Potential effects of different land uses on phosphorous loss over the slope in Hungary

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Abstract
Water erosion is a natural process and occurs on almost every open-air field. In, close-to-natural conditions soil degradation and soil formation reaches its climax, reflecting the environmental factors of a certain area. When we start agricultural production, forest and pasture or meadow management on an area, the threat of accelerated soil erosion occurs, thus the rate of soil degradation will exceed the rate of soil formation. In our study we have chosen slopes with pairs of contrasting land use (e.g. arable land with forest or arable land with meadow or meadow with forest, etc.) where the slope length and angle are similar under the different land use types. For methods we chose the methodology of the Hungarian Soil Information Monitoring System and took soil samples from the upper and from the lower third of the slopes in order to compare the soil properties on these slops. We performed laboratory measurements of basic soil parameters (pH [H_2O and KCl], SOM, P_2O_5, K_2O, $CaCO_3$). A good example of the results is with phosphorus because this is one of the best indicator for analysing the effect of water erosion as it is connected with the soil particles, so it is washed towards the lower slope together with soil aggregates where water erosion occurs. According to our measurements, the amount of the P_2O_5 is usually bigger at the lower third of the slope, and in those cases we found 2.6–680.3% more on the lower slope third. In general, the measurements provide help for farmers to reduce nutrient loss (save fertilizer), hold the nutrient at the right place and thus provide crops with the necessary amounts of nutrients to reach better yields, and this way they save the purity of surface water and use the environment in a considerate manner.

Key Words
Erosion, nutrient loss, slope sections, different crops.

Introduction
Soil erosion considered as serious problem on agricultural fields mostly in the humid tropics (Babalola *et al.* 2007). The average precipitation of Hungary in the hilly areas is between 600 and 800 mm/year. Even in these circumstances we can find high amount of soil and nutrient loss, severe erosion causing gullying and rills (Pottyondy *et al.* 2007; Bádonyi 2006; Jakab 2006; Várallyay 2007). The structure of crop rotations do not favour soil protection (Faucette *et al.* 2007), contains big number of medium or low soil protection crop (Barczi *et al.* 1999; Centeri 2002; Szilassi *et al.* 2006). Tillage practices cause large soil losses. Soil and nutrient loss, runoff and sediment yield calculations (Jakab and Szalai 2005) are important in protecting our valuable arable lands. Examination of soil parameters are essential to teach farmers better management practices in order to save nutrients, soils, money, time and to protect the environment (Jordan *et al.* 2005). Soil and nutrient loss are calculated in erosion models all over the world (Evelpidou 2006; Gournellos *et al.* 2004), especially in connection with cultivation (Hedin *et al.* 1995; Davidson 1969). Reduced soil fertility and subsequent reduction in plant growth lead to reduced canopy and soil cover, worse plant conditions and possible increase of weed species. In our work we show differences of sediment quality based on shallow drillings and deep soil profile descriptions for two remote areas.

Methods
Examination of the slope thirds followed the methodology of the Hungarian Soil Protection Monitoring Manual (Marth and Karkalik 2004). Samples for pedological survey were taken from the top 20 cm layer and basic laboratory analysis were done: pH (H_2O and KCl), $CaCO_3$ % (Scheibler method), humus % (Tyurin's method), P_2O_5 (mg/kg) and K_2O (mg/kg) (Buzás 1988). 41 slope section pairs are introduced in this paper, focusing on the phosphorous loss of the examined areas.

Results

It is not possible to include all basic soil descriptive data with the results of laboratory analyses we show the results of the Nemesgulács area as an example (Table 1.). The results of phosphorous measurements are in Table 2.

Table 1. Results of the laboratory analyses of soil samples, Nemesgulács, Hungary.

Sample site	Description	pH (H_2O)	pH (KCl)	$CaCO_3$ (%)	SOM (%)	AL-P_2O_5 (mg/kg)	AL-K_2O (mg/kg)
Nemesgulács	Horse pasture, upper slope third	7.81	7.39	14.51	4.25	164.5	214.9
	Horse pasture, lower slope third	7.65	7.23	1.32	4.74	374.5	441.8

Table 2. Values of phosphorous content for the upper and lower third of the slopes.

No.	Site name	Land use/crop	Upper Slope Third (P_2O_5) (mg/kg)	Lower Slope Third (P_2O_5) (mg/kg)
1.	Alsószuha	arable land (2004)	32.41	90.07
2.	Alsószuha	arable land (2006)	25.5	72.8
3.	Alsószuha	meadow (since 1990) (2004)	28.7	20.9
4.	Alsószuha	meadow (since 1963) (2004)	66.6	19.6
5.	Alsószuha	meadow (since 1990) (2006)	15.6	38.8
6.	Alsószuha	meadow (since 1963) (2006)	38.8	25.5
7.	Csopak	grey cattle pasture	501.6	1178.8
8.	Galgahévíz	arable land (2004)	1523.5	1322.0
9.	Galgahévíz	arable land (2006)	819.9	1652.8
10.	Galgahévíz, Sósi Creek	alfalfa	98.8	119.6
11.	Galgahévíz, Sósi Creek	deciduous forest I.	215.4	205.5
12.	Galgahévíz, Sósi Creek	deciduous forest II.	47.4	110.7
13.	Galgahévíz, Sósi Creek	arable land	160.1	169.9
14.	Gömörszőlős	arable land (2004)	140.8	166.4
15.	Gömörszőlős	arable land (2006)	88.4	141.0
16.	Gömörszőlős	meadow (2004)	110.1	181.6
17.	Gömörszőlős	meadow (2006)	128.2	163.5
18.	Maglód	black fallow	86.4	175.7
19.	Nagymező	horse pasture	108.7	56.6
20.	Nagymező	pasture, trampled	79.1	59.3
21.	Nagymező	control	53	36.8
22.	Somogybabod	alfalfa II	116.46	273.65
23.	Somogybabod	maize	16.25	39.14
24.	Somogybabod	black fallow II	8.77	29.94
25.	Somogybabod	winter wheat	8.37	45.41
26.	Somogybabod	black locust forest (2)	17.02	132.81
27.	Somogybabod	triticale (2)	277.09	303.1
28.	Somogybabod	alfalfa I (2)	88.99	99.63
29.	Somogybabod	alfalfa II (2)	155.27	247.93
30.	Somogybabod	maize (2)	261.09	267.94
31.	Somogybabod	black fallow I (2)	121.01	164.13
32.	Somogybabod	maize II (2)	76.84	130.12
33.	Somogybabod	black fallow II (2)	57.37	136.87
34.	Somogybabod	winter wheat (2)	48.6	101.97
35.	Tihany	horse pasture	163.5	185.4
36.	Pilismarót	winter wheat I.	46.4	93.9
37.	Pilismarót	winter wheat II.	86.9	100.8
38.	Pilismarót	alfalfa I.	72.1	59.3
39.	Pilismarót	alfalfa II.	63.2	34.6
40.	Pilismarót	maize	95.8	22.7
41.	Nemesgulács	horse pasture	164.5	374.5

The high amount of $CaCO_3$ content (Table 1.) proves that the examined soil was formed on loess parent material. Table 1 provides information on erosion processes concerning $CaCO_3$ content and other parameters. $CaCO_3$ content is approximately 12 times higher on the upper slope third because erosion took away the upper layers and tillage brought the $CaCO_3$ rich parent material closer to the soil surface. We can state that K_2O content is a good indicator of erosion, underlying our zero hypothesis of erosion causing nutrient runoff because K_2O content at the lower slope thirds is doubled compared with the upper slope third. Statistical analyses showed significant differences between the values measured on the lower and upper third of the slopes (T-probe, p=0.027) without distinguishing whether the amount was higher on the upper or lower slope thirds. According to our understanding about erosion and runoff processes, we assumed that there should be more phosphorous at the lower third of the slope. In case of samples No. 3., 4., 6., 8., 19., 20., 21., 38., 39. and 40. The phosphorous content was bigger on the upper third of the slope. There is an explanation for this because these are the areas where there is either extensive farming and/or soil protecting plants with smaller amount or no fertilizer used so the chance for severe soil and nutrient runoff is not as high as on intensive arable lands. The next step was – since we wanted to prove that there is significant difference between the slope thirds for the cases where there was more phosphorous on the lower slope third – we made an analysis with only those data where there were more phosphorous at the lower third of the slope. Statistical analyses showed significant differences with even less possibility of error (T probe, p=0.0097).

Conclusion

Soil nutrient loss can be proven by a simplified method as in our case. Based on the analyses of 41 slope third pairs we can state that the differences in phosphorous content of the upper and lower slope sections are significant. This simplified method can be used to prove the connection between soil water erosion and nutrient loss and not only its presence but its extent. These way farmers can choose the proper method of soil management and fertilization.

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