

Assessment of the special soil degradation (bench erosion) with GIS methods from the Great Hungarian Plain

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SUMMARY:

In the light of our findings it can be clearly seen that the process of bench erosion is a relatively rapid landscape transformation factor, restricted mostly to lowland areas utilized as pasturelands or meadows. Since the rate of erosion is in the cm scale, the effects of the process are rather considerable even within the span of a couple of decades. There are two important consequences of the process cited. On the one hand it causes significant soil erosion. On the other hand it also brings about a destruction of the protected microforms even in a natural, preserved setting without leaving any possibilities for actual preservation even among the highest measures.

KEYWORDS: soil erosion, remote sensing, photogrammetry

INTRODUCTION

The technical improvements of the past few decades opened up new possibilities for researchers engaged in the investigation of geomorphological processes. Methods like the application of various remote sensing and high resolution field mapping techniques, as well as those of absolute dating and modern material science can elucidate information on environmental changes, which previously had been regarded as unattainable. Improvements in computer science and technology opened up new gates for geoinformatics. The increasing accuracy of measurements on the other hand enabled the identification of even short-term changes and events as well. It was mainly this latter factor that gave an impetus for our work in initiating an investigation on the characteristics of the process of a special lowland bench erosion from the second half of the 1990s. With the help of the recorded data embedding 7 years, marked changes can be clearly identified.

Benches introduce some sort of versatility into the relatively uniform landscape of the Great Hungarian Plain. These geomorphological features are generally restricted to areas, which were frequently flooded before the water regulations. But they appear in connection to various landscape management measures as well (road, channel). The characteristic, 10-30 cm high microforms are mostly restricted to alkaline areas. This unique type of erosion, complemented by a gradually increasing aridity, may cause significant transformations in the environment.

THE DEFINITION AND GEOMORPHOLOGICAL CHARACTERISTICS OF LOWLAND BENCHES

Despite the extensive nature of areas effected by lowland bench erosion in the Great Hungarian Plain being almost a general feature of the pusztas of the national parks of this area and mentioned in certain works dealing with the process of alkalization as well, up to 1970 only a single study dealt with the detailed description of this geomorphological feature (Strömpl, 1931).

In our work, it was during the middle part of the 1970s through the course of preliminary investigations preceding the protection of the puszta of Szabadkígyós (Körös-Maros National Park) that we actually realized the problems deriving from the lack of adequate studies and descriptions of this feature. Our morphological and pedological investigations made it rather apparent (Dövényi et al, 1977) that the formerly established terminology is out of date and requires revision.

The starting main form of bench erosion is the alkaline bench, which is a continuously changing feature complex. Thus their components can hardly be interpreted on their own. This bench is composed of various sub-features such as the bench top, corresponding to the original surface, the eroded alkaline flat, from which the topsoil has been removed, and finally the continuously migrating bench margin, as a result of the progressive erosion (Figure 1.).



Figure 1. Soil benches at Tótkomlós, Hungary

During the process of bench erosion the original surface becomes dissected yielding island- and peninsula-like microforms of large variety. During the whole process the dissoluble salts either infiltrate into the ground or precipitate on the surface. The resulting rock fragments end up either in the fractures, which form during the arid summers and termed as alkaline veins or are transported away from the surface by the winds.

The process of bench destruction

The process of bench erosion must be divided into two stages. The first stage involves the actual development of the benches, while the second one is the destruction of these bench surfaces.

The majority of resources in the literature univocally mention the development of differences in the relief as a prerequisite of bench formation and bench erosion in lowland areas. Sometimes this can be even in the cm range. One of the most commonly appearing cases is when a natural dip in the surface is attributable to the presence of infilled ancient riverbeds and adjacent natural levees in a formerly fluvial landscape. But human activities creating different relief conditions are almost just as important. However, bench formation may initiate even in totally flat and smooth surfaces as well as a result of soil shrinkage attributable to arid conditions and the formation of extensive cracks in the ground. The further developmental path of these bench areas is primarily influenced by the relief conditions and the soil structure.

The solonetz alkaline areas with a well-deformed soil structure tend to give the typical sites for bench erosion yielding benches of the size of 10-30 cm via the erosional removal of the topsoil. We could identify 4 major types of bench erosion in the area of the Great Hungarian Plain.

- Retrogressive erosion. According to our field observations, this type tends to be the most commonly occurring with continuous soil erosion along an irregular line at the margin of the bench usually lacking surficial vegetation (Figure 1.). If the erosion process decelerates for some reason, the marginal areas of the bench can be widened to such a degree, when changes are observable in the alteration of the vegetation types alone, related to the resulting differential dissolved salt content of the underlying soils.
- Break-away erosion. This type of erosion could have been observed in Miklapusztá, now belonging to the territory of the Kiskunság National Park (Rakonczai – Kovács, 2000.). The

60-100 cm thick benches can break off in blocks of several ms together with the surficial vegetation as a result of scouring by waters, which accumulated in the low-lying areas.

- Linear erosion. This erosion type is mostly constrained to the block dissection of the bench surfaces. Very often we can also come across signs of the processes (cart tracks, animal paths) which initiated this type of erosion. As a result of this process the greater benches are transformed into island- or peninsula-like forms, their gradually increasing marginal areas progressively accelerating the erosion process as well.
- Areal erosion. As a result of this erosion process the surface of the original bench gradually becomes morphologically uniform with the adjacent lower-lying areas of the salt flats, though to a certain degree these two forms can be easily told apart via careful observation of the surficial vegetation. We have managed to record such transformation of 20-30 cm thick and 10-15 m wide benches in the puszta of Szabadkigyós, which embedded about 25 years.

THE METHODS APPLIED FOR RECORDING EROSION

Measuring and quantifying modern geomorphological transformations is a very complex problem. One of the major problems comes from the possibilities for generalizing short-term transformations, observed during the field measurements. Another major problem derives from the accuracy of the measurements, since in these short-term cases we are dealing with small values. Thus for our work a complex array of various methods have been collectively utilized considering the characteristics of the pilot areas, the available past data and the reliability of the measuring instruments. In places, where thanks to the special characteristics of the topography maps from former military surveys were also available, there was a chance of temporally extending the scope of our investigations. On the whole it must be stated that our investigations on the process of bench erosion were based on different annual data sources, containing data collected with different methods and resolutions.

Field measurements started as early as the 1970s in one of the alkaline areas of the Tiszántúl, the puszta of Szabadkigyós (Szöör-Rakonczai-Dövényi, 1978). These were then extended to other areas, bearing different characteristics (Tótkomlós, Miklapusza) and complemented by the use of more advanced methods and instruments for both data recording (GPS, geodesic stations) and data processing (photogrammetry) from the 1990s onwards (Rakonczai-Kovács, 2000).

Another possibility for a comprehensive evaluation of the degree of bench erosion might be the transformation of the data recorded in different times and in different mapping systems into a uniform system. This approach was best suited for the analysis of the erosion of benches with a relatively large size, something what we have encountered in the pilot area of Miklapusza. As a first step here data maps with a scale of 1:25.000 deriving from the 3rd Military Survey of 1883, as well as that from 1981 with a scale of 1:10.000 was looked at in details. Then in order to capture the modern transformations field measurements were taken using a GPS from 1997, and then a complex geodesic data recording device from 2003. The 1972 panochromatic Corona satellite photos with a geometric resolution of 2.5 m, as well as the 1994 black and white aerial photos on the area with a resolution of 2m, plus the color aerial photos of 2000 with a geometric resolution of 65 cm were also used in our work.

In order to capture the erosion of the low-lying benches field measurements were implemented. In case of the most important sites a direct comparison of the measured values of the recorded sites using the devices of a monitoring station or a GPS enables the attainment of a resolution at a cm scale. Lines prepared via connecting such data points may give the most reliable results on the transformations of the spatial extent of benches. Field measurements happened with the use of a GPS in the first stage of the work (TOPCON Turbo-S II., Trimble Basic+) via the application of a relative spot and go method, requiring a measuring time of 4-5 min before moving onto the next point. Consequently, only the most characteristic sites have been measured at this stage. Field measurements carried out in 2003 were relying on a much more accurate instrument of SOKKIA Set310 geodesic station. The accuracy of angle measurement with this device was 3", while that of the distance measurements was +/- 2 mm + 2ppm /2700 m.

THE RECORDED DEGREE OF BENCH EROSION IN DIFFERENT TYPE OF PILOT AREAS

Erosion of large benches with a chernozem soil (Miklapuszta)

The solonchak alkaline pilot area located in the northern part of Miklapuszta forms one of the most spectacular alkaline bench areas in Europe with “giant” benches of a height sometimes exceeding even 1 m.

During the comparative analysis spanning a period of approximately 100 years, the borderline of the benches was determined from the 3rd military survey (transformed into National Unified Projection), the map of 1981 with data complemented from the 2000 aerial photo of the area as well.

The calculated average annual rate of retrogression was extremely high: 10-15 cm! The degree of erosion for the individual benches compared to the data on the map of the 3rd military survey was 40% at an average. So while about 100 years ago approximately 21% of the 340 ha pilot areas was covered by benches, today this ratio is only 12%. This data seems to refer an annual rate of erosion of 1520 m³ calculated for a realistic bench height of 50 cm. we would state precisely these values with stereo photogrammetry methods.

Another characteristic feature in the pilot aream was the dissection of the bench ridges by roads and flock paths leading to the formation of new isolated bench islands. At the given resolution there was a one-third increase in the number of these separate bench islands in the area during the past 100 years, with several extensive benches are lacking in the modern maps.

The first step of higher resolution evaluations was the investigations of data and changes for the last 30 years with the help of the Corona satellite photos (Fig. 2.).

The calculated loss of bench islands of 4% /decade using the topographic maps was only 2%/decade using the satellite photo. Nevertheless the annual rate of retrogression was 8 cm, which is congruent with the values calculated in the long-term analysis.

At present we are assessing the degradation with stereo photogrammetry methods on the images from 2000.

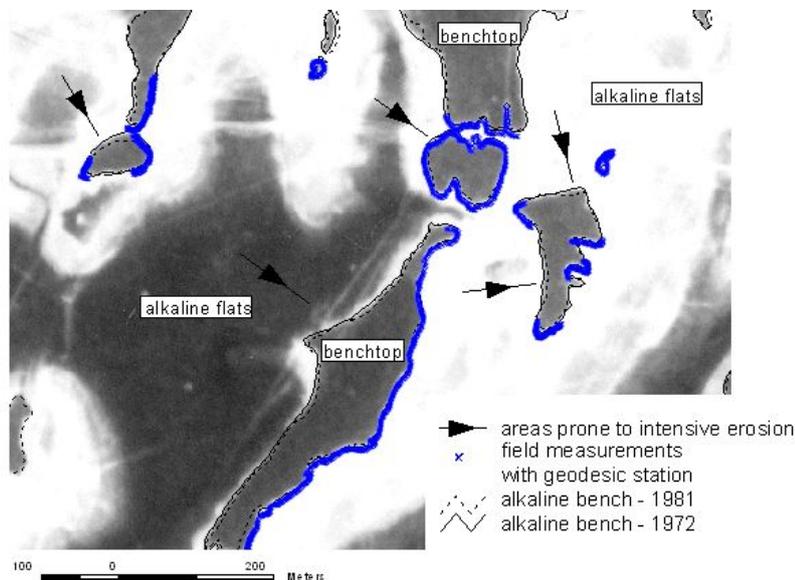


Figure 2. Interpreted bench margins and the comparative analysis of the results of 2003 field topographic survey (background: Corona satellite photo)

The bench erosion of solonetz alkaline areas (Tótkomlós)

10-20 cm high benches emerged as a result of the complete removal of the topsoil (A horizon) in the alkaline steppes SW of Tótkomlós. Here the construction of drainage channels and the ditches running along the roads must be unambiguously blamed for the initiation of the erosion process. Field surveys were carried out in this pilot area from the summer of 1997 (GPS and geodesic measurement station) (Picture 3.). According to our findings, here the retrogressive type was the prevalent form of erosion with an approximately 0-15 cm degree per 6 years.



Figure 3. Measuring with GPS

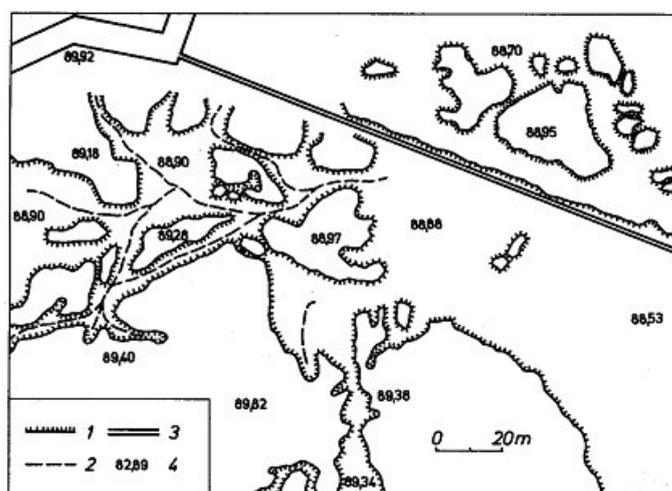


Figure 4. Micro-relief of the "puszta" at Szabadkígyós (Szöör-Rakonczai-Dövényi, 1978)

Legend: 1: boundary between natron bench and natron plain, 2: natron stream, 3: canal, 4: elevation above sea level (m)

The aerial erosion of solonetz alkaline areas (Szabadkígyós)

Detailed topographic mapping using a theodolite and accessory network was carried out in the alkaline puszta between Szabadkígyós and Kétegyháza in 1977, preceding the protection of the

microforms (Fig. 4.) During this time the microforms were bounded by sharp bench margins of 20-30 cm. The vegetation cover of the bench tops and alkaline flats were also clearly different. When we returned to the area during the summer of 2003, we have come across a completely altered landscape. The alkaline flat covered by halophyte plants now had a uniform grass cover, the extensive benches completely disappeared, and the margins of them were hardly discernible.

There were two important environmental changes, which affected the area during the past 25 years. As a side effect of the gradual increase in aridity and drop in the groundwater level the alkaline soils and the vegetation was largely transformed, just like the original bench microforms. The most spectacular changes from a morphological point of view was observable on several benches, which could have been clearly mapped and identified in 1977. The former morphologies were reflected only in their different vegetation cover without any discernible deviations in the topography. In the place of these former benches we have come across saline spots (*Limonium Gmelini*) or even fresh meadows.

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