DEPENDENCE OF SOIL ERODIBILITY FACTOR ON THE MEASUREMENTS OF SOIL PARTICLE SIZE DISTRIBUTION

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Abstract

There are a growing number of physically based soil erosion models and their use is increasing rapidly as well. Meanwhile, as the input need of physical models is much larger than those of the empirical models, any research investigating the punctuality of factors affecting the final outputs of the model are valuable. In the present case we did soil particle size measurements in different institutions (Debrecen and Szeged University and Geographical Institute) with different methodologies (laser, aerometer and pipette methods) on different soil materials (sandy, loamy and clayey). Results of measuring particle size fractions were used for calculating the soil erodibility factor, using the USLE methodology: 8 soils were examined and statistical analyses found significant differences among the particle size measurements. The purpose of the paper is to find out whether these significant differences in particle size measurements were causing significant differences in soil erodibility calculations, too?

Keywords: particle size distribution, different methods, USLE, K factor

Introduction

Soil is examined from various points of views (BARCZI, A. et al. 2009; PETŐ, Á. 2011; PETŐ, Á. 2013; MERINÓ, A. et al. 2004; FONSECA F. et al. 2012; KONDRLOVÁ, E.et al. 2013). Soil is the core interest of soil erosion researches as we want to protect the soil itself (KERTÉSZ, Á. 1993; SZILASSI, P. et al. 2006; BÁDONYI, K. et al. 2008; BARCZI, A. and JOÓ, K. 2009; MADARÁSZ, B. et al. 2011). Soil erosion modeling is a useful tool for predicting potential amount of soil loss (HENG, B. C. P. et al. 2011; ROJAS, R. et al. 2008; PRADHAN, B. et al. 2011). Soil erosion models have to be examined in situ where they are to be used in order to get as proper data as possible locally (CENTERI, CS. 2002; CENTERI, CS. et. al. 2009; CENTERI, CS. et al. 2011; CENTERI, CS. et al. 2012). Any additional data and research related to the increase of punctuality of the models are most welcomed by model users (MADARÁSZ, B. et al. 2012). In the present case, the soil erodibility factor is analyzed based on the liability of measuring an important input parameter: particle sizes. The research aims are to show if there were effects of particle size measurements methods on soil erodibility factor of the USLE model. As particle size is an important parameter for all other soil erosion models, these data can be used for other models as well.

Materials and methods

Eight soil samples were chosen from seven locations from various soils of Hungary (*Figure 1*). The samples represent a wide palette of soil texture and soil structure. In some cases there was no significant aggregating effect among the coarse particles (i.e. TUR, KMA). Other samples had higher clay content with additional inorganic and humus colloids that resulted in more resistant aggregates (i.e. samples from the BOR, GFH and GAH).

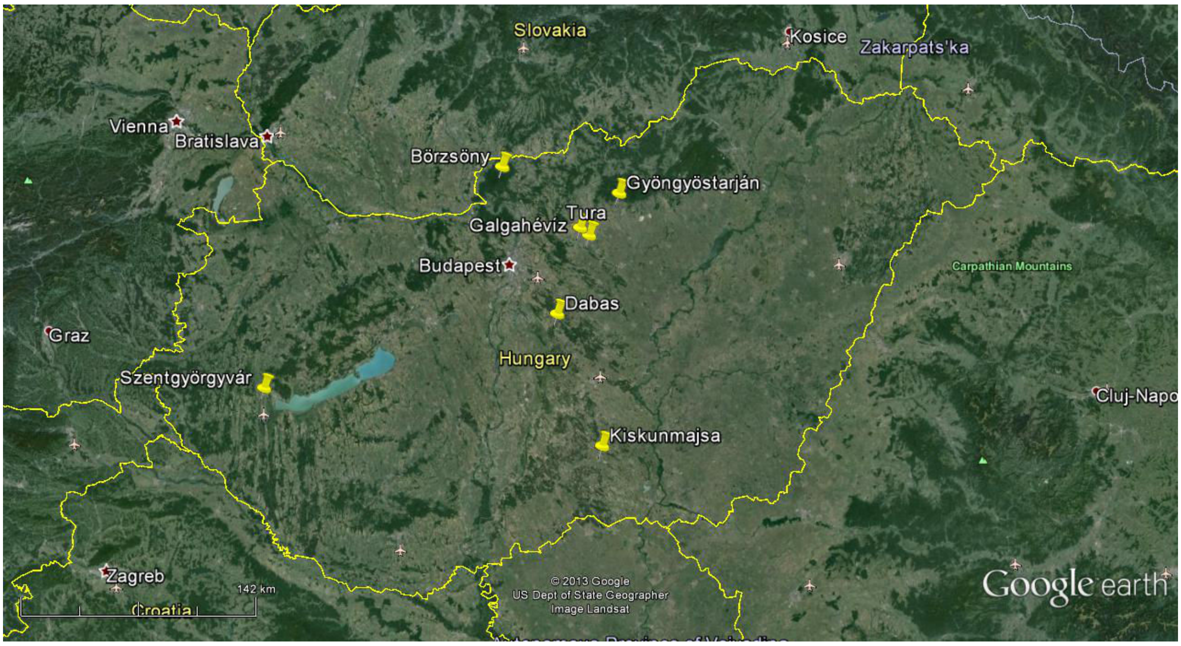

Figure 1 Origin of the eight soil samples from seven locations (Hungary)

Three institutions participated in the measurements. Three methods were used. Codification of all information is in *Table 1*.

Table 1: Codification of samples, sample sites and participating institutes

Code	**Name of the participating institute**
S	University of Szeged
D	University of Debrecen
F	Geographical Institute, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences
Code	**Sampling sites information**
BOR	Börzsöny Mountain, mountain top
GAH	Gyöngyöstarján, Mátra Mountain, lower third of the slope
GFH	Gyöngyöstarján, Mátra Mountain, upper third of the slope
SZG	Szentgyörgyvár, Zala Hills
TUR	Tura (lowlands of Hatvan along the Galga Creek)
KMA	Kiskunmajsa (sandy lowland)
FES	Dabas (sandy lowland)
GAL	Galgahévíz (lowlands of Hatvan along the Galga Creek)
Code	**Method of measurement**
A	Areometer (S)
L	Laser method (F)
P	Pipette method (S
P1	Pipette method, laboratory staff No. 1. (D)
P2	Pipette method, laboratory staff No. 2. (D)
Code	**Replicate**
1	replicate 1
2	replicate 2

Measurements with the Laser Particle Sizer Analysette 22 MicroTech

Sample preparation was carried out without OM takeout using sodium pyrophosphate in order to disperse the aggregates into elemental particles. 20g air dried soil was dispersed in 25 ml (0.5n) sodium pyrophosphate for 24 hours. Than the suspension was leached through a 500µm sieve and measured in a diffractometer Laser Particle Sizer Analysette 22 (Fritsch GmbH Germany). The measuring range of the used unit (MicroTec) was 0.1-600 µm. The coarse fractions (>500µm) were determined by sieving. The measuring unit of "Analysette 22" contains a helium-neon laser below 5 mW and a wave length of 655nm. The diffracted beams are gathered by Fourier lens onto the detector. The apparatus uses the Mie theory (MIE, G., 1908) to calculate grain-sizes from the intensity of the diffracted light. The results are classified into 102 size classes. One measurement was an average of 180 scans of the sample therefore no repetitions were applied.

Determination of particle size distribution with Köhn-pipette

Measurements were carried out according to BUZÁS, I. (1993) using the Hungarian patent of particle size distribution (MSZ-08-0205-1978). The method needed prepared soil samples (i.e. removed organic matter with H_2O_2, sieved with Ø=0.2 mm mesh size). A mortar was applied with water and continuous rubbing. Finest fraction was flowed into a sedimentation vessel. This procedure was repeated until there were no fine particles in the mortar when the whole sample was washed into the vessel. The suspension was filled up to 1000 ml with distilled water and 10 ml 0.2 M sodium-oxalate was added to prevent coagulation. The settling time was calculated of 10 cm-s within the suspension. Finally, after the finest (<0.001 mm) fraction had settled, the pipetted samples were dried at 105°C and than determined the weights. Using the weights and knowing the initial amount of soils particle size classes were expressed in percentage.

Determination of particle size distribution with aerometer method

The method is based on Stokes' law also. Suspension is made from 20–60 g sample. Moisture of the original sample is determined with gravimetry. To prevent coagulation 0.5–1 g sodium-pyrophosphate is added to the suspension and then it is filled until 1000 cm^3 with distilled water. The density of soil suspension must be measured at 30 s until 24 h by aerometer (MSZ 14043/3: 1979; BUZÁS, I. 1993).

Calculation of soil erodibility values

Soil erodibility has been calculated with the following equation according to SCHWERTMANN, U. et al. (1987):

$$K = 2.77 \cdot M^{1.14} \cdot 10^{-6} \cdot (12 - OS) + 0.043 \cdot (A - 2) + 0.033 \cdot (4 - D)$$

where *M* = (particle fraction between 0.063 mm and 0.002 mm (%) + particle fraction between 0.1 mm and 0.063 mm (%)) (particle fraction between 0.063 mm and 0.002 mm (%) + particle fraction between 2.0 mm and 0.063 mm (%)); *OS* is the percentual content of organic substance (if *OS* > 4% *OS* = 4 %); *A* = aggregate category; *D* = category of permeability. In this case *A* = 2 (soil aggregates are between 1-2 mm) and *D* = 3 (infiltration rate is between 10–40 $cm \cdot day^{-1}$) (SCHWERTMANN U. et al., 1987).

Input parameters for USLE modeling

For the USLE model running we have chosen the following parameters: R factor = 1300 (MJ mm ha^{-1} h^{-1} y^{-1}), LS = 3.5, C = 0.5, P = 1.

Results

Results of the K factor calculations based on the particle size measurements are in *Table 2*.

Table 2 Results of K factor calculations with USLE methodology based on the particle size distribution of 3 institutions (Szeged and Debrecen University, Institute of Geography) and 3 methods (laser, pipette and aerometer)

Site code		**K** (t ha h ha^{-1} MJ^{-1} mm^{-1})	**Site code**		**K**
	Minimum:	0.03350		Minimum:	0.03524
BOR	Maximum:	0.03560	TUR	Maximum:	0.03664
	Mean:	0.03470		Mean:	0.03573
	Minimum:	0.03400		Minimum:	0.03315
GAH	Maximum:	0.03600	KMA	Maximum:	0.03330
	Mean:	0.03508		Mean:	0.03316
	Minimum:	0.03470		Minimum:	0.03476
GFH	Maximum:	0.03600	FES	Maximum:	0.03614
	Mean:	0.03510		Mean:	0.03545
	Minimum:	0.03570		Minimum:	0.03640
SZG	Maximum:	0.03680	GAL	Maximum:	0.03760
	Mean:	0.03618		Mean:	0.03710

The calculated K factors (*Table 2*) were used to calculate the amount of soil loss with the USLE model. The results of these calculations are in *Table 3*.

Table 3 Amount of soil losses calculated with the different K factors by using the results of the particle size distributions measured with different methods

Site code		**Soil loss (t/ha/y)**	**Site code**		**Soil loss (t/ha/y)**
	Minimum:	76.2		Minimum:	80.2
BOR	Maximum:	81.0	TUR	Maximum:	83.4
	Mean:	78.9		Mean:	81.3
	Minimum:	77.4		Minimum:	75.4
GAH	Maximum:	81.9	KMA	Maximum:	75.8
	Mean:	79.8		Mean:	75.4
	Minimum:	78.9		Minimum:	79.1
GFH	Maximum:	81.9	FES	Maximum:	82.2
	Mean:	79.9		Mean:	80.6
	Minimum:	81.2		Minimum:	82.8
SZG	Maximum:	83.7	GAL	Maximum:	85.5
	Mean:	82.3		Mean:	84.4

Based on the soil loss calculations' maximum and minimum values, we expressed the difference between these two values. The figures in *Table 4* show the differences where the basis was the minimum value, so the percentage is expressing the difference of the maximum value compared to the minimum value (i.e. 6.1 % means that the maximum value is 6.1 % bigger than the minimum value).

Table 4 Differences in the amount of soil losses calculated with the different K factors by using the results of the particle size distributions measured with different methods

Site code	$Values_{max}$-$Values_{min}$ in %)
BOR	6.1
GAH	5.7
GFH	3.7
SZG	3
TUR	3.9
KMA	0.4
FES	3.9
GAL	3.2

Conclusion

The analyses of the effects of particle size measurements methods proved that there can be considerable differences among the calculated soil losses if we use the particle size measurements methods to calculate the soil erodibility factor and use these factors in the USLE model to calculate the amount of soil losses.

We can conclude that particle size measurements do have an effect on soil erodibility factors and thus on the amount of the calculated soil losses regardless of the fact that there were no analyses of significance on the soil erodibility and soil loss calculations.

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