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Gully Erosion Effect from Torrential Basins on the Environment

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Abstract. The paper contains data about the destructive effects of gully erosion on the environment. Provides general information about the gully erosion in several countries around the world including Romania and is considered a case study for a river basin located Semenic Mountains (Bârzava drainage area). For modeling of erosion processes on slopes and beds of Bârzava river sub-basin was used modeling program WEPP (Water Erosion Prediction Project).The case study is based on the following assumptions: the presence of different types of soil, constant rain intensity over the entire river sub-basins, land use is the same all over sub-basins; there aren't soil erosion control works. Model was applied to each area of bed (gully), by calculating the quantity of soil lost depending on soil type.

Sub-basin divided into sub-basins corresponding to the beds sectors taking into account the direction of water flow. Are noted sub-basins with H and river beds with C (river beds sectors). Each C is corresponding to one H. (Figure 1)

Data entered in the program are: the use of land - forests, climate - the average monthly temperature and precipitation, soil characteristics, sub-basins areas, river beds characteristics: average width of the river bed and river bed type (channel river bed in the forest area).

Keywords: gully erosion, exogenous factors, water erosion, anthropogenic factors, river basin, the calculation model

1. INTRODUCTION

The Earth has suffered and continues to suffer major changes due to the action and interaction between endogenous and exogenous factors.

Crust movements, caused by endogenous factors, leading to activation of exogenous factors such as gully erosion.

Estimates made by FAO, in 1983, shows that in the world, an area of 5-7 million hectares of land are removed from the culture due to degradation processes (erosion, toxic chemicals, soil salinization, urbanization, etc.) estimated losses at the end of year 2000 is of 100-140 million ha.

In Europe an area of about 115 million hectares (about 12% of Europe's surface) is affected by water erosion.

In Romania, taking into account specific indicator erosion intensity (t/ha/year) deviating significantly counties in the bend area of Carpathians Mountains (Buzau, Vrancea, with values of approximately 40 and respectively 35 t/ha/year) towards a maximum allowable erosion of 4-6 t/ha/year. After Motoc (1982) Romania weighted average was 16.28 t/ha/year. Gully erosion in the world has various effects on the environment, namely:

- In Russia, land area is degraded by approximately 500 thousand ha/year. Through water erosion were formed about 400 thousand gully erosion formations, covering over 500 thousand hectares (after G. Gardner 1996).
- In Pakistan 75% of the country is affected by water and wind erosion and gully erosion affects 36% of the agricultural area of the country (after G. Gardner 1996).
- Greece is about 40% of the total area of cultivated land affected by erosion, and over 800 active torrents transport over 30 million m^3 of solid material (Vousaros A. quoted by Băloiu V., 1986).
- China is affected by the erosion- approximately 3.7 million km^2 (about one third of the country (Mircea S., 1999).
- In India, gully erosion affecting 3.67 million hectares (Mircea S., 1999).
- In Lesotho, a country with an area of only 30,000 km^2, about 20-30 large thousand ravines occupy 4% of the arable area of the country (after Wenner, 1989, quoted by Mircea S., 1999).
- In Romania has been inventoried a network totaling over 25,000 km of gully erosion in formations assets (Mircea S., 1999).

The economically and environmentally point of view development works of the gully erosion formations are of particular importance. Development of these formations cause damage primarily agriculture, socio-economic objectives, silting of storage lakes and water courses. If a storage lake dead volume is calculated would be filled with silt in 80-100 years, there are cases when the storage lakes were out of operation by sealing in a few years or decades.

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The annual volume of sediments transported by rivers in Romania is over 44 million tons (C. Diaconu, 1971), on which gully erosion participating of 31% (Moțoc M. 1984)

2. WORKING METHOD

To estimate the losses of soil erosion on slopes have been developed various computational models (Laflen 2003 RUH-Ming 1973, Popovich 1991; Carvaiho 1994, Di Silvio 1998, Trott and Singer 1983, Wischmeier and Smith 1960, etc.).

Table 1

No. crt.	Formula	First appearance	Author(s)
1	$A \cong C' L^{0.6} S^{1.4}$	1940	Zingg
2	$A \cong C'' L^{0.6} S^{1.4} P$	1941	Smith
3	$e \cong \alpha v^{4.33} d^{1.07} i^{0.65}$	1945	Ellison
4	$E \cong C_a .* S * L * K * P$	1947	Smith and Whitt
5	$E \cong K_a * K.* C * P * L^m * S^n$	1960	Wischmeier
6	$E \cong L^{0.5} .* (S - S_0)^{1.4}$	1968	Meyer and Kramer
7	$E \cong L^{1.24} * S^{0.74}$	1969	Young and Mutchler
8	$E_s \cong K_a * K.* C * P * L^{0.3} * (1.36 + 0.97S + 0.138S^2)$	1970	Moțoc
9	$E \cong L^{1.035} * S^{1.664}$	1972	Kllinc
10	$E \cong 11.8(V * Q_p)^{0.56} \dfrac{K * L * S * C * P}{F}$	1975	MUSLE
11	$A \cong E_p * I_{30} * K(L/72.6)^{0.5} * C * P(65.4 \sin^2 \theta + 4.56 \sin \theta + 0.065)$	1978	USLE
12	$A \cong E_p * I_{30} * K(L/72.6)^{0.5} * C * P(a \sin \theta + b)$	1997	RUSLE
13	$A \cong R * K * L * S * C * P$		USLE

Universal soil loss equation developed by Wischmeier and Smith (1960) is based on the experimental technique applied by the two researchers. Subsequently, soil erosion assessment and prediction have been improved by modeling techniques and elaboration of computer programs that allow separate treatment of the deployment processes of soil particles and fluid flow.

Thus Trott and Singer (1983), using research into the rain simulator and measuring leakage, were developed for forest soils in California, an equation of sediment production based on granulometric composition:

SY= -9,391+25,298(P+A) – 0,2297(P+A)^2 – 12,551(Kaolinite) + 31,420(Smectit).

Where:

SY = sediment produced in g/m^2;

P+A = dust proportion + percentage clay;

Kaolinite = percentage kaolinite present in the soil;

Smectit = smectit percentage present in the soil.

This equation was developed by Covaci, D. (2002) using erosion tester and by Rogobete Gh. and Grozav, A. (2006) using the plot with the rain simulator and have developed the following equation:

SY= -9,391+ 25,298(P+A) – 0,2297(P+A)^2 – 12,551(Kaolinite) + 31,420(Smectit) -16,18(Humus).

Where:

Humus = percentage of humus on the soil surface

- *Estimation of solid leakage by applying WEPP model in Bârzava basin*

The perimeter studied of the doctoral thesis by Grozav, A. (2011), is located in Semenic Mountain close to Gozna Peak (1444m), being the catchment basin of the “Băile Vulturilor” source.

Studied area has a mountainous terrain with altimetry values between 600 and 1400m.

The case study is based on the following assumptions:

- the presence of different soil types (aluviosol, podzol, prepodzol, histosol, dystric cambisol)
- constant rain intensity over the entire river sub-basins;
- land use is the same all over sub-basins;
- there is no works to combat soil erosion.

Model was applied to each area of river bed sector (gully), by calculating the quantity of soil lost function on soil type.

Sub-basin was divided into sub-basins corresponding to the river bed sectors taking into account the direction of water flow. Is noted with H sub-basins and river beds with C (river beds sectors).

Data entered in the program are:

- land use - forest;
- climate - the average monthly temperature and precipitation;
- soil characteristics;

- sub-basins areas;
- river beds characteristics: the average width of the river bed and river bed type (river bed channel in the forest area).

River sub-basin scheme, resulting from the application of WEPP program is shown in Figure 1 and the river network diagram in Figure 2.

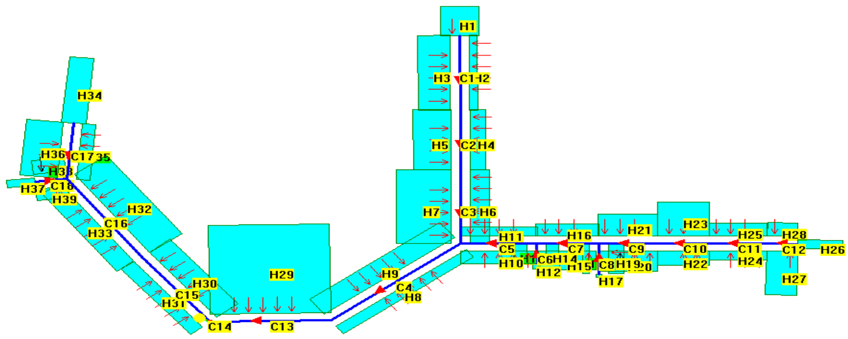

Fig. 1. Bârzava river basin scheme using WEPP

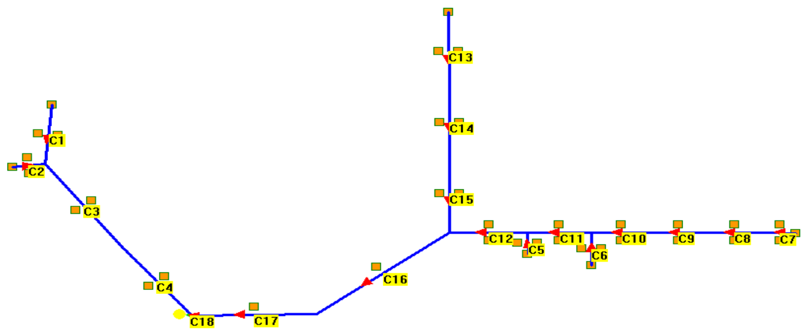

Fig. 2. Hydrographic network scheme in WEEP with associated river sub-basins

Table 2. The results of WEPP model throughout river basin (Grozav, A. 2011)

Numbering slopes		Surface	Soil Type	Leakage volume	Lost Soil	Sediment deposited	Sediment produced
AutoCAD	WEPP	ha		(m^3)	(kg)	(kg)	(kg)
H1	Hill H8	10,663	Dystric Cambisol	460,9	1346,7	0,0	1346,7
H2	Hill H9	20,796	Aluviosol	1214,0	10023,3	0,0	10023,2
H3	Hill H7	44,586	Dystric Cambisol	0,0	0,0	0,0	0,0
H4	Hill H6	15,716	Dystric Cambisol	373,6	5104,9	0,0	5104,7
H5	Hill H4	10,295	Dystric Cambisol	324,9	4965,9	0,0	4965,7
H6	Hill H5	24,991	Dystric Cambisol	740,1	14470,4	20,4	14450,0
H7	Hill H2	6,587	Dystric Cambisol	422,5	3581,7	0,0	3581,7
H8	Hill H3	26,551	Histosol	656,9	2552,1	0,0	2552,1
H9	Hill H1	12,277	Dystric Cambisol	556,3	1249,9	0,0	1247,9
H10	Hill H10	10,909	Dystric Cambisol	300,6	3673,2	0,0	3673,2
H11	Hill H11	7,331	Dystric Cambisol	700,1	4944,1	0,0	4944,1
H12	Hill H13	2,725	Dystric Cambisol	253,7	2371,9	0,0	2371,8
H13	Hill H14	2,810	Dystric Cambisol	94,9	1180,5	0,0	1180,5
H14	Hill H12	0,516	Dystric Cambisol	28,4	187,1	0,0	187,1
H15	Hill H16	8,466	Dystric Cambisol	783,5	10908,9	0,0	10908,7
H16	Hill H15	12,837	Dystric Cambisol	261,2	5080,5	0,0	5080,7
H17	Hill H18	2,341	Dystric Cambisol	287,3	2698,3	0,0	2698,4
H18	Hill H19	5,306	Dystric Cambisol	176,7	3282,3	0,0	3282,3
H19	Hill H17	0,231	Dystric Cambisol	13,2	27,1	0,0	27,1
H20	Hill H20	12,922	Dystric Cambisol	251,0	4444,0	0,0	4444,0

H21	Hill H21	14,017	Dystric Cambisol	602,4	12516,5	1,5	12514,9
H22	Hill H22	8,302	Dystric Cambisol	229,2	3803,5	0,0	3803,6
H23	Hill H23	19,382	Dystric Cambisol	469,0	9368,2	24,2	9344,0
H24	Hill H24	5,929	Prepodzol	202,5	1942,6	0,0	1942,6
H25	Hill H25	8,193	Prepodzol	743,1	11672,9	0,0	11673,0
H26	Hill H27	14,721	Prepodzol	0,0	0,0	0,0	0,0
H27	Hill H28	4,340	Prepodzol	0,0	0,0	0,0	0,0
H28	Hill H26	4,578	Prepodzol	0,0	0,0	0,0	0,0
H29	Hill H34	17,575	Podzol	0,0	0,0	0,0	0,0
H30	Hill H35	8,356	Dystric Cambisol	262,9	2734,7	0,0	2734,7
H31	Hill H36	23,086	Dystric Cambisol	645,3	10983,9	6,9	10977,1
H32	Hill H37	2,269	Dystric Cambisol	36,2	563,1	0,0	563,2
H33	Hill H38	4,683	Dystric Cambisol	284,5	3656,5	0,0	3656,5
H34	Hill H39	4,050	Dystric Cambisol	117,9	1060,0	0,0	1060,0
H35	Hill H32	43,287	Dystric Cambisol	1017,1	15284,1	4,2	15280,2
H36	Hill H33	23,277	Dystric Cambisol	455,8	5305,6	0,0	5305,6
H37	Hill H30	25,003	Dystric Cambisol	782,0	5840,6	0,0	5840,6
H38	Hill H31	14,270	Dystric Cambisol	335,7	1706,7	0,0	1706,7
H39	Hill 29	58,027	Dystric Cambisol	0,0	0,0	0,0	0,0
TOTAL		542,203					

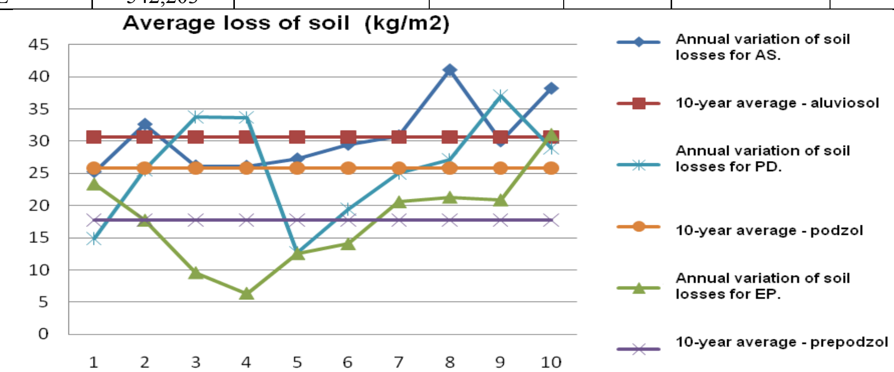

Fig. 3. Comparative values of different soil types in the Bârzava river basin (Grozav, A. 2011)

3. CONCLUSIONS

- The emergence and development of the torrential gullies in the river basin studied evolved over time;
- The values of erosion in this basin exceed the maximum allowable erosion;
- Leakage muddy produced on this river basin area affects including downstream lake;
- Massive deforestation in the area, without reforest in that area and without other works to combat erosion of this river basin lead to environmental degradation with serious long-term consequences.
- Lack of money (today) for erosion control works cannot be a reason for serious effects in the future.

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