The Gully Erosion Effect on the Environment

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Abstract. The paper contains data about the destructive effects of gully erosion on the environment. It 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 in the Semenic Mountains (Bârzava drainage area).

The case study is based on the following assumptions: the presence of different types of soil, the constant rain intensity over the entire river sub-basins, the land use is the same over all the sub-basins; there are no soil erosion control works.

The model was applied to the each area of the bed (gully), by calculating the quantity of the soil lost, depending on the soil type.

The data entered in the program are: the use of the land - forests, climate - the average monthly temperature and precipitation, the soil characteristics, the sub-basins areas, the characteristics of the river beds: the average width of the river bed and the 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

In its evolution, 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, lead to the activation of exogenous factors such as gully erosion.

In 1983, according to the estimates made by FAO in the world, an area of 5-7 million hectares of land were removed from the agricultural lands, due to the degradation processes (erosion, toxic chemicals, soil salinization, urbanization, etc.) the estimated losses at the end of year 2000, being of 100-140 million ha.

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

The most affected areas are the Mediterranean region and large areas in the central and eastern parts of the continent due to natural contributing factors (relief, climate,

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soil, etc.) and to anthropogenic factors (massive deforestation, improper practice of agriculture, overgrazing on the same area).

In Romania, taking into account the specific indicator of the erosion intensity (t/ha/year), counties in the bend area of the Carpathians Mountains (Buzau, Vrancea, with values of approximately 40 and respectively, 35 t/ha/year) are clearly different from the maximum allowable erosion of 4-6 t/ha/year. According to Motoc (1982), Romania weighted average was of 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, approximately 400 thousand gully erosion formations were formed, covering over 500 thousand hectares (according to 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 (according to G. Gardner 1996).
- Greece has 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 erosion - approximately 3.7 million km^2 (about one third of the country (Mircea S., 1999).
- In India, gully erosion affects 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 (according to Wenner, 1989, quoted by Mircea S., 1999).
- In Romania, a network totaling over 25,000 km of gully erosion in formations assets has been inventoried (Mircea S., 1999).

From an economic and environmental point of view, the development works of the gully erosion formations are of particular importance. The development of these formations causes damage primarily to agriculture, to socio-economic objectives, to silting of storage lakes and to water courses. If a storage lake has a calculated dead volume, which should be filled with silt in 80-100 years, there are cases when the storage lakes were no longer usable due to sealing, in only a few years or decades.

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

2 Working Method

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

In what follows, we treated soil losses through erosion and their impact on the environment in the Bârzava river basin (Romania) by two methods.

- *The estimation of the soil erosion in the Bârzava river basin by the physical modeling.*

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 were improved by modeling techniques and by the 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 with the rain simulator and measuring leakage, developed an equation of sediment production based on granulometric composition, for the forest soils in California:

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

Where:

SY = sediment produced in g/m^2;

P+A = dust percentage + clay percentage;

Kaolinite = kaolinite percentage present in the soil;

Smectit = smectite percentage present in the soil.

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

$SY= -9,391+ 25,298(P+A) - 0,2297(P+A)^2 - 12,551(Kaolinite) + 31,420 (Smectite)-6,18(Humus).$

Where:

Humus = percentage of humus on the soil surface

- *The estimation of the solid leakage by applying the WEPP model*

The perimeter studied in her doctoral thesis by Grozav, A. (2011), is located in the Semenic Mountains, near Gozna Peak (1444m), being the catchment basin of the Eagles' Bathroom's source.

The 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, districambosol)
- constant rain intensity over the entire river sub-basins;
- the land use is the same in all the sub-basins;
- there are no works to combat the soil erosion.

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

The sub-basin was divided into sub-basins corresponding to the river bed sectors taking into account the direction of the water flow. The sub-basins are noted with H and the river beds with C (river beds sectors). (Figure 2)

The data entered in the program are:

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

The scheme of the river sub-basin, resulting from the application of the WEPP program is shown in Figure 1 and the river network diagram in Figure 2. In addition to the quantities of soil loss, several graphs of variation of erosion and deposition processes on each slope and the maximum rate of entrainment of soil particles on each slope were also presented (Figures 3-7).

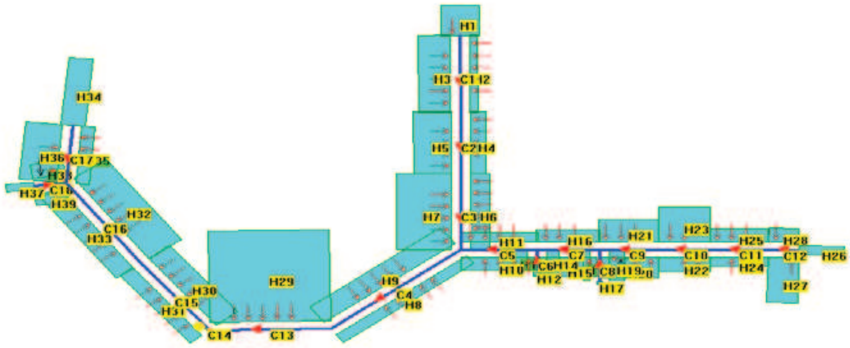

Fig. 1. The Bârzava river basin scheme using WEPP

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

Graphs of variation of erosion and deposition processes

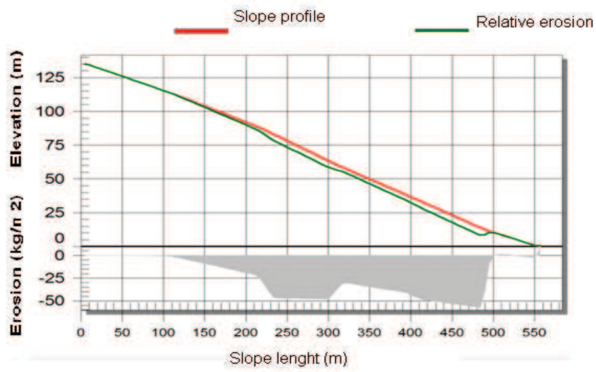

Fig. 3. The evolution of the erosion process on slope H2 (*Aluviosol*, maximum involvement of soil particles at 484m - 57.1 kg/m^2, the maximum deposit at 556m - 6.72 kg/m^2)

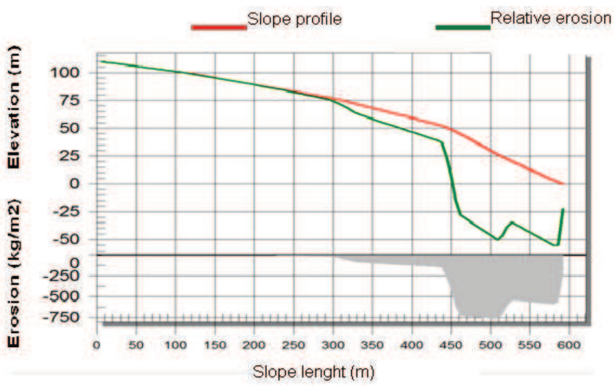

Fig. 4. The evolution of the erosion process on slope H8 (*Histosol*, maximum involvement of soil particles at 509m - 767kg/m^2, without deposit)

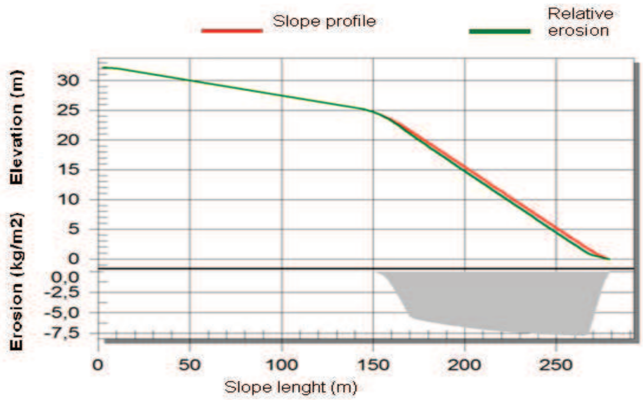

Fig. 5 The evolution of the erosion process on slope H26 (*Prepodzol*, maximum involvement of the soil particles at 264m - 7.79 kg/m^2, without deposit)

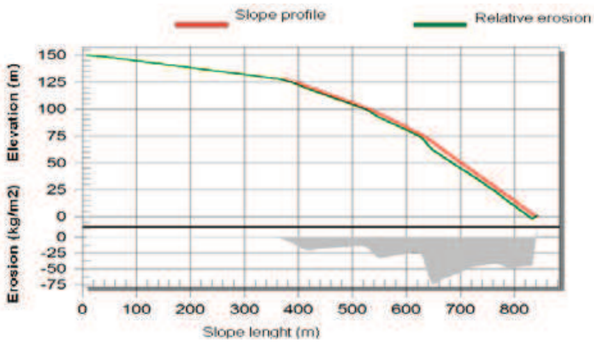

Fig. 6. The evolution of the erosion process on slope H29 (*Podzol*, maximum involvement of the soil particles at 648m - 74.2 kg/m^2, the maximum deposit at 842m - 11.5 kg/m^2)

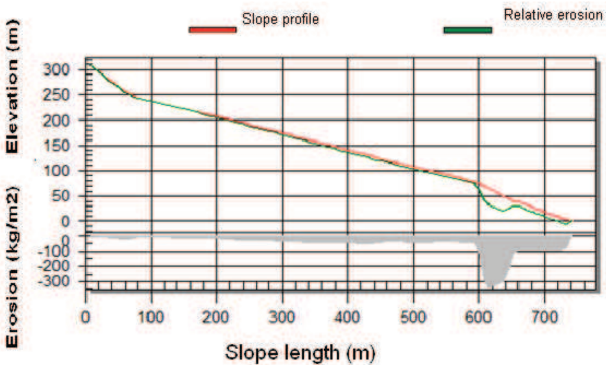

Fig. 7. The evolution of the erosion process on slope H6 (*Districambosol*, maximum involvement of the soil particles at 615m – 342kg/m^2, the maximum deposit at 741m – 10,5 kg/m^2)

Table 1. The results of the WEPP model on the whole river basin (Grozav, A. 2011)

Number of slopes		Surface	Soil type	Leakage volume (m^3)	Lost Soil (kg)	Deposited sediment (kg)	Produced sediment (kg)
Autocad	WEPP	ha					
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*					

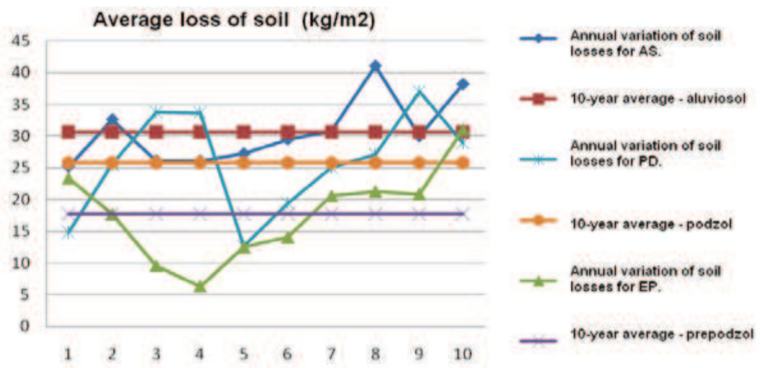

Fig. 8. Comparative values of different soil types in the Bârzava river basin (Grozav, A. 2011)

3 Conclusions

- The emergence and development of the torrential gullies in the studied river basin evolved over time;
- The erosion values in this basin exceed the maximum allowable erosion;
- The muddy leakage produced on this river basin area also affects the downstream lake;
- The massive deforestation in the area, without reforestation in that area and without other works to combat the erosion of this river basin, leads to the environmental degradation with serious long-term consequences.
- Because are not allocated money (in present) for erosion control works cannot be a reason for the serious effects from the future.

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