivation (Plain carbonaceous chernozem and other chernozem types).

The climate of the area is transitional between the cooler-wetter Nyírség and the warmer-drier Hortobágy. Sunlight is 1950-2000 hours while the precipitation varies between 500-550 mm. It is important to know that the water budget of the area is vaporising. Water required for agriculture is provided by irrigation. Extreme weather conditions together with irregular distribution of precipitation help the process of wind erosion. Rapid fall of great quantity of precipitation deteriorates the structure of the top-soil via the great drop energy of storms.

Water geographical conditions of the Hajdúhát are poor as it is one of the least supplied are of the Great Plane regarding inland channels. Only its western edge is crossed by the Eastern Main Channel the water of which is provided by the dam at Tiszalök. Irrigation in the area is also provided through this channel. Depth of groundwater table can be found around 2-2.5 metres, however, it was strongly reduced in the first half of the 1990s. This is important because capillary water elevation provides less amount of water for the plant roots. (In contrary uplift of the groundwater table is experienced within the area of the settlements due to inappropriate sewage handling.)

Materials and methods

For the research 16 soil samples were collected from cultivated areas (Fig. 1). Sedimentological analysis (with Köhn pipette) of the samples together with humus (with Tyurin’s method) and carbonate (with Scheibler’s technique) content determination were performed. Wind erosion experiments were completed in the wind tunnel of the Institute of Earth Sciences at University of Debrecen.

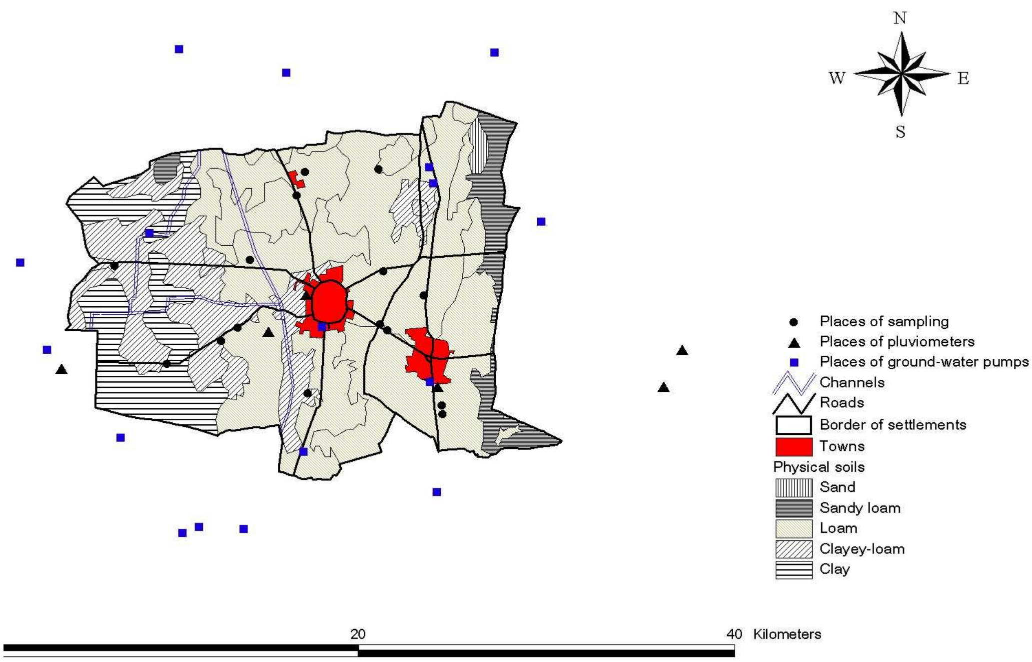

Fig. 1. General map of the study area

Samples with different moisture content collected for wind tunnel experiments were dried in oven. Following this contaminants (stubble remnants, weeds, roots, etc.) present in the soil together with larger soil aggregates were separated via sieves sized 2 mm.

Soil samples prepared in this way were placed into the wind tunnel in metal trays with the area of 30x50 cm and depth of 5 cm. A gentle elevating slope was constructed in front of the trays in order to prevent the collision of air into the vertical wall of the tray that would produce turbulence.

Experiments in the wind tunnel were performed at several velocity levels and wind velocity was measured at several points. The experiment series was aimed to provide for determining the erodibility index of different soil types.

First the critical starting velocity of the soils was determined. Then in order to gain more knowledge on agricultural soil deteriorations the quantity of transported material was determined at four velocity levels. The quantity was determined by the difference of the weight of the material before and after the experiment. The time period for the measurements was 5 minutes.

When studying the water retaining capacity of the soils irrigation covering 0.5, 1.0, 2.0 and 5.0 mm of precipitation was applied. Weight of the tray full of dry soil was measured before the experiment then water equalling the weight of the given amount of precipitation was sprinkled evenly onto the soil. Measurements lasted for 10 minutes. In the experiments with wet soils the time required for the evaporation of the sprinkled water at different wind velocities was measured.

Maps were constructed by software ArcView 3.2 while data analysis was performed by software Microsoft Excel.

Results

Results of sedimentological experiments

Soil samples were classified into three groups regarding their grain size distribution: loam, clayey loam and clay. 12, 3 and 1 samples belonged to loam, clayey loam and clay types respectively. There are significant differences between loam soils regarding the rate (6-27 %) of the fraction (0.1-0.2 mm sand) eroded most easily. Clay content reaches not (except for 1 sample) 10 %. In clayey loam and clay soils dust and clay fraction dominate (the two together reached more than 50 % in all four soils) with very little sand content. Transitional character can be observed in the structure of the soils as well: rate of sand gradually reduces in the favour of silt and clay from the marginal areas of the Nyírség towards the Hortobágy.

Rate of carbonate content important considering cohesion between grains varies generally between 5 and 10 % with humus content remaining below 5 % in every case.

Results of erodibility examinations

Soil samples were classified into four groups regarding erodibility that were created based on the classification of Lóki J. (2003) in order to maintain comparability.

I. category: Loam soils (variations of chernozem and sand soils). Their critical velocity speed is 9-11 m/s with the quantity of transported material more than 3.2 kg.

II. category: Also loam soils (lowland carbonate chernozem). Values of critical critical velocity speed vary between 7 and 11 m/s with 1.5-3.2 kg of transported material.

III. category: Loam soil that is deep saline meadow chernozem genetically. Its critical critical velocity speed is 10.2 m/s with 1-1.5 kg of eroded material.

IV. category: Soils of loam structure were classified here (meadow soils, meadow solonetz) together with clayey loam and clay structure soils erodibility values of which remained continuously below 1 kg with critical velocity speed between 9 and 12 m/s.

Examination of water-retaining capacity of soils

During the experiments the temperature and moisture content of the moving air was measured continuously by instruments placed into the wind tunnel. In the course of the experiments the temperature of the air depended on outer temperature while moisture content changed depending on the amount of water evaporated and temperature. In nature the joint effect of several factors influence these characters (wind, temperature, moisture content, sunshine, soil moisture, vegetation cover). Thus measured data can be used only for comparing the samples.

Studying the average results of the experiment series it can be stated that there are significant differences in the water retaining capacity of soils. It is visible already when water was sprinkled onto the soils that it infiltrates faster into soils of coarser grain size than in samples containing higher rate of silt and clay. In experiments with bond soils a thin water cover developed following the sprinkling of greater amount of water (5 mm) onto the soil. (Wind tunnel experiments were started after the infiltration of water in every case.) How the soil surface become wet, its water retaining capacity and water conductivity depends primarily on its mechanical composition, therefore this assessment was performed on the basis of textural classification of soils. Average values belonging to the given texture classes were determined from the data of the experiment then plotting the data and fitting a trend-line on them we tried to point out function relationship between wind velocity and the time required for evaporating the amount of water applied in the course of irrigation. Based on the results the followings can be stated (Table 1):

- Water conductivity and evaporation loss was greatest in the case of sand soils. Watering of the soils depends on the volume of irrigation. The drying of the surface of the sand within a few minutes was striking already at the experiment series with the second velocity grade. Wind started moving surface particles immediately following this rapid drying of the surface.
- Displaying the average experiment values differences caused by differences in the volume of irrigation on the one hand, effect of velocity increase on the second hand, together with differences in the soil categories are striking. It has to be noted that differences between the average values of the individual texture classes and the measured values of the individual samples belonging to the same categories are significant. This can be explained primarily by differences in grain size distribution, however, based on the analysis of the values of the individual samples the humus and carbonate content of the soils could have influenced the pace of drying of the soils.
- With increasing velocity the time of evaporation reduces significantly. Different water retaining capacity of soils was clear at higher velocity levels as well. Analysing the results revealed that there is a quality change at around 9 m/s of velocity regarding the relationship between wind velocity and time required for moisture evaporation. Evaporation is much slower in the case of wind velocities greater than 9 m/s.

- Drying time of soils depends also on the amount of water applied for irrigation. In case of applying small amount of irrigation water differences between soil types were eliminated. This can be explained by that in these cases only the top-soil becomes wet thus the role of adsorption capacity of the grains is not so significant.
- On surfaces lacking vegetation cover 1 mm of irrigation water should be applied and 0.5 mm of water provides protection against wind erosion for only a short period of time.

Table 1. Average values of wind velocities and drying time on examined soils

sand	Irrigation							
	0.5 mm		1 mm		2 mm		5 mm	
	m/s	min.	m/s	min.	m/s	min.	m/s	min.
	4.53	98.00	4.51	232.25	4.53	355.00	4.49	806.75
	7.93	67.00	7.63	122.00	7.60	233.00	7.68	570.25
	9.95	48.00	9.90	103.75	10.00	187.00	9.78	379.35
	15.53	30.75	15.80	52.00	15.38	100.00	15.38	251.44
loam	0.5 mm		1 mm		2 mm		5 mm	
	m/s	min.	m/s	min.	m/s	min.	m/s	min.
	4.85	177.09	4.83	238.73	4.77	495.18	4.87	1416.91
	7.57	89.73	7.55	144.91	7.29	243.36	7.63	625.00
	10.46	64.00	10.26	111.09	10.13	200.00	10.25	429.00
	15.45	38.00	15.35	74.30	15.65	124.55	15.46	347.00
clay	0.5 mm		1 mm		2 mm		5 mm	
	m/s	Min.	m/s	min.	m/s	min.	m/s	min.
	5.00	150.00	5.00	245.00	5.00	475.00	4.90	899.00
	8.10	75.00	8.10	125.00	8.00	299.00	8.00	675.00
	9.60	58.00	9.60	107.00	9.80	214.00	10.00	441.00
	15.70	30.00	15.80	60.00	15.80	120.00	15.80	300.00
clayey-loam	0.5 mm		1 mm		2 mm		5 mm	
	m/s	min.	m/s	min.	m/s	min.	m/s	min.
	5.03	111.00	4.87	361.33	4.83	411.00	4.93	944.33
	7.93	81.67	7.97	131.00	7.97	253.33	7.97	567.33
	9.70	58.67	9.70	106.00	9.63	216.67	9.60	460.67
	15.60	32.67	15.57	64.67	15.40	136.33	15.13	319.00

Summary

Effect of irrigation was studied on 16 soil samples in a study area located in the contact zone of the Hortobágy – Hajdúság – Nyírség where

factors influencing wind erosion (soil structure, vegetation cover, land-use, etc.) are present in wide spatial variability.

Based on the experiences of the experiments it can be stated that soil surface becomes wet due to irrigation or precipitation within a longer or shorter period of time depending on the water conductivity of the soils. Drying rate of the wet soil varies greatly depending on the mechanical composition of the soil. The drying of the soil is determined by its water retaining capacity in areas lacking vegetation cover. Water retaining capacity makes infiltration of water into the soil slower and reduces evaporation. Movement downward of water is determined by the water draining and conducting capacity of the soil the relationship of which with grain size distribution is known commonly (Birkás, 1993).

When discussing wind erosion reducing effect of irrigation its indirect effect has to be mentioned as well as seeds germinate faster in wet soils and plants grow better due to the faster disintegration and humification of organic material. Aerodynamic resistance and protection of the developed vegetation is beneficial in fighting against wind erosion.

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EXAMINATION OF GEOMORPHOLOGICAL MEASUREMENTS IN A HUNGARIAN SAMPLE AREA

Introduction

Geoinformatical methods and new techniques have brought fundamental changes into geographical research in the past few decades. A good example is the relative relief map, which was used to feature the quantitative properties of the surface. Nowadays it has been replaced by the high accuracy slope-category map, used even in wide areas as well (Püspöki et al., 2005, Szabó, 2006). Another good example is the Shuttle Radar Topography Mission (SRTM) database, which provides surface elevation data (for free!) about the major section of the continents. Thus it is not by chance that these methods and databases are widely used in every branch of geographical research.

However, every new method has its risks and we must be aware of them. During our research we had two aims:

- to compare the results of two widespread methods (map vectorising and SRTM) with those of a conventional research method (land survey),
- to analyze with geoinformatical methods whether the change in the number of sample points in a land survey causes a considerable change in the model surface.

Materials and methods

The sample area is located in Bükkalja (Fig.1). It is a pediment surface of the Bükk mountains in the North of Hungary.

The sample area is an about 300m long and 150m wide valley (Fig.2). The land use of the area is pasture, surrounded by agricultural fields. The bottom part of the valley is covered by shrubs and young trees.

The field survey was carried out with a Geodolite 506-B Geodetic Total Station. The number of the recorded survey points is 144. Figure 2 shows the distribution of the points. The average distance between the points is 15 meters.

Our reference point was a geodetic point (signed: 87-4077) at the upper end of the valley (Fig.3). The coordinate system is the GRS-67-based Uniform National Projection System, or in another name HD-72 (in Hungarian: EOV).

Fig. 1. Location of the sample area

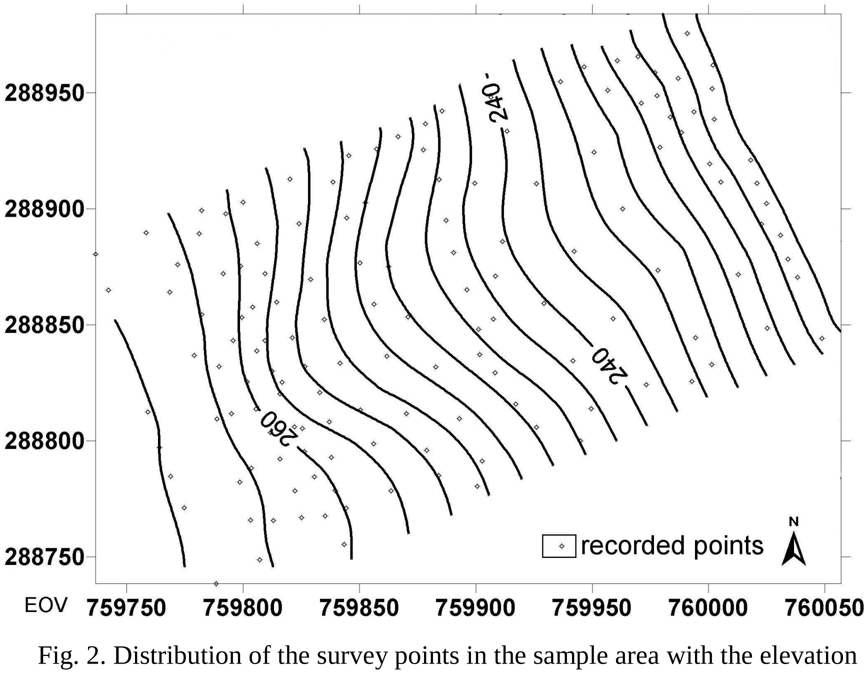

Fig. 2. Distribution of the survey points in the sample area with the elevation contour lines

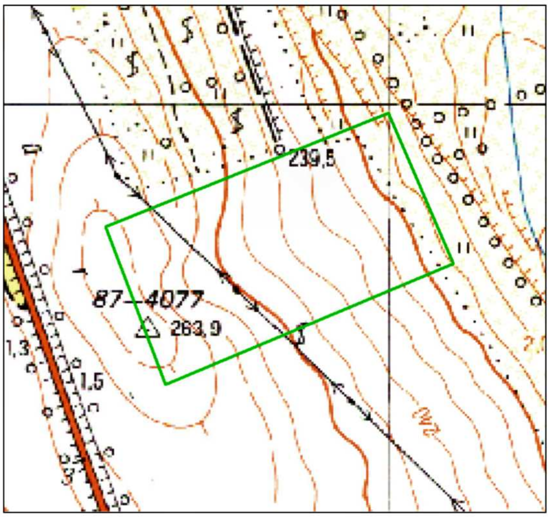

Fig. 3. Location of the sample area on a 1:10’000 topographic map

SURFER-8 software was used for processing data and interpolating DEM (dubbed “DEM15”). A 2m by 2m pixel-sized database was created out of the interpolated database, and was imported into IDRISI-32-Release2 software.

On the 1:10’000 topographic map the steps of the topographic contour lines are 5 meters. The vectorising of these lines was performed in ArcMap 9 software. Using the vertexes of the digitized contours a 2m by 2m grid-shaped digital elevation model was built in SURFER-8 software.

The SRTM database was transformed to 2m by 2m pixel size in IDRISI32 as well. Of course, the transformation of the SRTM surface did not result in a better quality or higher resolution, but this step was necessary for the later comparison of the three databases.

Later the pixel results of the different DEM databases were subtracted from one another to get the differences of the surface models.

The next step was to classify the DEMs into 9 elevation classes. The width of each class is 5 meters.

Next, cross-tabulation was applied on two-two DEMs respectively. In this method the Kappa Index of Agreement (KIA) shows the amount of difference between two databases (0: total difference, 1: complete similarity).

The number of the survey points was reduced in a way that the average distance between the points was first changed to about 30m (called “DEM30”) then to about 60m (called ”DEM60”). The points were imported into SURFER-8 software and DEMs were created. The volume of the slope, surrounding the valley, was calculated in SURFER-8 as well, choosing for bottom surface the 200m height above mean see level.

Results

Comparing the two DEMs composed of the survey points and the 1:10’000 topographic map, it is obvious that the DEM of the topographic map is higher in most cases than the DEM of the survey. The difference is the most significant at the higher parts of the slope: it shows almost two meters (1,9m). In the lower parts of the valley the DEM of the survey database is the top layer, the maximum difference is 1,5m. The key is the direction of the elevation contours: in the upper part of the slope the contours are “over curved” on the map, to emphasize the valley for map users (Fig.3). This condition affects the DEM interpolation. The DEM involving the survey points shows the “real” conditions of the slope (Fig. 2), thus the contour lines are less curved.

Comparing the DEM of the survey points with the SRTM database it can be set out that the differences are more significant than in the previous case. At the center area of the upper part of the slope, the SRTM surface shows higher values. The maximum difference is more than 4m. In contrast to that, in the lower parts and on the rims of the slope the SRTM surface is the lower one, and the maximum difference is more than 8m. The reason for this is the resolution of the SRTM database: originally the size of an SRTM pixel is 60m by 60m, thus we can get just one elevation value from this rectangle-shaped area. The valley has the most diverse relief at the upper part of the slope, thus here is the most significant effect of averaging, causing inaccurate surface on this area.

Hereinafter the maps categorized into 9 classes (composed of survey points versus map data) were compared. The values of KIA are more than 0,9 in the majority of the sections of the slope, except for the higher parts of the valley (245-260m), where the values of the top three categories are less than 0,8. The reason is again the method of drawing the topography map contours.

Comparing the field survey surface with the SRTM database the similarities are far smaller than in the previous situation. The mean KIA is 0,72, and reaches the 0,8 value in just two categories out of the 9. In most cases it is about 0,5-0,6, thus only 3/4 of the pixels of the two databases fall in the same category. There are two main reasons for this significant difference. The low resolution of SRTM dataset is a strong restrictive factor in such a small-range valley. On the other hand, in the lower part of the valley, the shrubs and trees affect radar-measuring.

Doubling the distance of the survey points (from 15 to 30m), the largest variances are between -60 cm and 1m. Extracting the surface of DEM30 from the “all point DEM” we get the function shown in Fig. 4.

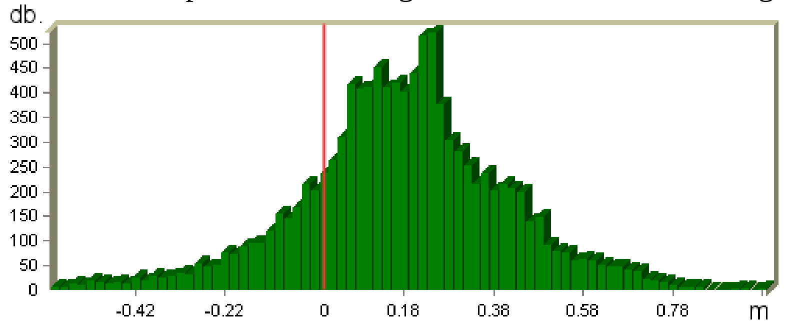

Fig. 4. Function of the differences of the 30m DEM and the 15m DEM datasets

The function shows a nearly normal distribution dataset, the median is at the positive section of the scale. Thus it is obvious that interpolating DEM with 30m range field points, the resulted surface is lower than the original surface.

The following step was the doubling of the space (to 60m) between the survey points (i.e. reducing the number of points). Comparing DEM60 with the original DEM15 the local differences are larger than before: -1,43m to 2,08m. The function (Fig.5) shows that the most frequent values are at the positive half of the scale, which means that DEM60 is usually lower than the original DEM15. Table 1 shows the volumes of DEMs using 200m height above mean sea level as basis plain. The table shows that reducing the number of survey points the calculated volume changes drastically. Comparing the volume of DEM60 to the volume of DEM30 the difference is not double but more than tenfold.

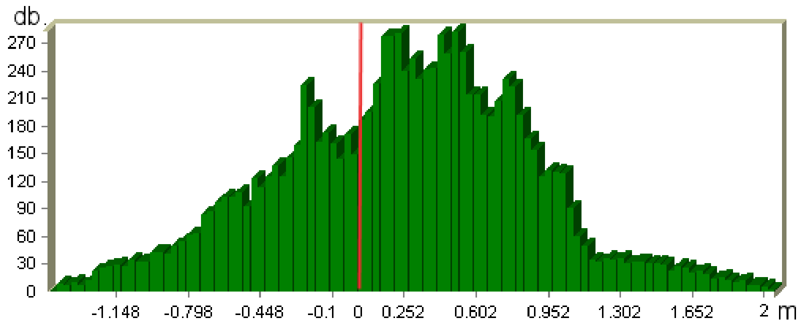

Fig. 5. Function of the differences of the 60m DEM and the 15m DEM datasets

Table 1. The volumes of the different DEM-s (basis plain: 200m MSL.)

Mean distance between survey points	Volume m^3(basis: 200 mBf)	Difference (m^3)
15 m	3210522	0
30 m	3210216	306
60 m	3206648	3568

Summary

It can be stated that using different datasets to model a valley causes significant differences in digital elevation models. This difference is smaller in the case of a 1:10’000 topographic map and more significant at the popular SRTM database. In a field survey the density of the recorded points can affect the results. It is important to take into account that doubling the distance between the points aberration will be much more than double.

The results of the examinations could be affected by numerous factors:

- The density of the recorded points. Recording much more points than needed (e.g. every 10cm), which is possible with modern surveying stations, it is not sure that reducing the number of points causes significant difference in the interpolated surface.
- The applied method of the interpolation affects the surface.
- In many cases topographic maps contain smaller or larger inaccuracies because of aiming for better interpretation.

Our examinations have shown that geoinformatical and measuring methods, which are widely used in geographical research, can have numerous risks, which we have to take into account.

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THE KEY FACTORS OF THE DRY STONE WALLS DILAPIDATION ON THE SÁTOR HILL AND CSOBÁNC HILL, HUNGARY

Introduction

The study has been carried out on two smaller hills in famous Hungarian wine regions. The Sátor Hill is the part of a world heritage site, the Tokaj foothills (Tokaj-Hegyalja) Historical Wine-producing Region, while the Csobánc Hill is located in the Badacsony Historical Wine Region near Lake Balaton. Both regions have strong viticultural traditions, which have survived for over 1000 years, and significantly transformed the landscape as a result of vine cultivation.

Unfortunately, nowadays land degradation is a common phenomenon in the terraced vineyards, characterized by steep slopes and higher altitudes of the hilly wine producing regions, where vineyards are cultivated with very low management and incomes. The land use change directly related to economic conditions plays an important role in the process of the landscape degradation and terraced ground dilapidation. Since one of the most representative forms - the dry stone walls have also been destructed on cultivation vineyards too, the dilapidation process may not bring into connection with the vineyard abandonment.

In the study, the effect of natural processes modified by anthropogenic impacts and land use change on the dry stone walls dilapidation is assessed by several basic investigations.

Materials and methods

To measure the effects of dilapidation processes, 4-4 different environments of the dry stone walls have been selected on the slopes of both research areas (Sátor Hill, Csobánc Hill). Topographic maps of scale 1:10000, and field survey were used to recognise the environments of the dry stone walls, representing different land uses. The different vegetation stages were grouped in three main land use types according to the age of abandonment: recently cultivated vineyards, vineyard abandonment recently (dense weeds and cleared shrubs), long-time abandonment (dense shrubs and trees). In the course of the field survey the parameters of the supporting walls (height, length, frequency and types of the wall-breaks) were measured in each environment. Moreover, soils of each terrace level (in front of it and at the back of it) and the segments of the destructed supporting walls were sampled at every 10 centimetres. In the laboratory, samples were air-dried (20 C°) and basic measurements (pH, organic carbon and $CaCO_3$ contents) were carried out. Finally, the grains with different size of the samples have been separated by boiling water to determine particle size distribution.

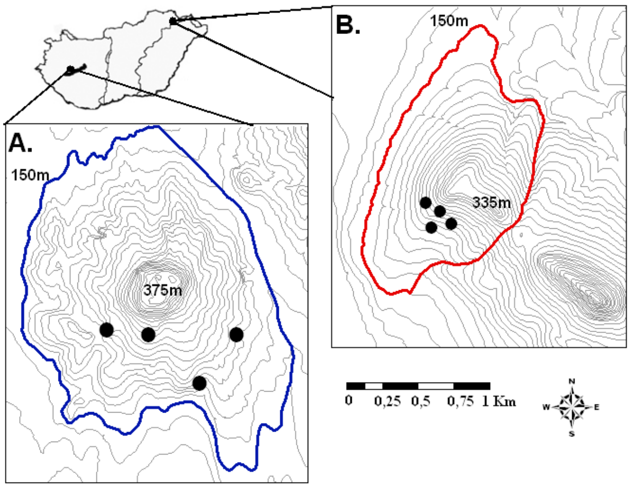

Fig.1. The research areas with 4-4 different environments, Csobánc Hill (A.) and Sátor Hill (B.)

Area description

The viticulture might have started in the region of Tokaj and Badacsony as early as in the Roman times, several findings point to the existence of viticulture.

1. The most famous and the well-known wine region abroad, Tokaj foothills Historical Wine-producing Region is situated on the pediment of the Tokaj Mountains, a member of the inner Carpathian volcanic range, NE Hungary. In 2002 UNESCO incorporated it into its World Cultural Heritage list as a region of outstanding cultural significance, because of the untouched, original form of viticultural traditions that were developed over the last thousand years, the characteristic vineyards, individual wine cellars,

villages and towns. The region consists of 28 villages and 7,000 hectares of classified vineyards, extended from the Sátor Hill of Abaújszántó to Sátor Hill of Sátoraljaújhely. The Sátor name denotes the shape of hills, which means tent.

Next to the city of Abaújszántó (48º 16’ 30”N, 21º 11’ 01”E), the Sátor Hill is located in the NW border of the wine region in the buffer zone. It occupies an area of 1,4 km^2, ranging from 150 to 335m above sea level. The parent material consist of Sarmatian - Pannonian acid rocks, rhyolitic tuff and rhyolite lava composing several hundreds meters wide strata. (SZEPESI 2007) More than 50% of the whole area is characterized by steep slopes (17-25%, 25-40%), moreover the slopes having a gradient of more than 40% occupy further 11,42%. On the hill vineyards have been cultivated up to nearly 300 m above sea level shown by terrace-dry stone wall system. In general, on the Sátor Hill the height of the supporting walls is between 100-250 centimetres, however it can reach four meters on the steep slopes. Consequently, the average width of the terrace grounds vary between 25-53 meters and in case of steeper areas it decreases to 5 m.

2. The Badacsony Historical Wine Region near the NW shore of Lake Balaton is located in the Tapolca Basin, one of the most famous Hungarian basalt-volcanic regions. The Tihany Peninsula and the area of the Tapolca basin by a collective nomination is entered on the Tentative List of UNESCO.

The Csobánc Hill is situated next to the village of Gyulakeszi (46º 52’ 08”N, 17º 28’ 55”E). The basaltic circumdenudated butte covers an area of about 3 km^2, ranging from 150 to 375m above sea level. The bedrocks of the Csobánc Hill consist of mainly Sarmatian limestone, Pannonian gravel, sand, sandy-silt, clay, and clayey-marl and Pliocene basalt. (BORSY ET. AL. 1987) The Csobánc hill can be divided petrographycaly into three levels: the basaltic mesa with extremely steep slopes, the area of the basaltic debris slope and the foothill area. From approximately 270m altitude, the foothill area consisting of the Pannonian sediments is bound to the viniculture characterized by mainly slopes less steeper than 40%. Since the Csobánc hill has a small difference in level and has relatively gentle slopes, thus the establishment of the economically viable benches did not require height supporting walls. The average height of the dry stone walls is between 70-150 centimetres with 18-35 meters wide terrace benches, however toward the basaltic debris slope the height of the supporting walls increases to 250 centimetres following the approximately 8 meters wide terrace ground.

Anthropogenic landscape

For centuries, land use and vine cultivation have been transforming the landscape in both wine regions. Numerous new man-made features were created both under- and over-ground (terraces, dry stone walls, stone hedges, waterways, sediment traps, wine-press houses and cellars), which have been integrated into the landscape as its organic parts and influence geomorphic and environmental processes.

The rise of Tokaj foothills Historical Wine-producing Region can be dated back to the early 16th century. In consequence of innovative processes the landscape was transformed significantly. Wage labourers coming from the Saxon (German) settlements of the Felvidék ('Upper Hungary'), for example Metzenzéf began the construction of the terraces. However, on the Csobánc Hill the terrace and the supporting wall systems with water channels were constructed with the method learned probably from Italian farmers to ensure an economically viable ground.

The purpose of forming terraced surface is to reduce the gradient of the steep slopes, so as to protect the top-soil against erosive removal as well as to influence favourably the drainage of the slopes, to reduce the surface run-off, to improve the water storage capacity of the soil. On the Sátor Hill, at first a base had been sunk into the parent material (Rhyolite) to support the stability of the dry stone wall. This was uncharacteristic on the slope consisting of loose material (sand, sandy-silt) of the Csobánc Hill. The supporting walls were built of flat stones without any binder, their cross-section was trapezoid, therefore the front is slightly inclined backwards. Compactness and stability was worked out by socketting the huge blocks (∅ 80cm) in the first row of the supporting walls, and filling the gap with smaller stones. Behind and next to the dry stone walls water channels with a mud-hole at the end had to be formed to drain off rainwater. On the Sátor Hill the sediment traps (also known as lictor-holes in Hungary) can be found in the vineyards between the rows.

Results and discussion

The characteristics of wall-breaks have shown significant differences among its occurrences. The different wall-breaks can be grouped in three main types according to the depth from the crown of the dry stone walls: wall-breaks in the uppermost zone (0-40 cm), dilapidation in middle zone

(40-100 cm), and total destruction zone at the bottom of the supporting walls (below 100 cm). (Photo 1-2.)

In the uppermost zone the soil accumulation on the crown of the dry stone walls plays a key role in the degradation of dry stone walls. Cultivation without any kind of management activities might cause significant land degradation problems due to the fact that the hydrological infrastructures (grassed waterways and the ditches strengthened by stones, sediment traps, or also known as lictor-holes), which protected the soil from erosion, have been progressively collapsing, mainly as a result of the strong removal of the top soil. This phenomenon leads to the dilapidation of the crown of the dry stone walls. Generally, the crown of the dry stone walls is covered up by 30-50 cm height sediments initating the accumulation on the lower terrace ground, and causing the vine-stocks fell down and the downwards movement of vine-stocks. Nevertheless it can not cause the total destruction of dry stone walls because the soil accumulated on the crown with some rocks from the wall move away through mass movements passing step by step, and it affects the uppermost several centimetres of the dry stone wall.

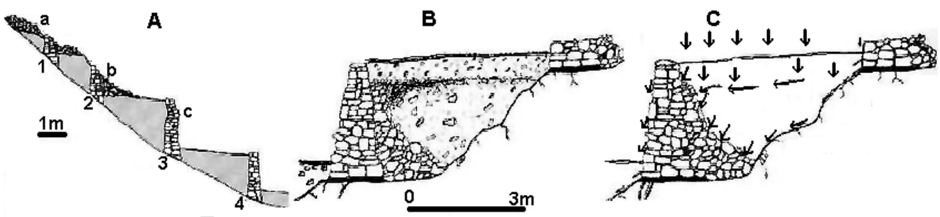

Fig.2. The terrace dilapidation process in Cinque Terre (Carl and Richter 1989)
A. Phases of terrace destruction in profile: 1. Old wall break, 2. New wall break, 3. Imminent wall break, 4. Intact wall; a. Debris, soil is washed away, b. Debris with soil material, c. Wall-belly; **B**. Cross-section of a terrace with compaction horizon; **C**. Water movement within the terrace soil and the supporting wall

The process which generally causes total destruction of the dry stone walls takes place through breakdown and slide. According to T. Carl and M. Richter (1989) the dilapidation of the dry stone walls is caused by having a compaction horizon at the depth of 40cm as a sliding surface in the Cinque Terre (Fig.2.). Due to the water movement in the terrace soil and in the supporting wall small channels build up and the water accumulates above the compaction horizon. Thus, in the contact zone between wall and compaction horizon it may come to an increased sludging of fine material into the joints. After the initial convex bulge (wall-belly) the upper third of the wall collapses leading to the formation of a steep slip face. A breach in a wall structure may also lead to the devastation of terrace level.

The analysis of pH, organic carbon, $CaCO_3$ content and grain size distribution was performed in order to assess whether differences in soil properties existed among the profile of the destructed supporting walls or not. The dry stone walls examined on the Sátor Hill were 50-53 m long and 200-250 cm high; on the Csobánc Hill it was 28-50 m long and 70-240 cm high.

● In both study area, the soil pH ranged from 7,22-8,8 (neutral-poorly alkaline), related to the parent material, slightly lower by acid rock (rhyolite) than Pannonian sandy material, except for the test hole number 4 on the Sátor Hill, which presented a very acid pH 4,31-5,8. Along the profiles of the terraced grounds no significant differences have been found.

● Soils with mould are shallow ranging from 10 to 20 cm depth, soil organic matter presents the highest value in long-time abandonment environments (6,45%), reaching the lowest value in cultivated vineyards (1-2%). Organic carbon content decreases suddenly from 10-20cm depth toward the lower layers of the terraced soils to 0-1%. For both studied areas, the second highest values of organic carbon were measured at 60-70 cm depth (at the so-called "root zone"), characterised by 3,85-1,95%.

● On the Csobánc Hill $CaCO_3$ content is generally higher (8,87-44,44%) than the samples from the Sátor Hill (8,8%-13,55%). In both studied area maximum recorded values were defined at 3 depths: 10-20 cm, 60-70cm and the third was the lower parts of the destruction zone.

● Particle size distribution differs in the two study areas, rhyolite-debris dominates on the Sátor Hill and the sand fraction is predominant on the Csobánc Hill. In the samples taken on the Csobánc Hill the ratio of rubble, pebble and coarse-grained sand fractions is imperceptible contrary to soil material of the Sátor Hill. (Fig. 3.)

In each environments the low percentage of clay was recorded, it was slightly higher on the Csobánc Hill (from 2,4% to 25,1%) than on the Sátor Hill (2,4-13,8%). Fine fractions (<0,02mm) presented the same trend as the $CaCO_3$ content, the highest values are related to the maximum values of the calcareous material. Higher proportions have been determined at 60-70cm and at the foot of the dilapidations in both studied area. At the bottom of the supporting walls, 20-30 cm above the parent material the third maximum values can be found as an accumulation zone (on the Csobánc Hill 100-140cm, on the Sátor Hill 100-190 cm), where the total destruction of the dry stone walls take place.

In general context, accumulation of the fine-grained material within the wall structure lead to the appearance of the wall-belly like in the case of the sample of the Cinque Terre. However, the compaction horizon at the depth of 40 cm couldn’t be observed in both examined area, moreover it can be found three different dilapidation zones.

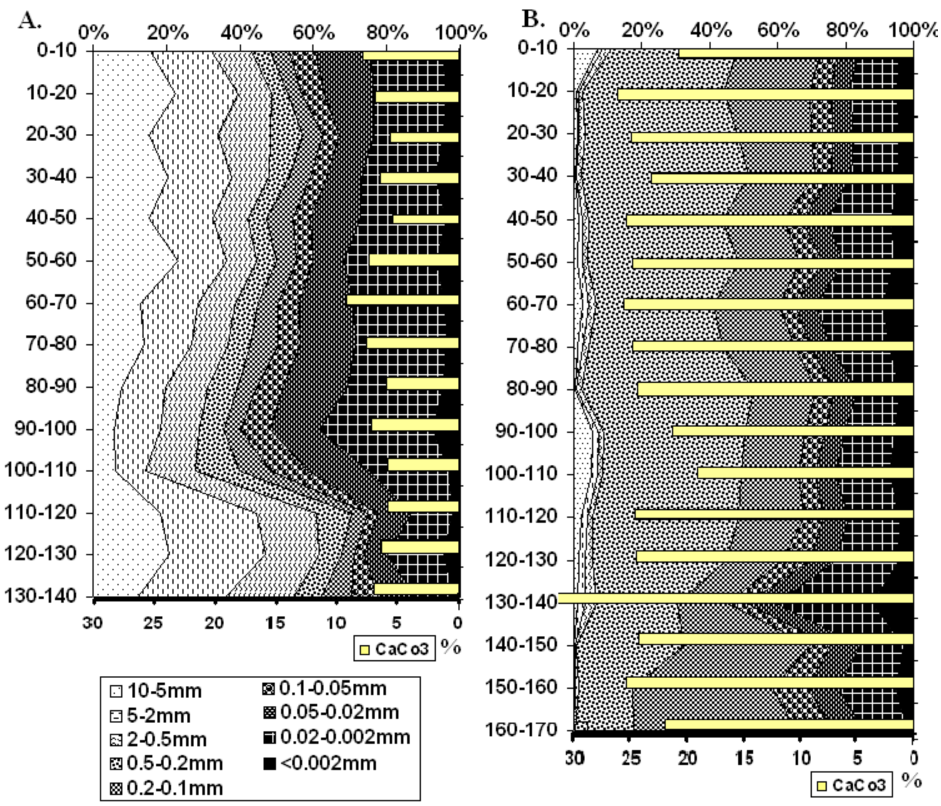

Fig. 3. Particle size distribution and $CaCO_3$ contents behind the destructed dry stone walls on the Sátor Hill (A.) and the Csobánc Hill (B.)

● Frequency of the wall breaks (all types) at the long-time abandonment environments characterized by dense shrubs and trees shows the highest values (50% of total length of the dry stone walls). In vineyards abandonment recently with dense weeds and cleared shrubs this value decreases to 37% and reached the lowest rates (18-28%) at the cultivated parcels. Wall-bellies have developed every 2-3 m representing 56-75% of total wall breaks at the cultivated vineyards. However, this ratio is decreasing with the age of abandonment to 16% (at long-time abandonment environments), while the proportion of the total dilapidations is increasing from 25% to 84% of total wall breaks. The length of the significant destructions is between 2-13 m. Having indicated a chain-reaction, after the dilapidation the process will take place at the nearby wall-belly.

At long-time abandoned terraces the mechanical force of root pressure can also generate the occurrence of the wall-belly and wall breaks.

Photo 1-2. Wall-breaks above a cultivated vineyard, on the Sátor Hill
1. The mark of the wall-belly in the uppermost zone (40 cm), and the dilapidation in middle zone (80 cm) (Left),
2. Block pushed out from the wall-belly at the bottom of the supporting walls (120 cm)

Conclusions

Some of the most important soil properties (Organic carbon and $CaCO_3$ content, particle size distribution) vary according to the depth of terraced soils, in both studied areas these show 2 or 3 maxima. The maxima of the $CaCO_3$ content and the fine fractions (<0,02mm) are the main factors responsible for dry stone wall dilapidation in both studied area.

It seems that the dilapidation process do not depend on the soil pH. There is an indirect relationship between the slope gradient and the frequency of the dry stone walls destruction, due to the land use change (abandonment) on steeper and higher slopes, but the land use change do not press directly the dilapidation process to take place. Land abandonment may lead to the beginning of erosive processes, at the same time the vegetation cover may provide a protection for the soil. Where the fine material and

$CaCO_3$ accumulate a wall-belly appears, finally the dry stone wall will be destructed at three different dilapidation zone. This process takes place on cultivated and abandoned vineyards too, however in case of cultivation the huge dilapidations have to be repaired to follow growth. Unfortunately, vineyards are cultivated with very low management and incomes related to economic conditions, more and more wall breaks can be seen in the vine producing regions, which are protected thanks to their unique cultural values.

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A STUDY OF ENVIRONMENTAL CHANGES IN A MODEL AREA IN THE TISZAZUG REGION

Introduction

The remnant areas of quasi-natural wooded steppe communities are among the greatest and most endangered natural values in Hungary and the Carpathian Basin.

Studies indicate that the total surface area in Hungary of this special land type was less than 5000 hectares at the end of the 1990s (Molnár–Kun 2000). The long-term sustainability of these isolated remnant areas of wooded steppe will hopefully be ensured by Government Resolution No. 275/2004 on Nature Conservation Areas of Community Interest, which classifies these wooded steppe mosaics among priority Community habitats (semi-natural dry grasslands and low shrublands) belonging to the Natura 2000 Network.

Wooded steppe is an independent vegetation zone within the transitional zone between the closed forest and steppe climate zones, where the development of closed forests is mainly prevented by unfavourable climatic, precipitation and soil conditions. It is a complex and sensitive system consisting of mosaics of woody and non-woody communities, in which the specific communities emerge in systematic and regular interconnection. No uniform position has yet been accepted regarding their emergence, development and dynamics. It is certain, however, that besides natural phenomena and wild animals, human activities (e.g. deforestation, grazing) have also largely contributed to the disintegration of wooded steppe areas (Molnár et all., 2000; Bartha, 2001).

With a view to effective conservation and protection, around the year 2000 experts took stock of natural and near-natural grasslands and woodlands at national level. In 1999, a database was completed on remnant mosaics of wooded steppe, a type of vegetation once covering a significant part of the Hungarian Great Plain (Molnár–Kun 2000). Between 2001 and 2004, within the framework of a study of the naturalness of Hungarian forests (the so-called TERMERD project), foresters and biologists carried out naturalness estimates on some 3000 Hungarian forest sections using a linear scale, based on national representative sampling, using several quantitative indicators (tree stand, shrub stratum, grass stratum, offspring, damage by wild animals, habitat) (Bartha, 2004).

Location of the model area, aims

The pasture with wild pear trees of some 70 hectares serving as our model area is located in the southwestern part of the nearly 200 square km Tiszazug sub-region, in an area called Körtvélyes, which is part of the Kisbokros-puszta and Nagybokros-puszta areas that belong to the village of Tiszaug (Fig. 1.). It is part of a Neo-Holocene terrace positioned relatively high (84-86 m above sea level) within the flood basin, consisting of river sand, silt and infusion loess (Aldobolyi, 1954). The lower part of this area had frequently been inundated by the River Tisza before the construction of the dam near Tiszaug in 1866-67, however, afterwards it underwent salinification due to the lack of floods (Endes et all., 1985).

To the north and east, the model area is bordered by a young oxbow lake cut off one to two thousand years ago, the so-called Sántaleány-ere, whose eastern and northeastern section has created a steep erosion surface on the edge of the Tiszakürt-Bogaras sand land facing the flood basin. The area is diversified by series of point bars and swales resulting from the slow movement of the river bend in a western direction. The middle of the old river basin is now occupied by the Homokrét-Sántaleány-ere side channel, which carries the inland waters of the area into the oxbow lake of the Tisza. To the south and west, the model area is bordered by farm trails.

In 1953, the Hungarian Academy of Sciences performed research in the Tiszazug and Körösszög areas concerning microclimate, vegetation and soil (Benedek, 1954, Tímár, 1954, Aldobolyi, 1954). The findings also include data on the model area. From the 1970s, the staff of the Tiszazug Geographical Museum (located in the town of Tiszaföldvár) performed occasional photographic documentation in Bokros-puszta, followed in 1994 by longitudinal and lateral levelling. The surveyed wild pear trees and the shrub species of the accompanying community were represented on a sketch map.

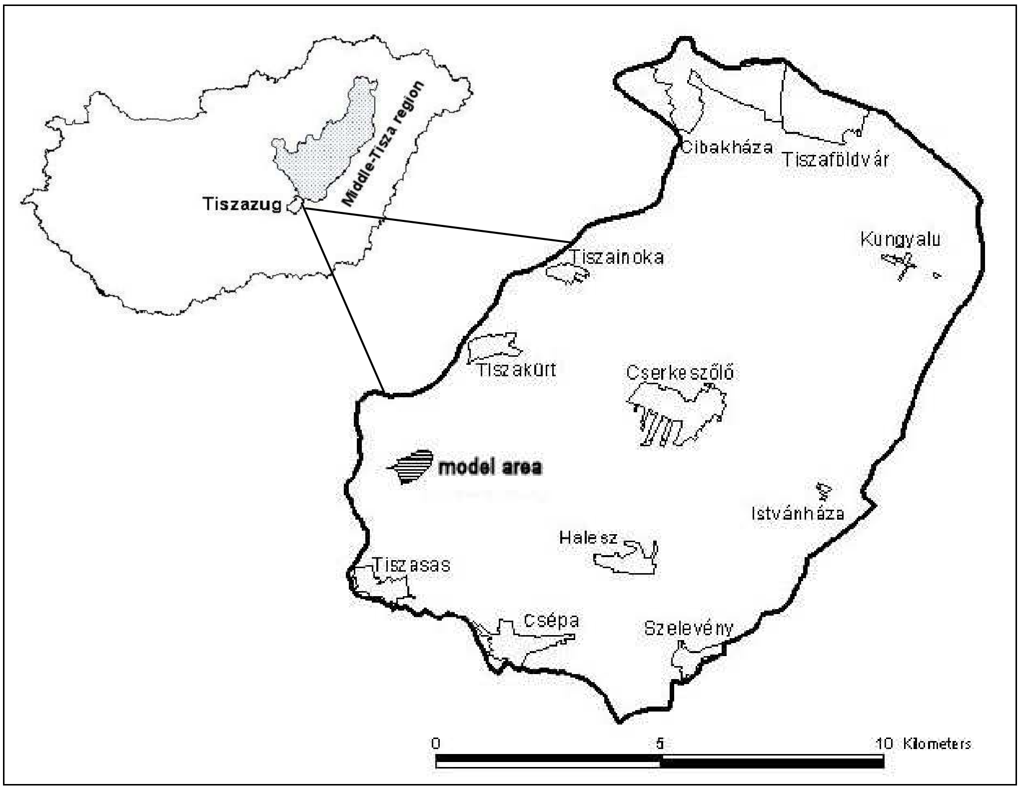

Fig. 1. Geographical location of the model area

Our objective was to carry out an environmental survey of Bokros-puszta, including the recording of wild pear tree status data, the identification of the changes having occurred in the past fifteen years, the partial evaluation of the habitat, and research on the origin (natural or artificial) of the vegetation at issue.

Materials and methods

In autumn 2007, observations were made in the model area on two occasions, namely at fruit ripening and after the fall of leaves. Besides photographic documentation, an on-site record was made on living tree specimens of a height of more than 1 m, including age composition and the following status data: chest height diameter (measured at 1.3 m), generative reproductive capacity, trunk shape (single or twin), health status (damage caused by biotic and abiotic factors, as well as human activities), shrub species and their specimen numbers in the accompanying community (within a circle having a radius of 10 m). The characteristics of standing or lying dead trees or stumps were also noted (Bartha et al. 2003).

Simple wood stock measurement methods were applied to determine the living wild pear stock as well as the volume of standing and dead trees. For each trunk, tree height was measured using a clinometer, according to trigonometric rules. Trunk circumference was measured in centimetres using a tape measure. Circumference data were then used to calculate chest height diameter (Pápai 1999). The partial evaluation of the habitat was based on upper deposit sampling and monthly sampling of ground water from a well in the middle of the pasture, the laboratory analysis of these samples, as well as a phytosociological survey of herbaceous plants.

Changes in the model area over time were examined using bibliographical sources, archive documents, as well as military and cadastral maps, and data were sought to decide whether the wild pear stock concerned was autochthonous or allochthonous.

On the site, the geographical coordinates of wild pear trees were recorded using DigiTerra Explorer v4 on a PDA. The resulting point map was transformed and completed with attribute data using the ESRI ArcMap 9.2 software. The sketch maps and the digital elevation model were edited using ArcView GIS 3.2 and ESRI ArcMap 9.2, respectively. The statistical analyses were prepared using Microsoft Office Excel 2007.

Results and conclusions

In the Middle Ages, orchards did not exist independently of forests, which served as the primary places of fruit production. Historical sources often refer to (wild) fruit trees spared by deforestation as landmarks indicating community borders. This function is still manifested in some toponyms (e.g. “Körtvélyes” near Tiszaug (“körte” means “pear” in Hungarian) (Csőre, 1980). According to a deed dating from 1330, the southern border of the village of Ug was marked by a pear tree (Györffy, 1963). The first military map (1782-1785) represents between the villages of Tiszakürt and Tiszaug a long and narrow stretch of forest similar to the model area in terms of vertical position within the flood basin and habitat characteristics, designated as “Körtve Fa”, i.e. “pear tree”. The second military map (1861) represents the western part of Bokros-puszta as a pasture, and its eastern part as a marshy meadow strewn with streams and sporadic patches of shrubs (possibly including wild pear). The representation of a farm on the eastern edge of Homok-rét indicates the increasing use of the pasture, which gradually dried up due to river control and flood prevention. The cadastral map (1881) does not, yet the third military map (1883) does show shrubby patches. Thus, the historical sources do not provide solid evidence on the previous existence of wild pear trees in the model area, and, besides examining the natural processes influencing forest composition and size, it also remains necessary to further examine the impact of increasing human activities. However, in view of the features of the habitat, one can reasonably suppose that wild pear used to be a characteristic species in the closed or partly open mixed communities of tartar maple and loess oak, a forest type dominating the upper flood basin areas marked by old riverbeds, having loess and fine sand as base rock, and characterised by transitional (continental-submediterranean) climate (Photo 1.).

Due to differing aims and technical conditions, the comparison of the levelling record with our on-site record only provides a limited opportunity to evaluate the quantitative and qualitative changes in the wild pear stock that have occurred over the past nearly fifteen years. In 1994, the museum staff surveyed 89, mainly old specimens, occasionally recording data on foliage and trunk shape. During GPS measurement, each living or dead specimen having an independent trunk higher than 0.5 m (altogether 208 specimens) was specifically localised and represented on the point map. In some cases, it was impossible to measure height, chest height diameter etc. because of impenetrable accompanying vegetation. Thus, statistical analysis was performed using the status data of 202 specimens.

6.9 % of the stock (14 pcs) were standing or lying dead trunks or stumps, adding to the diversity of the forest or grassland. Considering the saw and axe cuts visible on their surface, most of these were a result of the previous, occasional selective thinning of healthy, ill or dead trees (Photo 2.). Next to a stump, a turion of 2.5 m was found, which had shot after the removal of the overground part. Wild pear has slight vegetative renewal capacity: its sprouting off the stem is moderate, and it hardly ever sprouts off the root (Gencsi et all., 1992, Bartha, 1999). Consequently, the former statement that wild pear reproduces through root sprouting in the model area (Varga 1994) is questionable and requires further examination.

The development of wild pear is largely dependent on habitat conditions: it needs warmth and sunlight, is xerophylic/moderately xerophylic and halophyte, and likes basic soil. Under favourable ecological conditions, it may develop a relatively tall trunk and a slim crown, possibly reaching a height of 15 m (Bartha, 1998). However, in the Körtvélyes model area, most wild pear trees are small, and have a crooked trunk and an irregular and underdeveloped crown.

Out of the 188 living specimens, 22 (11 % of living trees) showed some trunk defect, primarily furcation, which is called a twin trunk when occurring directly above ground level. 12 double twin trunks (54.5 %), 6 triple twin trunks (27.3 %), 2 quadruple twin trunks (9.1 %) and 2 twin trunks with five or more twins (9.1 %) were found. When the tree stands free, side branches grow thick and protrude far from the trunk. Branch loss and damage caused by animals and human activities mostly affected older and taller specimens, resulting in knobs on remaining branch stumps (Tompa 1975).

Photo 1. Characteristic landscape in Bokros-puszta with old wild pear trees on the edge of a swale (photograph by Csaba Tóth, 2007)

Wild pear, a secondary/tertiary species growing in mixed communities, becomes productive relatively quickly, at an age of approximately ten years. In a favourable habitat it reproduces well through seed germination, which generally takes 90-100 days under cold weather conditions (Barna 1998). Seed dispersal is mainly ensured by wild boars, a species living in the model area as well, with pear seeds passing through their intestines without suffering any damage. Generative reproductive capacity was determined empirically, based on the quantities of fruits found on tree branches and on the ground (Photo 4.). Due to the high ratio of old and ill, unproductive specimens and that of young specimens not yet productive, no fruits were found in the case of nearly three fourths (146 pcs, 72.3 %) of the stock. The young specimens found in swales and on point bar slopes (consisting of deposit whose fineness increases in an upwards direction) emerged naturally, probably through seed germination (Photo 3.).

Photo 2.: One of the numerous dead wild pear trees found in the model area, probably dried up due to fungal infection (photograph by Csaba Tóth, 2007)

The health status of living specimens raises concerns. Damage sources and pathological factors are often interconnected, creating the necessary conditions for one another and resulting in so-called damage chains (Tompa, 1975, Pápai, 1999). It would be very difficult to identify the mechanisms of these primary and secondary damage factors, or their positive and negative effects on each other. Such an examination is out of the scope of the present study. Nearly all specimens showed some dead parts or missing wood (e.g. dead branches, branch stumps, hollows, cavities, gaps under detached barks etc.), therefore, in the absence of quantitative indicators, the number of specimens affected by various types of damage and that of healthy specimens were estimated. Damage by the abiotic environment (wind, lightning etc.), biotic damage (insects, fungi) and mechanical damage caused by human activity affected 11, 38 and 16 trees, respectively. The remaining 123 specimens (65.4 %) can be regarded as healthy.

In declining dry oak woods, wild pear usually grows together with the characteristic shrub species of the accompanying community, such as blackthorn (16 pcs), hawthorn (12 pcs) and wild rose (20 pcs), therefore it has an important role in the secondary succession of woody communities (Gencsi–Vancsura 1992). Within a circle having a radius of 10 m around the specimens, the following tree species were found: *Elaeagnus angustifolia L.*, (3 pcs, planted during alkaline soil afforestation), elder (4 pcs), *Ulmus laevis* (2 pcs), as well as wild apple, mulberry, *Celtis occidentalis* and grey poplar (1 pc each).

Photo 3.: Several young wild pear specimens were found on the edges of marshy patches in Bokros-puszta (photograph by Csaba Tóth, 2007)

Using the status data recorded individually, i.e. height and chest height diameter, the height curve of the wild pear stock was drawn (Fig. 2.). Based on such status data, the age composition of the stock can be indirectly estimated. According to bibliographical data, abroad there are even 30 m high specimens with a chest height circumference of 470 cm, estimated to be 500 years old. However, 200-year-old specimens are considered extremely old in Hungary (Bartha 1998).

Photo 4.: Healthy wild pear specimens bore many fruits in autumn 2007 (photograph by Csaba Tóth, 2007)

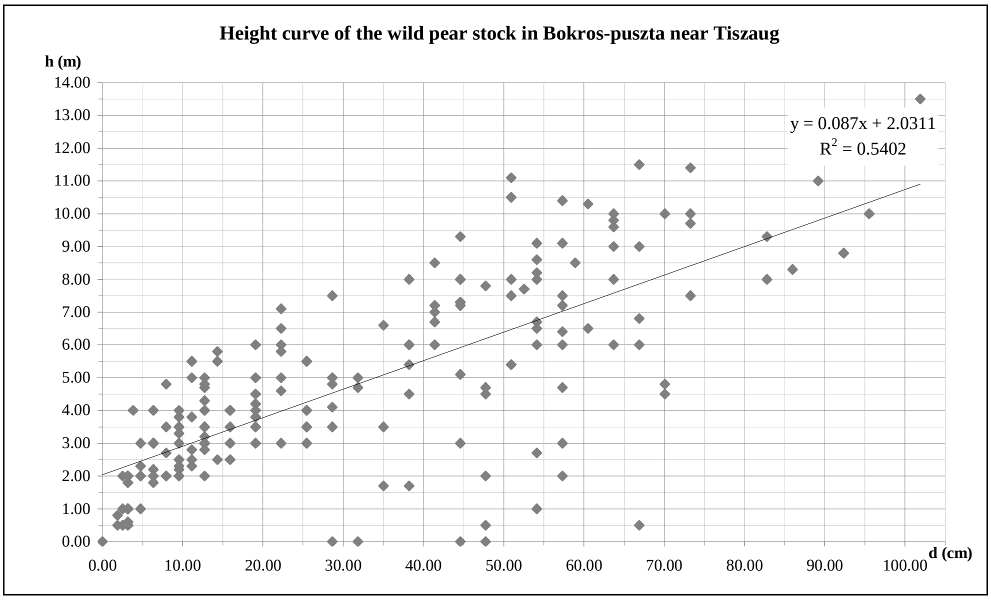

Fig. 2. Height curve of the wild pear stock in Bokros-puszta near Tiszaug

Based on the data on old wild pear trees available on the website *“Magyarországi faóriások és famatuzsálemek” (“Giant and old trees in Hungary”, http://oregfak.emk.nyme.hu)*, and considering differences in habitat conditions, the average age of the main stock (50-60 specimens) was estimated at 100-120 years. (In our survey, the largest and probably oldest specimen was 13.5 m high, with a chest height circumference of 320 cm.) These trees were mainly found sporadically at the edge of the pasture, i.e. on the edge of the bank of the former riverbed, and were probably remnants of an alkaline soil oak forest that had first opened up and was then cut down. The other specimens found near the pheasantry on the eastern edge of the pasture, the considerably silted water ditch crossing the model area and the demolished animal husbandry facilities of a former Tiszaug cooperative were of the same age and followed a linear pattern at similar intervals. This implies artificial planting rather than natural growth.

The two most frequent plant communities in Bokros-puszta are *Achilleo Festucetum pseudovinae*, covering large uninterrupted areas in lower swales and in the middle of the model area, and *Cynodonti-Poëtum angustifoliae*, found in upper areas and on point bars. The latter community type is probably the result of the degradation processes caused by the excessive grazing of former areas of *Salvio-Festucetum rupicolae.*

The vegetation is diversified by the presence of small and often isolated patches of dry alkaline soil vegetation on the edges of lower areas, resulting from secondary salinification, including *Puccinellietum limosae*, *Artemisio santonici-Festucetum pseudovinae* and *Camphorosmetum annuae*. Due to the extreme water and salt conditions of these habitats, they are rather open and naturally poor in species.

The marshy patches in the southeastern part of the area are characterised by *Puccinellietum limosae* and *Schoenoplectetum tabernaemontani* (Nótári 2008). These include several wild pear seedlings. As there are no natural wild pear offspring in the dry steppe on account of intensive grazing, the specimens found in such wet patches and in the shrubby edges of the area may be the ones that will ensure the survival of the wild pear stock concerned.

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