Tracking the signs of recent geomorphological processes in the landscape in Hungary

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ABSTRACT

Soil erosion by water is a natural process fastened by human activity. During soil formation processes soil degradation and soil formation reached its climax, resulting in final soil properties. Anthropogenic influence accelerates soil erosion at a rate that exceeds the rate of soil formation. In our study we wish to show the differences in basic soil parameters over the slopes of chosen landscapes in Hungary. The method is based on the Hungarian Soil Information and Monitoring System. Soil samples were taken from the upper and from the lower third of the slopes in order to compare the soil properties on these slope sections. Basic soil parameters (pH [H2O and KCl], SOM (%), P2O5 (mg/kg), K2O (mg/kg), CaCO3) were measured in the laboratory. A good example of the results is with phosphorus because this is one of the best indicators for analysing the effect of water erosion as it is connected with the soil particles, so it is washed towards the lower slope sections together with soil aggregates in case water erosion occurs. According to our measurements, the amount of the P2O5 is 2,6–680,3% more on the lower slope section. Basic parameters such as phosphorous can prove the speed of the soil degradation processes and can help to understand the landscape forming processes and its scale.

Keywords: water erosion, soil loss, nutrient loss, slope sections, landscape change

1. INTRODUCTION

The parent material and other soil forming factors, structure of crop rotations and tillage practices (Barczi et al., 1998, 1998, 1999; Barczi, 2004) can be the source of high amount of soil loss (Wischmeier and Smith, 1978; De la Rosa et al., 2000; Bakker et al., 2008; Kertész and Centeri, 2006). There are easy methods to prove this high amount of soil loss and its economical effects with the measurement of the soil accumulation at the bottom of the slope (Centeri et al., 2008; Marth and Karkalik, 2004).

Human activities seriously accelerate erosion through stripping of natural vegetation for cultivation and cause indirect negative changes in land cover through overgrazing and controlled burning. Changes in the intensity of land use (Bádonyi, 2006), large scale farming, poor maintenance of terrace structures can be the source of human induced erosion (Bakker et al., 2008; Jordan et al., 2005; Szilassi et al., 2006; Gournellos et al., 2004; Jones et al., 2004). According to the assessment of the European Environmental Agency (2003) approximately 17 % of the total land area in Europe is affected to some degree by some kind of erosion, of which cca. 92% is due to water and to lesser extent to wind erosion.

Awareness of the importance and scale of soil erosion has led to the improvement of its prediction. Many models and studies were developed in order to better assess soil erosion risk at the European scale (Gournellos et al., 2004, Evelpidou, 2006).

Soil and nutrient loss, runoff and sediment yield calculations (Jakab and Szalai, 2005) are important in protecting our valuable arable lands. Investigation of different erosion forms from splash (Govers, 1991) through surface (Centeri et al. 2009) to gully erosion (Jakab 2006) can explain most of the reasons of the fast changing landscape forms of these days.

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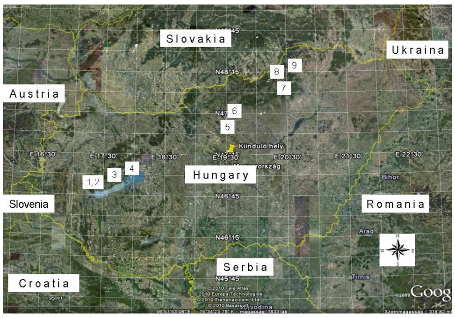

Figure 1: Sampling sites of the pedological investigations, Hungary (Source: Google Earth) The samples were taken from the Trans-Danubian and from the Northern Mountain Ranges of Hungary (1=Nemesgulács, 2=Csobánc, 3=Tihany, 4= Csopak, 5=Maglód, 6=Galgahévíz, 7=Nagymező, 8=Gömörszőlős, 9=Alsószuha)

One of the most important finding in the formation of the landscape is that taking into account the most influencing soil formation factor, the human activity, we can state that soil is a non- renewable natural resource (Várallyay, 2007).

This recognition emphasizes the importance of the control of soil degradation processes, especially water erosion. The areas can be characterized by 600-800mm , 5-12% slope angles, parent material rich in $CaCO_3$ content and under agricultural land use form.

2. METHODS

Soil sampling

For examination of different slope thirds, methodology of the Hungarian Soil Protection Information and Monitoring System was used (Marth and Karkalik 2004). Soils were examined on the field at the depth of 0-100cm with the Pürckhauer type soil core sampler (Finnern 1994). Average samples were taken across the slope thirds at the depth of 0-20 cm in a cross section. 5-6 kilograms of soil was collected in each case to a bucket from at least 5 points on each section. Soil was mixed and 1–2 kilograms were taken to the laboratory. Detailed map of each sampling site are in Figure 2.

Soil laboratory analyses

The distribution of P_2O_5 (ammonium-lactate soluble, flame photometer method), K_2O (ammonium-lactate soluble, flame photometer method), $CaCO_3$ (volumetric method, calcimeter) and soil organic matter content (wet combustion, Turin method) was examined in the upper and lower slope sections of the examined slopes. Soil samples were analysed at the Szent Istvan University according to Buzás (1993).

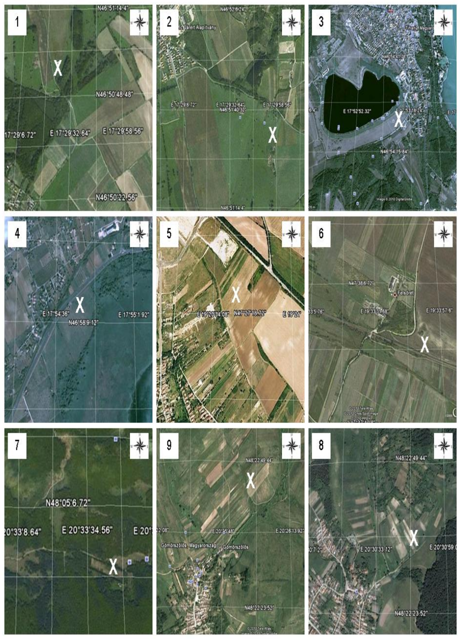

Figure 2: Sampling sites of the pedological investigations, Hungary (1=Nemesgulács, 2=Csobánc, 3=Tihany, 4= Csopak, 5=Maglód, 6=Galgahévíz, 7=Nagymező, 8=Gömörszőlős, 9=Alsószuha)

Table 1: Results of soil laboratory examinations on different slope sections, Balaton Upland, Hungary

Sample site	Land use	Slope section	pH (H_2O)	pH (KCl)	$CaCO_3$	SOM*	AL**-P_2O_5	AL-K_2O
					(%)	(%)	(mg/kg)	(mg/kg)
Tihany	pasture (horse)	UTS	7.9	7.3	37.3	14.4	163.5	706.2
Tihany	pasture (horse)	LTS	7.8	7.1	9.0	8.8	686.0	1200.7
Csopak	Pasture	UTS	7.5	7.1	7.9	6.9	501.6	753.1
Csopak	Pasture	LTS	7.6	7.1	6.7	7.6	1178.8	825.0
Csobánc	Pasture	UTS	6.1	5.3	0.0	7.0	113.0	294.5
Csobánc	Pasture	LTS	6.2	5.4	0.0	4.4	111.0	302.6
Nemesgulács	pasture (horse)	UTS	7.8	7.4	14.5	4.3	164.5	214.9
Nemesgulács	pasture (horse)	LTS	7.7	7.2	1.3	4.7	374.5	441.8

*SOM=Soil Organic Matter, **AL=ammonium-lactate, ND=no data

Location of the sample sites are on Figure 2. (No. 1. Nemesgulács, No. 2. Csobánc, No. 3. Csopak, No. 4. Tihany)

3. RESULTS

Examination of the soil samples taken on the different sites of the Balaton Upland can be seen in Table 1. The zero hypotheses were that differences between the slope sections can be proven based on basic soil parameters. Some of the soil parameters can not underline the hypotheses but carefully chosen sites, soil types and measured soil parameters are able to serve as indicators of soil erosion processes. In Tihany and Nemesgulács $CaCO_3$ content of the upper slope sections are significantly higher (37.3 versus 9.0 in Tihany, 14.5 versus 1.3 in Nemesgulács) than on the lower slope sections (Table 1). Higher $CaCO_3$ content on the upper slopes is the result of the high $CaCO_3$ can be detected because usually soils at this spot it is a mixture of the soil layers (sediments) eroded from the upper sections and the soil layers of the upper slope sections with the higher $CaCO_3$ content are not yet sedimented. Soil organic matter tends to accumulate at the bottom of the slopes but it can not be proven at the Balaton Upland. Nutrients are good indicators of soil movement. Phosphorous is better than potassium because phosphorous makes tight connection with soil particles thus moving together with the soil over the slope. Phosphorous contents of the soils at the lower parts of the slopes were higher on all sites except Csobánc at the Balaton Upland. K_2O content followed our hypotheses regardless of our expectations to have better results with the phosphorous.

The same hypothesis has been investigated on the sites of the Northern Mountain Ranges of Hungary (Table 2.). As we can see, on the pastures the influence of animals is obvious. In the Nagymező region the upper slope section had higher nutrient values and higher soil organic matter content because the animals spent more time there, organically and naturally fertilizing the soil of the upper third of the slope.

In most of the cases we could establish the connectionbetween the lower slope sections and the higher nutrient content in case of the arable lands. The exception is a slope in Galgahévíz where higher nutrient contents were connected to the upper slope section in 2004 but it turned to prove our hypotheses in 2006. $CaCO_3$ contents were almost double on the upper slope sections in Gömörszőlős. On the other sites there was not significant $CaCO_3$ content in the examined soil layer in the Northern Mountain Ranges. We have to keep in mind that extremely high nutrient contents were measured in Galgahévíz that is also a source of landscape formation, e.g. through the fastening of natural succession processes on the peaty meadows in the valley of the Galga Creek. This does not occur in Alsószuha where extremely low nutrient

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Table 2: Results of soil laboratory examinations on different slope sections, Northern Mountain Ranges, Hungary

Sample site	Land use	Slope section	pH (H_2O)	pH (KCl)	$CaCO_3$	SOM*	AL**-P_2O_5	AL-K_2O
					(%)	(%)	(mg/kg)	(mg/kg)
Nagymező	pasture (horse)	UTS	7.1	6.6	0.0	39.2	108.7	458.7
Nagymező	pasture (horse)	LTS	5.7	4.9	0.0	28.0	56.6	366.0
Maglód	arable land	UTS	8.0	7.4	1.3	3.8	86.4	194.7
Maglód	arable land	LTS	8.2	7.5	3.3	5.1	175.7	273.6
Galgahévíz (2004)	arable land	UTS	6.9	6.7	ND	2.0	1523.5	218.4
Galgahévíz (2004)	arable land	LTS	7.2	6.9	ND	1.5	1322.0	218.4
Alsószuha (2004)	arable land	UTS	6.5	5.4	0.0	2.6	32.4	162.7
Alsószuha (2004)	arable land	LTS	6.7	6.0	0.0	3.3	90.1	184.4
Alsószuha (2004)	meadow (1990-)	UTS	6.3	5.3	0.0	3.0	28.7	141.9
Alsószuha (2004)	meadow (1990-)	LTS	6.2	5.3	0.0	2.4	20.9	118.7
Alsószuha (2004)	meadow (1963-)	UTS	6.9	6.5	0.5	2.5	66.6	166.2
Alsószuha (2004)	meadow (1963-)	LTS	6.4	5.7	0.3	2.9	19.6	188.0
Gömörszőlős (2004)	arable land	UTS	7.8	6.7	21.3	2.3	140.8	464.0
Gömörszőlős (2004)	arable land	LTS	7.8	6.8	7.8	3.2	166.4	558.6
Gömörszőlős (2004)	meadow	UTS	7.3	6.7	19.3	3.9	110.1	483.0
Gömörszőlős (2004)	meadow	LTS	7.2	6.6	9.7	4.5	181.6	532.2
Galgahévíz (2006)	arable land	UTS	7.8	6.9	7.6	2.2	819.9	185.9
Galgahévíz (2006)	arable land	LTS	8.1	6.9	3.9	2.4	1652.8	197.8
Alsószuha (2006)	arable land	UTS	7.4	6.3	0.0	2.0	25.5	158.1
Alsószuha (2006)	arable land	LTS	7.1	5.9	0.0	2.1	72.8	142.3
Alsószuha (2006)	meadow (1990-)	UTS	6.4	5.5	0.0	2.4	15.6	144.5
Alsószuha (2006)	meadow (1990-)	LTS	6.2	5.1	0.0	2.3	38.8	111.7
Alsószuha (2006)	meadow (1963-)	UTS	6.9	6.3	0.7	2.4	38.8	177.7
Alsószuha (2006)	meadow (1963-)	LTS	6.9	6.4	0.2	2.5	25.5	151.3
Gömörszőlős (2006)	arable land	UTS	7.7	6.7	20.3	1.8	88.4	270.4
Gömörszőlős (2006)	arable land	LTS	7.6	6.7	9.1	2.1	141.0	382.2
Gömörszőlős (2006)	meadow	UTS	7.5	6.9	22.1	1.7	128.2	250.3
Gömörszőlős (2006)	meadow	LTS	7.4	6.8	12.3	1.9	163.5	274.3

*SOM=Soil Organic Matter. **AL=ammonium-lactate. ND=no data

Location of the sample sites are on Figure 2. (No. 5. Maglód, No. 6 Galgahévíz, No. 7. Nagymező, No. 8. Gömörszőlős, No. 9. Alsószuha)

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Table 3: Results of soil laboratory examinations on different slope sections, Somogy Hills, Hungary

Sample site	Land use	Slope section	pH (H_2O)	pH (KCl)	$CaCO_3$ (%)	SOM* (%)	AL**-P_2O_5 (mg/kg)	AL-K_2O (mg/kg)
Somogybabod	Acacia forest	UTS	7.6	6.6	ND	2.8	243.8	181.1
Somogybabod	Acacia forest	LTS	7.3	5.9	ND	3.2	198.9	276.2
Somogybabod	Potato/maize	UTS	7.9	6.8	ND	1.2	303.4	104.5
Somogybabod	Potato/maize	LTS	7.8	6.5	ND	1.6	315.7	128.6
Somogybabod	Cereal (Triticale)	UTS	7.9	6.8	ND	1.0	254.4	91.9
Somogybabod	Cereal (Triticale)	LTS	7.8	6.7	ND	1.1	271.2	168.1
Somogybabod	Alfalfa I.	UTS	7.9	6.8	ND	1.0	283.3	98.1
Somogybabod	Alfalfa I.	LTS	7.8	6.6	ND	1.2	197.4	168.1
Somogybabod	Alfalfa II.	UTS	7.9	7.3	ND	0.9	116.5	118.5
Somogybabod	Alfalfa II.	LTS	7.4	7.0	ND	1.4	273.7	446.1
Somogybabod	Maize	UTS	8.1	7.6	ND	0.5	16.3	40.8
Somogybabod	Maize	LTS	7.6	7.2	ND	0.8	39.1	48.4
Somogybabod	Black fallow I.	UTS	7.2	6.9	ND	1.4	22.0	73.9
Somogybabod	Black fallow I.	LTS	6.5	5.5	ND	1.1	15.5	65.0
Somogybabod	Maize (fallow)	UTS	7.3	6.5	ND	1.1	124.5	32.0
Somogybabod	Maize (fallow)	LTS	7.5	6.7	ND	1.1	108.6	87.9
Somogybabod	Black fallow II.	UTS	6.4	5.4	ND	1.5	8.8	85.5
Somogybabod	Black fallow II.	LTS	7.4	6.9	ND	1.7	29.9	78.5
Somogybabod	Cereal (winter wheat)	UTS	6.7	5.6	ND	1.0	8.4	56.5
Somogybabod	Cereal (winter wheat)	LTS	7.8	7.3	ND	1.0	45.4	40.8

*SOM=Soil Organic Matter. **AL=ammonium-lactate. ND=no data

contents were found, however the high amount of soil loss in this case is enough to be considered as landscape forming factor.

It is important to draw attention on the opposite result on the slopes where arable farming ceased in 1963. It shows the importance of the investigation of the landscape and its elements over the time. Farmlands that were turned from arable to meadow use can show the rate of landscape change and the process of regeneration. Average nutrient contents were measured in some part of the Somogy Hills (Table 3), but there were extremely low values as well.It is important to analyze the soil under the forest. It used to be under arable farming this is why there are so high values of nutrient content. The maize had very low nutrient values but still, it was proving the high rate of erosion by the more than double amount of phosphorous at the bottom of the slope. ‘Black fallow I’ did not prove the hypotheses in case of the phosphorous content but ‘black fallow II’ resulted in a much bigger difference (8.8 on the upper third and 29.9 on the lower third of the slope). K_2O content had opposite results, having higher amount at the lower section of the slope.

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4. DISCUSSION

There is a great need for easy and cheap methods to find out where soil loss reaches unacceptable levels. However the methodology used in this research has not been widely introduced all over the world and not even in Europe. What we can discuss is only the Hungarian experiences. Related researches started at the beginning of the 1990s as part of the Soil Information Monitoring System. The first results of these measurements were published at the Hungarian Geography Conference in 2001 by Béla Novaky (Nováky, 2001). The results represented by Nováky (2001) is focusing on soil loss and sedimentation and does not mention soil nutrient loss at all, however soil samples were taken and soil nutrients were measured in the laboratory.

Based on the research represented in this paper we can state that it can be a useful method for highlighting hotspots of erosion where soil protection measures should be introduced. The main results of this study is that an easy method can tell the exact location of the place where soil protection measures has to be taken. It is obvious that a simple in the field and in the laboratory analyses is not enough to fully understand what happened on a specific site because human effects always influence the results of *in situ* measurements (e.g. nothing explains why one alfalfa field has a better soil protection effect than the other one until we do not know the exact background of the two fields, like the amount and form of fertilizers applied, the amount of – at least the – yearly precipitation received, the date of planting, the soil management and other yield influencing factors). This is why we have to emphasize the importance of these researches and to collect a bigger number of data to find the best, most proper way of using this methodology.

It is also important to state that no matter how many soil loss is caused, nutrients and thus money is lost, human made objects are destroyed it is still wide spread to start introducing some measures after the effects of some extreme erosion event. In most of the cases it is easier to clean up than to think in advance.

5. CONCLUSIONS

In general, we can state that basic soil parameters can prove the soil water erosion to reach extreme rates. This can be a good indicator of landscape formation and landscape formation rate. Further investigations of different slopes (under different land use, on different soil types and parent material, with different inclinations, farming practices etc.) can add important details in order we wish to understand the landscape formation on our arable lands.

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