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QUANTIFYING THE GEODIVERSITY OF A STUDY AREA IN THE GREAT HUNGARIAN PLAIN

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Abstract

Geodiversity is understood as the diversity of the abiotic nature. It expresses the variety of stones, minerals, fossils, places, landforms, processes, soils and elements of hydrology. As geodiversity assessment is a rather new research area, the number of publications concerning geodiversity is growing fast. In this paper we quantified the geodiversity of a study area located at the Danube-Tisza Interfluve in the Great Hungarian Plain using the method worked out by Hjort and Luoto (2010). We wanted to know how the diversity varies in space at lowland areas applying different indexes. Geodiversity was represented by three different indexes. Total geodiversity was calculated by summarizing the geologic features, the landforms and the elements of hydrology found in each unit. Then we grouped the landforms by the (exogenic) processes which formed them, and the number of these processes gave the value of the geomorphologic process diversity. Finally we calculated the geodiversity index by Serrano-Canadas and Ruiz-Flano (2007). The absolutely homogenous units (totally waterlogged areas and the flat sand sheets) have the lowest geodiversity. It is higher at the border of the sandy, peaty and waterlogged areas. At this lowland area there is no relationship between the geodiversity and the relief. This is the first work applying this method in Hungary, so the results are yet not comparable.

INTRODUCTION

The objective of this paper is to quantify the geodiversity values of a study area located at the Danube-Tisza Interfluve in the Great Hungarian Plain using the method worked out by Hort and Luoto (2010). A further aim is to know how the diversity varies in space at lowland areas applying different indexes, which are the areas with lower and higher geodiversity values. We also intend to decide (if it is like hilly areas), whether the areas with diverse relief (sand dunes, deflation holes) have the highest geodiversity values or not.

On hearing the word diversity most people think about biodiversity (the variety of the biotic nature), but geodiversity is an equivalent and inseparable part of the landscape, and one the premises of the development of biodiversity. Geodiversity is understood as the diversity of the abiotic nature. It involves the variety of stones, minerals, fossils, places, landforms, processes, soils and the elements of hydrology. The term geodiversity is a new concept used since the middle of the 1990s. As geodiversity assessment is a new research topic, the number of publications concerning geodiversity is growing fast. New experiments are being carried out to quantify geodiversity. Our approach is practice-oriented approach, which summarizing and quantifying the abiotic features (and their threats) found in the study area to support the development, tourism and conservation plans.

According to geologists geodiversity means only geological diversity (Keveiné Bárány 2007, 2008), i.e. the variety of geological features, without involving other factors. It is stated in Gray's definition (Gray 2004) that geodiversity includes the variety of geological features (stones, minerals, fossils), geomorphology (landforms and processes) and soils, as well as their assemblages properties, interpretations, systems and relationships.

In the view of Kozlowski (2004) geodiversity includes surface waters and the consequences of anthropogenic processes are equal with those of nature.

The previous definitions were summarised and completed by Serrano-Canadas and Ruiz-Flano (2007): "Geodiversity is the variability of abiotic nature, including lithological, tectonic, geomorphological, soil, hydrological, topographical elements and physical processes on the land surface and in the seas and oceans, together with systems generated by natural, endogenous and exogenous and human processes, which cover the diversity of particles, elements and sites."

Another aspect focuses on examining the values of geodiversity which play an important role in determining the area independently from their distribution and frequency, instead of making a list of all of the elements found (Panizza 2009). Some studies (Ruban 2010) evaluate the scientific or touristic values of geodiversity, their threats and possible ways of conservation. Other studies regard geodiversity not as geomorphological heterogenity, but as the premise of biodiversity and focus on the variety of the conditions of life (Jarvis 2005, Parks – Mulligan 2010, Santucci 2005).

These approaches search for relationships between the factors of the abiotic environment and the species diversity in relatively small study areas. Using the revealed relations help to express the potential species diversity based on geodiversity without a detailed biodiversity monitoring. Geodiversity investigations in larger areas aim to support development, tourism and conservation plans.

In the beginning few experiences were made to quantify geodiversity. Most of the authors supposed quantifying geodiversity, but only a few of them actually did it. It was Kozlowski (2004) who first prepared a geodiversity atlas of Poland, he assessed the geodiversity of his country at regional level. He scored 5 elements of geodiversity: geology, topography, soils, surface waters, and landscape structure separately on a five-degree scale ranging from very low to very high level. Not only did he examine the amount of the features but also dealt with their quality such as the quality at surface waters. He also considered the influence of people on the landscape.

The first and most popular geodiversity index was worked out by a team of scientists in Spain. They computed the index values to geomorphological units. They took the abiotic features stock, filling a table with the present elements of geodiversity at every unit. The index value was calculated according to the following formula (Serrano-Canadas et al. 2009):

$$Gd=\frac{Eg * R}{\ln S}\text{, where}$$

Gd = geodiversity index,
Eg = number of the elements of geodiversity,
R = roughness, here expresses the slope,
S = area of the surface (km^2).

The value of "Eg" was calculated on the basis of the number of elements (lithology, geologic structure, morphostructure, landforms, processes, hydrology, soils) indicated in the tables. Each element got one score, independently about its quantity in the unit. The variety of the topography and climate was represented with the roughness value, which was calculated with valuing the slope histograms. This influences the flow of energy and the intensity of the land forming processes.

In this method the weight of the areas of the unit influences the index values more than it should, so the index values do not express the variety correctly (Őrsi 2010). To eliminate the problem, Finnish authors (Hjort – Luoto 2010) calculated geodiversity to areas of identical sizes using a grid network. They took the geological geomorphological and hydrological features into consideration. The authors expressed geodiversity with four different indices. Total geodiversity was calculated by reviewing the stones, landforms and hydrological elements in each unit. Landforms were grouped according to the processes, whose number gave the value of geomorphological process diversity. The units were categorized according to the number of the periods their surface was evolving, giving the temporal diversity value. Finally, the previously mentioned geodiversity index by Serrano-Canadas et al. (2009) was computed.

They also examined how relief affects the value of geodiversity. They used Spearman rank correlation coefficients. None of the index values correlated with total geodiversity, although it seems that geodiversity is the highest on the steepest slopes. The probable reason is that the correlation between roughness and geodiversity is not linear. However, in spite of the weak correlations, they found that roughness is the highest in 90 percent of the units with highest geodiversity values.

STUDY AREA

The study area is located around Kiskőrös in the Great Hungarian Plain (*Fig. 1*). It belongs to the area of Homokhát in Bugac. It is a moderately undulating alluvial plain dissected by basins. The area ascends from NW to SE. It is a transition from the floodplain of the Danube to the higher lying part, i.e. to the Ridge. The surface was formed by the Danube, later it was reworked by wind. Waterlogged areas, wetlands and peat vary with sand sheets and sand dunes. Beside the dunes blowouts, deflation hollows make the area diverse. The wide shallow depressions used to be the channels of the Danube, which lost the connection with the river as it was incising. The deposits of the higher lands accumulate here, those with less favourable drainage are covered by water during the whole year (Szilárd 1955).

METHODS

The quantification of geodiversity was carried out by the method of Hjort and Luoto (2010). The whole area was divided into 500x500 m units. The geological, geomorphological and hydrological elements of the units were reviewed during our activities. The variety of the micro features was ignored because a survey would have been too complicated. We also neglected topography because the opinion of scientists is not unanimous about topography being and element of geodiversity.

Geodiversity is represented by three different indexes. Total geodiversity was calculated by counting geological features, landforms and the elements of hydrology found in each unit. The categories of the detailed geomorphological map (Juhász 2000) were simplified. *Table 1* shows the elements we took into consideration.

Then landforms were grouped according to the processes which formed them and the number of these processes gave the value of the geomorphological process diversity. Calculating the values of temporal diversity does not make sense in this area because the surface has been forming since the Pleistocene. This index was not treated separately, it was taken into consideration when calculating the geodiversity index.

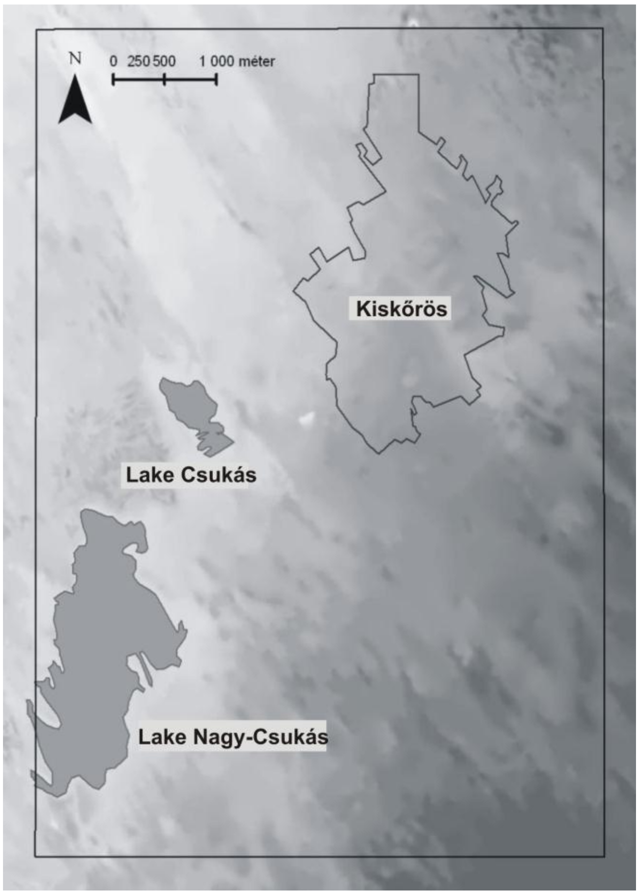

Fig. 1 The study area

Table 1 The elements of geodiversity in the study area

Geology	Geomorphology	Hydrology
Quicksand	Flats in low position (intermittently water-logged)	Lakes, intermittent lakes
Lime tuff	Flats between ridges in higher position	Swamps in the phase of uplifting
Clayey aleurit	Dry flats between ridges	Swampy flats, permanently water-logged
Loess	Dell- like depressions, deflation hollows	Flats intermittently waterlogged
Aleurit	Broad and level ridges in low position	Flats episodically affected by water
	Narrow asymmetric ridges in low position	
	Ridges covered with wind-blown sand in intermediary position	
	Gently sloping ridges in higher position	
	Narrow asymmetric ridges, mounds	
	Extensive sand dunes, short ridges	
	Dunes	
	Wind furrows	
	Wind holes	

Finally the geodiversity index by Serrano-Canadas et al. (2009) was calculated (see previous chapter). Smaller modifications were carried out in the formula because of the same size of the units. The geodiversity index was calculated by the number of the elements multiplied by the roughness value. The calculation of the roughness value is based on the average slope angle the units. It was originally worked out by the Spanish scientists for valuing the geodiversity of hilly and mountainous areas. As the slope of every unit is small on lowlands, the roughness of every unit is 1, say the number of the elements has to be multiplied with 1 when calculating the geodiversity index. According to the Spanish authors a wider range of elements was included in the survey: not only geology, geomorphology, hydrology, but also soils and the date of formation were taken into account, however, anthropogenic forms were ignored.1: 100 000 geological maps, 1:10 000 geomorphological maps (Juhász 2000) and 1:100 000 soil maps from the AGROTOPO database were used in the analysis. An elevation model has also been made based on the Unified National Map System (EOTR) maps (1: 10 000) with 10 m pixel sizes and 1 m contour intervals.

RESULTS

First of all, it should be emphasized that these results (*Fig. 2*) only inform us about the variation of geodiversity in this area. As no other attempt has been made in Hungary up to now, the results cannot be compared with those of other areas.

The values of total geodiversity in the 500 m x 500 m units vary from 2 to11, the average and the median values are 6. The values of 2-11 refer to the number of elements within each 500x500 m unit (see *Table 1*). The geodiversity in the sand sheet in the NE part of the study area is smaller than the average. The homogenous units containing either only sand or only water have the smallest total geodiversity values. The highest values are at the units where sandy areas merge with wetlands. On the whole we can state that the southern part of the area (located a bit higher) has higher geodiversity values, but total geodiversity values do not follow the elevation values.

In the lowland area only a few processes formed the landscape (the number of processes given by the Finnish authors was nine). The value of geomorphic process diversity is 1 on the units totally covered by sand, 2, if there are wetlands in the unit and 3, where peat can be found, because besides wind and water, biogenic processes are also important. The values of the geodiversity index range from 5 to 11, the average is 17. This variation is similar to that of total geodiversity, but higher on the muskegs. No significant correlation could be identified between geodiversity and relief.

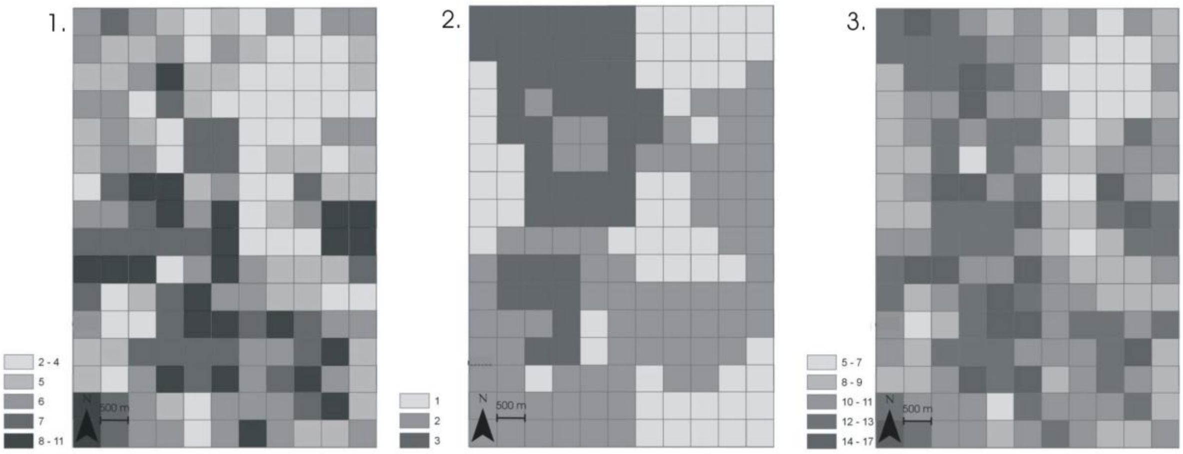

Fig. 2 Measures of geodiversity at a resolution of 500 x 500m

1. total geodiversity, 2. geomorphological process diversity, 3. geodiversity index.

CONCLUSIONS

The different explanations, representations and ways of quantifications of geodiversity were shown in this paper. The latest and probably the most detached method was applied on a lowland study area. The absolutely homogenous units (totally waterlogged areas and the flat sand sheets) have the lowest geodiversity values. The values are higher at the borders of the sandy, peaty and waterlogged areas. On this lowland area there is no relationship between geodiversity and relief. This is the first attempt to applying this method in Hungary, so the results are not yet comparable. Further research is needed on various landscapes for the identification of the applicability of the method.

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