METHODS FOR ASSESMENT OF SOIL EROSION

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Abstract: *Excessive erosion can threaten the production of agricultural and forest products. Erosion may also have a negative impact of water streams and lakes. The main objectives of the study were to develop the methods for assessment of soil erosion, with an application in three territories from catchment area Bârzava. The first method is based on the detachment model and estimates the soil erosion with Trott's equation, modified by Rogobete and Grozav. The new equation was obtained using a soil pan in order to study the effect of row-sideslope shape, rain energy, and rain intensity on interrill runoff and erosion. Left plot has uniform 20 % slope; right plot has curved complex-shaped surface. Soil detachment represents a major improvement in erosion modeling compared with that used in the Universal Soil Loss equation. A more rigorous framework is needed for studying and making further advances in predicting the detachment process. The theoretical framework is presented in a generalized form where assumptions can be challenged and the relationship modified and improved by future research. The amount of sediment production were calculated for 6 soil profiles, based on particle size analyses, humus content and Kaolinite and Smectite content. The greatest values were of Vertic Luvisols from Berzovia (18,53 t/ha) and Vertic Planosols (11,88 t/ha). The smallest values of sediment production was of Gleyic Fluvisols (5,05 t/ha) and of Eutric Gleysols (5,46 t/ha), soils which have had a great quantity of humus. Soil profile reconstitution was the second method used in order to establish the soil erosion phase. The values of the depth of horizons which were eroded varies between 2 cm and 45 cm with an amount of soil lost between 238 t/ha to 6435 t/ha. Maximum value was at Luvisols –eroded phase. Conservation measures in order to reduce soil erosion include contouring, strip cropping, conservation tillage, terraces, buffer strips, and use of polyacrylamide. One of the most effective means of reducing erosion is to maintain a vegetative or residue cover on the soil surface.*

Key words**:** *erosion, predict, equation, soil, reconstitution*

INTRODUCTION

Water erosion is caused by the detachment and transport of soil by rainfall, runoff, melting snow or ice, and irrigation. Early efforts to understand and predict soil erosion were primarily empirical. Erosion plots were established and used to measure soil loss for different rainfall, soil and topographic and land use characteristics. The Universal Soil Loss Equation (USLE) was developed from this data base (WISCHMEIER and SMITH, 1960). More recently, substantial improvements have been made in predicting erosion using process – based models, such as those used in the Water Erosion Prediction Project – WEPP (FOSTER, 1987).

Process based models are useful in solving a wider range of problems as well as providing a framework for studying erosion processes. Although WEPP and similar models like CREAMS, SWRRB, EPIC; ANSWERS and AGNPS, substantially improve modeling efforts, a more rigorous framework is still needed for studying and making further advances in predicting the detachment process. For example, using the WEPP approach, the soil erodibility is directly related to the detachment model. If a different detachment model is used, a different erodibility value is obtained for the same soil conditions. Excessive erosion can threaten the production of agricultural and forest products. Erosion may also impact water conveyance and storage structures, and contribute to pollution from land surfaces. Water erosion may occur within rills, interrill areas, gullies, ephemeral gullies, stream channels, forest areas and construction sites.

Conservation measures that have been effectively used to reduce soil erosion on agricultural areas include contouring, strip cropping, conservation tillage, terraces, buffer strips, and use of polyacrylamide on irrigated areas. Specialized erosion control practices have been developed for use within stream channels, forest areas, and constructive sites. One of the most effective means of reducing erosion is to maintain a vegetative or residue cover on the soil surface. Erosion is a natural process. Topographic features such as canyons, stream channels, and valleys are created by long-term geologic erosion. Accelerated erosion results from the removal of natural vegetation by human activities such as farming, ranching, forestry and construction.

Nutrients, pesticides, and pathogens transported by sediment can contribute to pollution of stream and lakes, thus reducing their suitability for aquatic organisms and their use as water supplies. A large nutrient concentration in streams and lakes can also cause excessive vegetative growth, resulting in seasonal oxygen deficiencies. The objective of this study is to present the methods for assesment of soil erosion and some results obtained in the Bârzava hydrographical basin, using a general equation (ROGOBETE, 2006) to estimate interrill detachment coefficients for sediment production model and the method of soil profile reconstitution.

MATERIAL AND METHODS

Soil surveys effectuated during last years in the superior part of the hydrographical basin Bârzava, has revealed that the dominantly soil types are Luvisoils and Cambisoils. This research was located at the territories Re□ita, Boc□a and Berzovia, situated on the hills by Dognecea Mountains. On the slopes all the soils are affected by sheet erosion, moderately or strongly eroded, with low fertility.

For the first method, we have used the Trott's equation (Trott and Singer, 1983) altered by Rogobete and GROZAV (2006) in order to establish sediment production resulted by erosion. The index was calculated with dispersed soils and aggregated soils. The study was conducted using a 1.04 m. square soil pan that was filled with soil to a depth of about 75 mm. Two plots, each of 0.3m.wide x 0.45m long were prepared side - by - side within the pan and centered beneath the rainfall simulator nozzle. One plot was uniform 20% steepness. The other averaged 20% steepness from top to bottom, but had a complex-shaped cross-section typical of row sideslopes in a bedded field. Simulated rain was applied to both plots simultaneously, and runoff was collected in containers beneath the lower ends of the plots. With all variables significant at the 95% confidence level, the resulting equation to predict sediment yield is:

$$SP = -9.391 + 25.297(Si+Cl) - 0.2297(Si+Cl)^2 - 12.551(Kaolinite) + 31.420(Smectite) - 16.18(Humus) \quad (1)$$

where:

SP = sediment production, in grams/m^2;
Si+Cl = percent silt plus percent clay (from particle - size analysis)
Kaolinite = percent Kaolinite clay present in soil;
Smectite = percent Smectite clay present in soil;
Humus = percent humus present in the topsoil.

A set of samples for all 6 soil profiles was collected from each profile. Laboratory tests to determine particle - size distribution were effectuated in accordance with standard methods. For Smectite and Kaolinite content were used X - ray analysis, differential thermal analysis and infra-red analysis.

For the second method - soil profile reconstitution were studied 14 sites with 3 soil profiles an each versant, one of the superior part of the versant (on plateau), one of the middle of the versant (which was eroded), and the third of the bottom of the slope. The soil lost by sheet erosion was calculated using equation:

$$HorizonA, eroded, reconstituted = \frac{(\mathrm{ACy} + \mathrm{Cy}) \cdot \mathrm{Ax}}{\mathrm{ACx} + \mathrm{Cx}} \tag{2}$$

where:

Horizon A, reconstituted = depth, cm;
Ax, A/Cx = soil horizons from plateau profile, cm;
Ay, A/Cy, Cy = soil horizons from the slope, eroded, cm.

RESULTS AND DISCUSSIONS

The general framework for particle detachment (Wilson, 1993) is based on the dislodging and stabilizing forces, and associated moment lengths (figure 1). Forces acting to dislodge the particle are the z - direction lift force (F_L), the x - direction drag force (F_d) and the x - component gravity force ($W_s \sin\alpha$). Forces resisting movement are the contact forces (F_{c1}, F_{c2}, …, F_{cn}) and the z-component gravity force ($W_s \cos\alpha$). Particle detachment occurs if the moment associated with dislodging forces is greater than those associated with stabilizing forces.

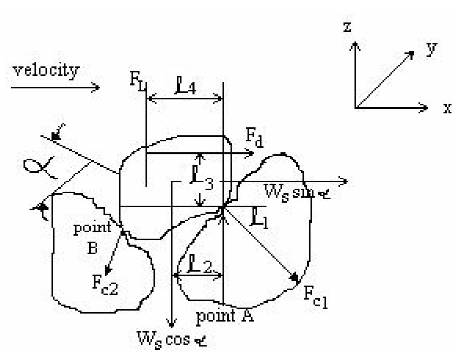


Figure 1: Important forces and moment lengths (WILSON, 1993)

The point of incipient motion is then defined as:

$$l_1 W_s \sin\alpha + l_3 Fd + l_4 F_L = l_2 W_s \cos\alpha + Mc \tag{3}$$

$$Mc = \sum_{i=1}^{n_c} \delta_{ci} a_i l_i \tag{4}$$

where terms are as defined in figure 1 and Mc is the sum of moments of cohesive and frictional resistance forces, n_c is the number of contact locations, σ_{ci} is a particle-to-particle stress term, a_i is the contact area and l_i' is the moment length for each contact location.

Assuming that the drag and lift forces are proportional, the moment balance of equation 3 can be rearranged as:

$$F_d = W_s\left(K_{ls} + fc\right) \tag{5}$$

If the left side (primarily fluid flow characteristics) is greater than the right side (primarily particle and bed characteristics) the particle is detached, otherwise it is not.

The results of this consideration provide the basis for estimating the relative erodibility of soils on sheet overland flow areas for use in physical process-type models of sediment production.

Table 1

Analytical data - Berzovia

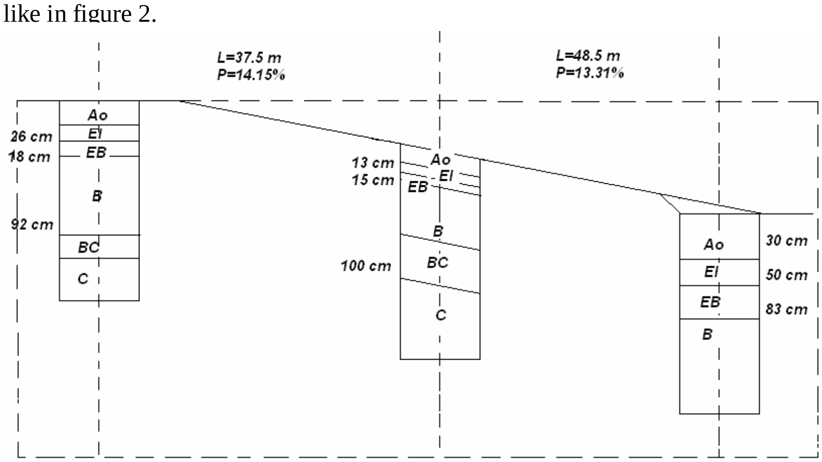
No.	Soil	Silt %	Clay %	Humus %	Kaolinite %	Smectite %	SP g/m^2	SP t/ha
1	*Stagnic Luvisols*	27,8	30,6	4,09	3,0	14,0	990,65	9,91
2	*Vertic Luvisols*	31,4	31,6	3,50	8,0	42,0	1853,31	18,53
3	*Vertic Planosols*	35,5	20,7	1,65	8,0	20,0	1188,16	11,88
4	*Eutric Gleysols*	18,4	29,2	4,84	4,0	0,0	545,84	5,46
5	*Gleyic Fluvisols*	34,3	47,9	2,74	5,0	3,0	505,24	5,05
6	*Luvisols eroded phase*	28,4	40,8	2,38	1,0	16,0	1092,87	10,93

Table 1 shows the wide variety of sediment production because of soil types and as a function of textural and clay mineralogy.

The greatest yield sediment is on Luvisols and Planosols and the smallest are on Fluvisols and Gleysols. It is correlated with a large content of smectite in the clay fraction.

We recognize that the amount of coarse fragments and humus content can reduce sediment detachment and transport, and of coarse the amount of sediment production.

For soil profile reconstitution it will be presents the method for one site from Bocşa. It were identified the horizons and measured the thickness, were taken soil samples for soil analysis – bulk density, particle – size, soil chemical, for all three soil profiles situated on the versant like in figure 2.



Non eroded profile	Eroded profile	Cumulic profile

Figure 2 Soil profile reconstitution, Chromic Luvisols

In order to calculate the humus, nitrogen, phosphorus, potassium reserves we can use the next formula:

$$X_r = X_g \cdot DA \cdot H \qquad (6)$$

where:

X_r=component reserve, t/ha, on depth H;

X_g=massic component (g/100g soil);

DA=bulk density, g/cm^3;

H=depth, cm.

Profile 1 no eroded

A_o+E=26 cm

EB = 18 cm

Bt = 92 cm

Profile 2 eroded reconstituted

A_o+E=13 cm

EB = 15 cm

Bt = 100 cm

Substitution in formula 2:

$$A_{erodedreconstituted} = \frac{(15+100)\cdot 26}{18+92} = 27{,}18cm$$

$$Soil.lost = 27{,}18cm - 13cm = 14{,}18cm$$

Profile 3:

A_o+E= 46 cm

A_o+E, +E-B= 83 cm

For soil profile reconstitution method using equation 2 and 6 we have obtained the results of the soil lost and humus. It can be calculate also the lost of nourishing at the same time with the lost soil by erosion.

Table 2

Examples of soil lost obtained by soil profile reconstitution method

No.	Soil types SRTS – WRB	Bulk density g/cm^3	Horizon depth cm	Soil lost t/ha	Lost humus t/ha
Reşiţa					
1	Luvosol tipic – Haplic Luvisols	1,19	2	238	5,43
2	Luvosol stagnic – Stagnic Luvisols	1,21	4	484	13,26
3	Eutricambosol tipic – Eutric Cambisols	1,30	10	1300	37,83
4	Eutricambosol tipic – Eutric Cambisols	1,22	12	1464	66,17
Bocşa					
5	Luvosol tipic – Haplic Luvisols	1,18	2	236	7,36
6	Luvosol roscat – Chromic Luvisols	1,26	14,18	1786,7	57,57
7	Luvosol roscat – Chromic Luvisols	1,25	13	1638	28,83
8	Luvosol stagnic – Stagnic Luvisols	1,16	2	232	4,87
9	Eutricambosol rodic – Rhodi-eutric Cambisols	1,22	9	1098	42,60
10	Erodosol argic – Luvisols-eroded phase	1,43	45	6435	205,92
Berzovia					
11	Preluvosol stagnic – Stagnic Luvisols	1,22	6	732	29,94
12	Preluvosol pelic – Vertic Luvisols	1,28	28	3584	110,74
13	Luvosol pelic – Vertic Luvisols	1,08	9	972	34,02
14	Erodosol argic – Luvisols-eroded phase	1,42	30	4260	63,47

The values of the depth of horizons which were eroded, varies between 2 cm and 45 cm with an amount of soil lost 238 t/ha to 6435 t/ha. The greatest values are registered of Luvisols – eroded phase. This values reflected a long time of soil erosion, since these areas were ploughing.

CONCLUSIONS

The soil lost was evaluated using two methods. The predicted sediment yield values can be considered an index of relative interill erodibility. Sediment yield was determined with an equation modified by Rogobete and Grozav, which consider that the sediment production is related with soil texture, kaoline and smectite content and humus content. The great sediment production were found at Luvisols and Planosols (18,53 and 11,88 t/ha). The second method used was the soil profile reconstitution, which is based on the depth of the horizons of soil profile situated on the middle of the versant, where is a strong erosion. The great amount of soil lost were at Luvisols – eroded phase (6435 t/ha) from Bocşa and in Berzovia – Luvisols – eroded phase (4260 t/ha), with a depth of horizon of 45 cm and respectively – 30 cm.

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