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Soil and nutrient loss in Galgaheviz, Hungary

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Abstract:
The Galga River is surrounded by arable lands, orchards and small forests where new owners of the former cooperative cope with shrinking market's need. There is no chance to construct a soil protection crop rotation because the market does not buy any products, that we consider soil protective (e.g. alfalfa). The cash crops are corn and sunflower that farmers usually combine with winter wheat or other cereals. This is the reason of big amount of soil loss on the slopes facing the Galga River. The humic layer on two arable foothills reaches 2.6 and 3.0 meters in depth. Soil management is down the slope. According to the soil examinations, P_2O_5-content of the soil is above 1000 ppm, no matter on which part are we measuring it on the slope. This high amount of nutrient is moving down and washes into the Galga river meaning serious fertilizer loads. We work on investigations to show trends in nutrient movements to offer economically viable soil protection measures for local farmers.

Introduction:

Rural areas, like Galgaheviz in the Galga watershed suffer unemployment, population is getting old, younger people move to larger cities. Still, there is a huge potential in rural areas, like Galgaheviz. There is strong agriculture, local farmers produce what they need and extra for nearby city markets. Arable lands surround the river, roads and railway lines running parallel to the river valley. Animal husbandry was greatly reduced so soil nutrients are greatly improved by arificial fertilizer. Without increasing the number of animals it is difficult to construct a soil protection crop rotation. The market does not buy hay, alfalfa or any of those products, protecting the land. Cash crops are corn, sunflower and sometimes sugar beet. Farmers combine cash crop with cereals. Hungary has almost a whole year crop of winter wheat in storage.

Thanks to the structure of crop rotations and tillage practice, there is big amount of soil loss on the slopes facing the Galga Creek. The measurements on two arable foothills proved the humic layer to be 3,2 and 2,65 meters, respectively. Except having a crop rotation that give very little protection against soil loss, cultivation is down the slope.

In the region peaty areas, like the one in Galgaheviz are important for water storage, on the other hand people try to remove water from these areas as fast as possible in order to start soil management earlier. Water is an essential agent for sustaining the wetlands and its important natural values.

Soil and nutrient loss, runoff and sediment yield calculations (Jakab and Szalai 2005) are important in the life of the landscape. Monitoring the change of vegetation (Tinya and Tóth 2005) itself is not satisfactory to analyse the reasons. It is important to know about the water management and the change of soil parameters, too. In our work we show differences of

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sediment quality based on shallow drillings. We use the USLE model to calculate the time needed for sediment to fill up a certain area at a bottom of an arable slope.

Materials and methods:

We investigated the deeper horizons up to 3.2 meters to measure the nutrient and soil loss from arable farming. We had shallow drillings on the arable field facing Galgaheviz and took soil samples every 20cm. The laboratory experiments were done based on the Hungarian regulations in the Institute of Soil Science and Agricultural Chemistry, Hungarian Academy of Sciences.

We used the USLE model to calculate the potential soil loss that might have uploaded to the sediment area. In Hungary Centeri (2002a, b, c) used and validated the model. USLE uses physical factors to quantify the amount of soil lost per hectare per year. Its well known equation is: $A = R * K * L * S * C * P$

A = Soil Loss ($t * ha^{-1} * y^{-1}$),
R = Rainfall Erosion Index ($MJ * mm * ha^{-1} * h^{-1} * y^{-1}$),
K = Soil Erodibility Factor ($t * ha * h * ha^{-1} * MJ^{-1} * mm^{-1}$),
L = Slope Length (dimensionless),
S = Slope Gradient Factor (dimensionless),
C = Cropping Cover Management Factor (dimensionless),
P = Agricultural Practice Factor (dimensionless).

Results:

The laboratory results of the shallow drilling of Site 1. are in Table 1. and of Site 2. are in Table 2.. There is a great difference between Site 1. and Site 2. Site 1. is a more disturbed field, that is proved by the distribution of the humus, Ca and P_2O_5 content, and the pH with the depth (Table 1. and 2.).

On Site 1. and 2. pH (H_2O) and pH (KCl) is in the middle range, above 7 but below 8.7, so there is lime in all the layers of the buried soil or we might call it sediment that is proved by the Ca content, too. The Ca content is ranging from 0.7 to 7.5%. The values are greatly fluctuating that is proving that these are sediment layers, mixing with the lower horizons (richer in $CaCO_3$).

Based on the model simulation with USLE, the shallow drillings and the in situ observations, it is obvious that there is erosion on the area. It is important that regardless of the high erosion rate, the humus content of the upper 20cms are above 3% on Site 1. and above 2% on Site 2. This is a considerably good value for humus in the present farming practice in Hungary, especially considering that we are on a slope with more than 10% gradient.

Code	**pH_{KCl}**	**pH_{H_2O}**	**Humus**	**Ca**	**AL-P_2O_5**	**AL-K_2O**
			(%)	**%**	**$mg*kg^{-1}$**	**$mg*kg^{-1}$**
B 0-20	7.98	7.25	3.05	2.25	1944	334
B 40-60	8.02	7.23	1.79	1.74	1968	295
B 60-80	7.97	7.07	2.73	1.21	2247	283
B 80-100	8.09	7.30	2.40	1.34	1950	277
B 100-120	7.78	8.42	1.04	0.90	2221	320
B 120-140	8.01	7.29	0.00	1.00	2455	357
B 140-160	7.47	8.10	0.24	1.39	2284	353
B 160-180	8.12	7.32	0.95	0.70	2204	379
B 180-200	8.23	7.44	1.86	0.71	2040	355

B 200-220	8.30	7.48	0.80	0.77	1291	312
B 220-240	8.10	7.40	0.04	1.76	941	262
B 240-260	8.26	7.43	0.00	2.68	834	253
B 260-280	8.27	7.35	0.00	2.15	706	217
B 280-300	8.33	7.45	ND	2.27	502	222
B 300-320	8.62	7.63	0.17	7.48	182	107

ND = no data, KH = limit of measurability, N = sunflower (field), B = cereal (field)

Table 1. Laboratory results of the shallow drilling near the orchard

Code	**pH_{KCl}**	**pH_{H_2O}**	**Humus (%)**	**Ca %**	**AL-P_2O_5 mg*kg^{-1}**	**AL-K_2O mg*kg^{-1}**
N 0-20	8.12	7.40	2.03	ND	ND	ND
N 20-40	8.09	7.20	2.60	1.33	1266	383
N 40-60	7.72	7.16	5.35	1.31	1283	430
N 60-80	8.02	7.15	2.39	1.06	1371	272
N 80-100	7.95	7.20	1.72	0.82	1540	294
N 100-120	7.91	7.19	1.78	1.03	1304	392
N 120-140	8.32	7.56	1.28	1.03	392	407
N 140-160	8.22	7.52	0.00	1.21	660	424
N 160-180	8.37	7.67	0.00	2.10	669	478
N 180-200	8.47	7.79	0.28	3.39	1012	438
N 200-220	8.46	7.95	0.85	6.08	863	329
N 220-240	8.48	8.15	1.01	7.29	895	246

ND = no data, KH = limit of measurability, N = sunflower (field), B = cereal (field)

Table 2. Laboratory results of the shallow drilling near the center of the cooperative

	pH_{KCl}	**pH_{H_2O}**	**Humus %**	**$CaCO_3$ %**	**AL-P_2O_5 mg*kg^{-1}**	**AL-K_2O mg*kg^{-1}**
Galga (A horizon)	7,03	8,05	2,67	4,9	1767,32	199,31

Table 3. Laboratory results from the A horizon of Site 1. (soil profile examination)

The Ca content is mostly following the pH values. It shows disturbance of Site 1. at a greater scale. Values are below 1 and above and it changes twice. The content is a good figure with it we can tell that we are reaching the Ca rich parent material. Values are above 7 on Site 1. and 2., too.

AL-P_2O_5 were above usual calibration of 1000ppm. In the present case they had to be re-calibrated because we had as high as 2455ppm on Site 1. This time there is more change on Site 2. At the depth of 100-120cm AL-P_2O_5 content is 1304ppm while at 120-140cm it is low (392ppm) but it is raising again until 180-200cm (1012ppm) and at the deepest layer it is 895ppm. These values are very high. Farmers should start mining this soil and spread it as fertilizer but they do not need to put phosphorus fertilizer in the following years for sure. On the other hand if the sediment is reaching the river it might cause serious damage in nearby meadows by this high phosphorus load. The distribution of AL-K_2O is quite even.

As indicated in the title of our recent work, we were dealing with soil loss. We calculated the soil loss with the USLE model.

1. An average R factor for the simulations of the previous years was determined (R factor: 670 MJ * mm * ha^{-1} * h^{-1} * y^{-1}) by the map of Thyll (1992).
2. The K value of the chernozem brown forest soil was 0,0162 t*ha*h*ha^{-1}*MJ^{-1}*mm^{1}.

3. We used an average slope gradient (12%) and length (100m). The LS value was calculated by the RUSLE model's manual because USLE does not takes rill and interrill erosion into account. RUSLE does. We used Table 4-2. from the RUSLE manual that showed a value of 3,81 for a 12% slope that is about 130 meters long and there is a moderate rate of rill and interrill erosion.
4. C factor was calculated by the surface cover, dominated by cereals and corn/sunflower, so the average value used was 0,25.
5. The tillage practice was up and down the slope so it was constant = 1.

According to the calculations the average soil loss per year is 10,34 $t*h^{-1}*y^{-1}$. It means that the sedimentation area (10m by 100m = 0,1ha) was built up from this material on our sample slope. The calculated 10,34 $t*h^{-1}*y^{-1}$ soil loss arrived on this 0,1ha area. This means 0,66 $mm*h^{-1}*y^{-1}$. that is 6,6mm/0,1ha upload. If the original soil profile was 80 cm deep that is now covered by 220 cm sediment than 333 years of erosion had to occur to build this amount of sediment (220cm).

Since there has not been arable farming in the last 333 years, the rate of erosion must have been two or three fold, opposite the calculation with the model. The reason for the low calculated soil loss figure can be a result of the low calculated C factor (so there should have been more plants with low erosion protection value) or the local rainfall intensities were much higher than it was calculated by the small scale erosivity map. The USLE do not calculate with rill and interrill erosion, however we calculated the LS value based on the tables from the RUSLE manual that is taking rill and interrill erosion into account.

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