

# ESTIMATING SOIL EROSION RATES BY USING CONVERSIONAL MODELS. A COMPARATIVE STUDY BETWEEN SIMULATED AND MEASURED ON RUNOFF PLOTS DATA

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## Abstract

The study has been made on some runoff plots at RDCSEC Perieni, Romania, all with a cropping history, fully instrumented for measuring runoff and soil loss under different conditions concerning vegetative cover. In order to determine Cs-137 activity, from each plot soil samples were collected accordingly with a samples design disposed on six lines and were analyzed at National Institute of Physics and Nuclear Engineering “Horia Hulubei”, Magurele – Bucharest. The approach used to estimate erosion and deposition rates was founded on the comparison of measured Cs-137 inventories ( $\text{kBq/m}^2$ ) with a reference value that represents the inventory at a site where neither erosion nor deposition can be observed. The comparison between measured (based on historical registrations from the runoff plots since 1985) and simulated data by different models (Proportional Model, Mass Balance Model1, MB2 and MB3) showed that models worked good enough for values of erosion which ranged between 4 and 7  $\text{t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$ . Outside of this interval, simulated data were, generally, either underestimated (for  $E > 7 \text{ t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$ ) or overestimated (for  $E < 4 \text{ t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$ ).

**Keywords:** soil erosion, conversional models.

## Introduction

Fallout radionuclides, such as Caesium-137 (associated with atmospheric nuclear weapons tests in the 1950s and 1960s and the Chernobyl accident in April 1986), are being increasingly used to estimate erosion rates on agricultural land because of some advantages over conventional monitoring techniques. The main benefit is the potential for deriving retrospective estimates of erosion and deposition rates based on a single site visit in the landscape and the fact that information can be used to study spatial patterns of soil redistribution.

## Materials and methods

The study has been made in Upper Tarina Valley, a representative small watershed from Tutova Rolling Hills, Romania, and has been focused

on some runoff plots, all with a cropping history, fully instrumented for measuring runoff and soil loss under different conditions concerning vegetative cover. They were cultivated with different crops as follows: corn, beans, soybeans, winter wheat, brome grass. The plots are 25 m by 4 m (100 sq. m) with 1 m border areas between them. Collecting of runoff is made in three calibrated recipients disposed in cascade. The soil is moderately deep, with medium fertility (cambic chernozem), medium textured, and moderately eroded, with a 12% slope.

The approach used to estimate erosion and deposition rates, was founded on the comparison of measured Cs-137 inventories ( $\text{kBq/m}^2$ ) with a reference value that represents the inventory at a site where neither erosion nor deposition can be observed (Zapata F., 2002). The reference value provided an assessment of total Cs-137 fallout input to the site, corrected for the radioactive decay to the time sampling. The estimates of the erosion or deposition rate ( $\text{t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$ ) represented an average rate for the period extending back from the time of sampling to the beginning of Cs-137 fallout. The reference sites have been under continuous vegetation cover in the last 60 years and are situated on the line, which separates selected basins. The first one is an old rural burial ground and the second is an area used like a pasture.

From each plot, samples were collected accordingly with a samples design (Figure 1). Sample points were disposed on six lines (F2-F7) at 0.5m, 5m, 10m, 15m, 20m and 24.5 m from the upper plot border. F1 is placed outside of plot area, in the upper part. On each line, three sample points have been established for obtaining a single composite sample.

Analysis of data has been realized based on the historical registrations collected from the runoff plots since 1985.

A comparison between measured and simulated data by different models (Proportional Model, Mass Balance Model1, MB2 and MB3) has been made.

The project has been realized in collaboration with the National Institute of Physics and Nuclear Engineering “Horia Hulubei”, IFIN-HH Magurele – Bucharest.



**Figure 1** Soil sample design on Runoff plots, Perieni, Romania

### Results and Discussions

Through time, each plot was affected by erosion in a different way. In Table 1 data since 1985 are presented.

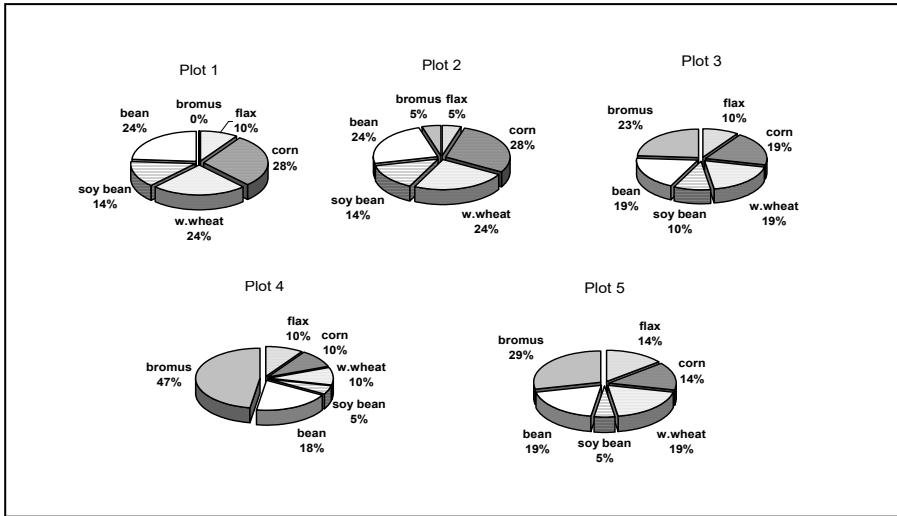
**Table 1** Annual soil loss from runoff plots for different crops, since 1985 until now.

Plot No.	Total soil loss between 1985-2005	Annual erosion rate ( $t\ ha^{-1}\cdot y^{-1}$ )
1	145.43	6.925
2	188.06	8.995
3	86.35	4.112
4	68.67	3.270
5	45.22	2.153

Major differences among measured data can be explained by the fact that the crop structure of plots was different (Figure 2)

Most eroded was the plot No. 2 from which an amount of 188.064 t/ha of soil was detached by water. It corresponds to a structure where the crops of corn and bean were cultivated in 28% and, respectively 24% of the period since 1985 until now.

Less eroded was the plot No.5 from which only 45.221 t/ha of soil was lost. During 21 years, the crops that offered a very good protection of soil against erosion summarized 62% of time (bromgrass 29%, flax 14% and winter wheat 19%) while the crops vulnerable to erosion occupied the rest of 38% of time (corn 14%, bean 19% and soy bean 5%).



**Figure 2** Crop structure of runoff plots at Perieni, Romania, between 1985 and 2005

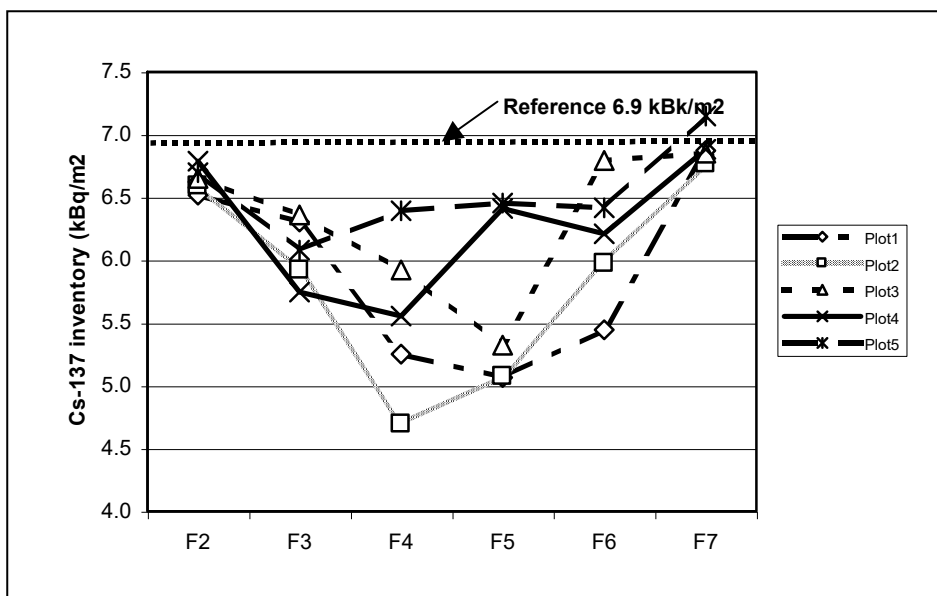
In Figure 3 and Table 2 data of Cs-137 inventory on transects through five plots are presented.

As shown above, measurements of Cs-137 activity were made in six sample points uniformly distributed along the plots

The runoff plots area is situated approximately in the middle of the distance between the reference site no.1 where calculated  $^{137}\text{Cs}$  inventory is  $6.90 \text{ kBq/m}^2$  and the reference site no.2 where  $^{137}\text{Cs}$  inventory is  $4.98 \text{ kBq/m}^2$ . In consequence, an average of  $5.94 \text{ kBq/m}^2$  for  $^{137}\text{Cs}$  inventory reference appears to be the most probable value. However, having in sight that the slope is looking to the west (direction of predominant wind) the maximum value of  $6.9 \text{ kBq/m}^2$  has been choused.

**Table 2** Cs-137 inventory on runoff plots from Perieni, Romania (kBq/m<sup>2</sup>)

Point sample	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
F2	6.518	6.693	6.652	6.789	6.697
F3	6.305	5.922	6.360	5.745	6.079
F4	5.251	4.697	5.922	5.554	6.393
F5	5.066	5.075	5.322	6.412	6.455
F6	5.446	5.975	6.795	6.211	6.417
F7	6.872	6.678	6.852	6.884	7.147



**Figure 3** Transects through runoff plots, cultivated soil, concerning Cs-137 inventory

Almost as a rule, the minimum values of Cs-137 inventory were measured approximately in the middle of the plots (in F3 for the plot 5, in F4 for the plots 2 and 4 and, in F5 for the plots 1 and 3). They varied between 4.697 and 6.079 kBq/m<sup>2</sup>.

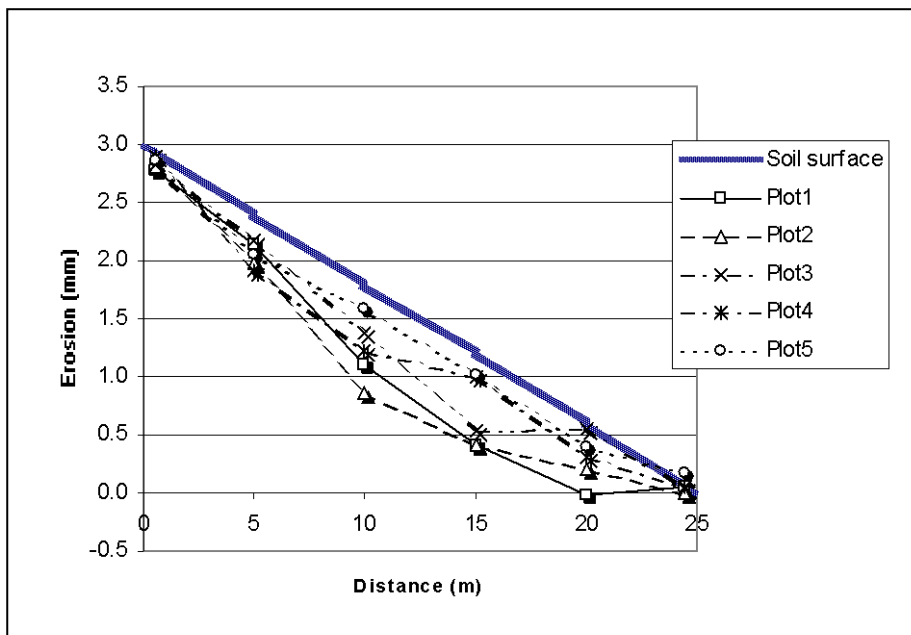
At the upper and the lower edges of the plots, values of Cs-137 inventory were relatively high. A single value of 7.147 kBq/m<sup>2</sup>, corresponding to F7 from Plot 5, was higher than the reference value, indicating a sedimentation process.

Table 3 presents results obtained by Proportional Model, Mass Balance Model 1 MB2, and MB3 (Walling D.E., Quine T.A., 1995).

**Table 3** Erosion on runoff plots from Perieni, cultivated soil, calculated by conversion models

Point sample	Proportional Model				
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
F2	1.954	1.570	1.269	0.568	1.038
F3	3.044	5.003	2.762	5.908	4.200
F4	8.435	11.269	5.003	6.885	2.593
F5	9.432	9.335	8.072	2.496	2.276
F6	7.437	4.732	0.637	3.524	2.471
F7	0.143	0.675	0.246	0.082	-1.402
Soil delivery ratio	4.924	5.567	3.246	3.349	2.061
Point sample	Mass Balance Model 1				
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
F2	2.439	1.950	1.568	0.695	1.279
F3	3.860	6.539	3.489	7.834	5.421
F4	11.666	16.408	6.539	9.276	3.268
F5	13.277	13.118	11.095	3.141	2.855
F6	10.113	6.158	0.657	4.503	3.108
F7	0.174	0.828	0.299	0.100	-5.221
Soil delivery ratio	6.745	7.774	4.298	4.416	2.581
Point sample	Mass Balance Model 2				
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
F2	2.290	1.830	1.470	0.650	1.200
F3	3.640	6.220	3.280	7.490	5.130
F4	11.320	16.240	6.220	8.920	3.070
F5	12.970	12.810	10.740	2.950	2.680
F6	9.750	5.850	7.120	4.250	2.920
F7	0.170	0.770	0.280	0.100	-9.500
soil delivery ratio	6.528	7.581	4.698	4.216	2.386
Point sample	Mass Balance Model 3				
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
F2	4.520	3.610	2.900	1.290	2.370
F3	3.860	6.620	3.520	8.030	5.500
F4	11.850	16.910	6.470	9.090	3.070
F5	13.160	12.740	11.080	2.770	2.760
F6	9.710	5.640	7.050	4.420	3.030
F7	0.660	0.620	0.380	0.440	-2.150
soil delivery ratio	6.936	7.935	4.996	4.401	2.672

Figure 4 shows the level of eroded soils from each cultivated plot using data calculated by Proportional Model.

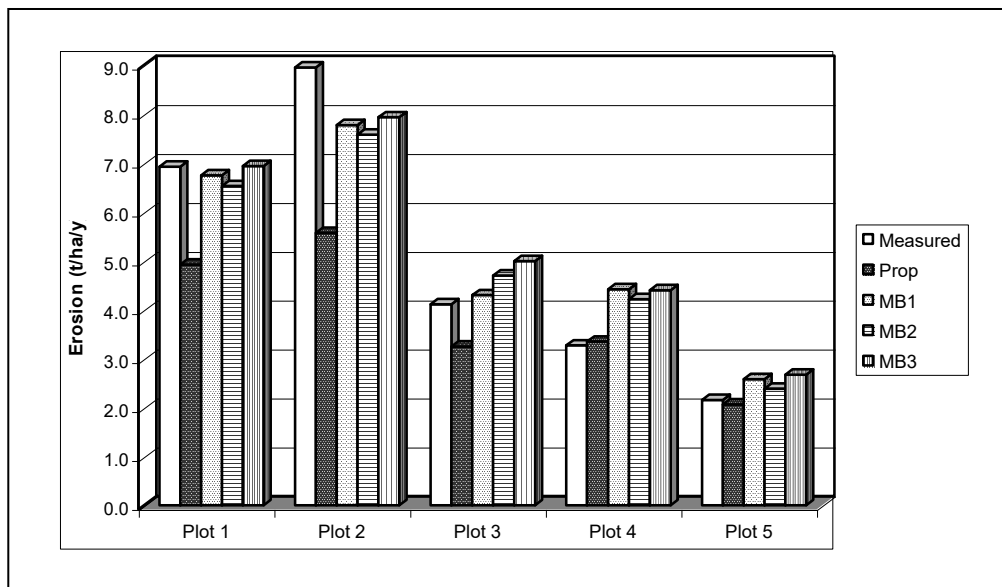


**Figure 4** Graph of soil loss along the runoff plots from Perieni, using simulation with Proportional Model

In the upper part of plots erosion process is just initiated, so values of soil loss are very low. In the lower part of the plots erosion decreases to zero and, even a sedimentation process can be observed. Explanation is done by the fact that the discharge device works like a weir and favors deposition of sediments.

Figure 5 presents a comparative graph between measured and simulated data by Proportional Model, Mass Balance Model 1, MB2 and MB3.

Comparing measured with calculated data by proportional model it can be noticed that values of soil loss in plots 1, 2 and 3, which vary between  $5.56$  and  $3.24 \text{ t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$  are underpredicted while values of plots 4 and 5 are almost the same.



**Figure 5** Erosion on runoff plots from Perieni, Romania, cultivated soil, determined by Proportional Model for the period of 1985-2005

Values obtained by Mass Balance Model 1, 2 and 3 are rather grouped, they are underpredicted for the plot 2 and are overpredicted for the plots 3, 4 and 5.

### Conclusions

Measurements effectuated on runoff plots from Perieni Station for the period of 1985-2005 indicated that erosion has different values depending on the crop rotation that characterized through time each plot. Less eroded was the plot No.5 from which only  $2.153 \text{ t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$  of soil was lost and it corresponds to a structure where crops that offered a very good protection of soil against erosion summarized 62% of time. Most eroded was the plot No. 2 that was cultivated most of the time with corn, bean and soy bean and, from which an amount of  $8.995 \text{ t}\cdot\text{ha}^{-1}\cdot\text{y}^{-1}$  of soil was detached by water.

Minimum values of Cs-137 inventory were measured approximately in the middle of the plots and they varied between 4.697 and  $6.079 \text{ kBq}/\text{m}^2$ . At the upper and the lower edges of the plots, values of Cs-137 inventory were relatively high.

- Comparing measured data on runoff plots with calculated data by proportional model it can be noticed that values of soil loss in plots 1, 2 and

3, which vary between 5.56 and 3.24 t·ha<sup>-1</sup>·y<sup>-1</sup> are underpredicted while values of plots 4 and 5 are almost the same.

- Values obtained by simulating with Mass Balance Model 1, 2 and 3 are rather grouped, they are underpredicted for the plot 2 and are overpredicted for the plots 3, 4 and 5.

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# PROTECTION OF HILL LAKES, PLACED IN AREA WITH DOMINANT AGRICULTURE LAND USE, THROUGH EROSION CONTROL WORKS

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## Abstract:

The problem of soil erosion, sedimentation and water quality degradation of dam storage is ominously in the world not only in the local area. It requires development of a new global strategy starting with the study of watershed processes and finishing with the draft of land reclamation, exploitation and conservation measures of agricultural lands, of rivers and reservoirs.

Soil erosion has a great impact on reservoirs, owing to sedimentation and the degradation of water quality.

The sedimentation process cannot be stopped, only decrease, and has negative consequences on normal exploitation of reservoirs.

The degradation of water quality is mainly due to a decrease in water depth and to the natural or artificial addition of fertilizers.

An relative recently analyze, by M. Motoc (1984), it come out that on Romanian lands total erosion is of 126.0 million to/year and from these 44.6 million to/year there are sediment effluence (0.35 effluence coefficient). Provide area point of view, 84.5% (106.8 millions to/year) is from agricultural area and 15.5% of erosion provide from forestry area and bank rivers. Generating processes point of view about 49.0%-61.8 million to/year provides from sheet erosion and about 23.6%-29.8 millions to/year provides from gully erosion.

Sheet erosion and gully erosion has a different weight (49.0–23.6 %) in total erosion. The effluence coefficients on these category are also different (0.26% for sheet erosion and 0.46% for gully erosion), but their contribution at sediment effluence are very near – 16.1 millions to/year (36.2%) sheet erosion and 13.8 millions to/year gully erosion;

Autonomous Administration Romanian's Water consider that on the whole Romania, during last 15 years, in reservoirs placed on inner rivers, it was fall about 200,000 millions m<sup>3</sup> sediments (13.4 millions m<sup>3</sup>/ year that means 27% from total years average sediments carry)

In the studied reservoirs, these processes are due to the deposit of sediments from the main water supply of the reservoir and of those that are due from erosion from hill slopes and watersheds located in the vicinity of the reservoir. The bigger sediment effluence provide from the micro watersheds who are directly coming into the reservoir (7.93–9.87 to/hectares from the direct slopes and 1.8–30.5 to/ha from these kind of micro watersheds.

There are made erosion and sediments effluence differentiation in a watershed with erosion control works and same watershed without erosion control works.

The comparative analyze of these tow situation, with erosion control works and same watershed without erosion control works, set of some conclusions:

The erosion are reduced under acceptable limits (17.2 m<sup>3</sup>/ha without erosion control works relative to 3.9 m<sup>3</sup>/ha with erosion control works);

A proper cultivation structure mixed with erosion crop system reduced erosion and sediment effluence with 20%;

A good erosion control works capitalized efficiently rainfall, surface runoff are reduced with 11-30%;

An adequate reclamation of outlet network reduces gully erosion with 60%;

Ensemble of land reclamation (cultivation structure, erosion crop system, erosion control works on outlet network) reduces erosion and sediment effluence with 23%.

**Key words:** erosion, reservoirs, sedimentation

## **Introduction**

Autonomous Administration Romanian's Water considers that on the whole Romania, during 15 years, in reservoirs placed on inner rivers lakes, it was fall about 200,000 millions m<sup>3</sup> sediments (13.4 millions m<sup>3</sup>/ year that means 27% from total years average sediments carry).

The problem of soil erosion, sedimentation and water quality degradation of dam storage is ominously in the world not only in the local area. It requires development of a new global strategy starting with the study of watershed processes and finishing with the draft of land reclamation, exploitation and conservation measures of agricultural lands, of rivers and reservoirs.

Ichim Ionita (1993,1996) considers the fact that only a concept named "sediment systems" can offer an adequate frame for elaborating such strategy who can ensure an adequate frame for elaboration an efficiently strategy. This strategy must assure better processes understanding a pragmatically approach of erosion reducing and reservoir sedimentation. In decision processes from reduce sediments transport, when are interested in reservoir protection, it must accord inters through "sedimentation processes" and "sediments storage" who in sediment system must be looking distinctly but, at time and space scale god define and in connection.

M. Motoc (1984) realized a general view (table 1) concerning provides area reference to lands use and the processes like sediments sources offer total erosion, effluence coefficients and sediment effluence give by sources and processes on Romanian lands.

Analyzing the present date (table 1) it comes out that: on Romanian lands total erosion is of 126.0 millions. to/year and from these 44.6 millions to/year there are sediment effluence (0.35 effluence coefficient); provide area point of view: 84.5% (106.8 mil. to/year) are from agriculture area and 15.5% provide from forestry area and bank rivers; generating processes point of view: about 49.0%-61.8 mil. To/year provide from surface erosion; about 23.6%-29.8 mil. To/year from gully erosion; sheet erosion and gully erosion has a different weight (49.0–23.6%) in total erosion; effluence coefficients on these category are also different (0.26% for sheet erosion and

0.46% for gully erosion), but their contribution at sediment effluence are very near–16.1 million to/year (36.2%) sheet erosion and 13.8 million to/year gully erosion. Following only effluence coefficients, the bigger are for gully erosion (0.46) and for bank and riverbeds erosion (0.54), these two kind of process erosion take part with 46.3% (20.6 to/year) to total sediment effluence.

Table 1

Erosion and sediments effluence differentiation in Romania  
(after M. Motoc 1984)

Land use	Total erosion		Effluence coefficient	Sediment effluence	
	mil. to/year	%		mil. to/year	%
Land use category (provide area)					
Arable	28,0	22,3	0,28	7,9	17,7
Pastures	45,0	35,7	0,27	12,3	27,6
Orchards	2,1	1,7	0,29	0,6	1,4
Vineyards	1,7	1,2	0,28	0,5	1,1
Gully erosion (unproductive)	29,8	23,6	0,46	13,8	31,0
TOTAL agriculture area	106,8	84,5	0,32	34,2	78,8
Forestry area (gully erosion and landslides)	6,8	5,4	0,40	2,7	5,9
Bank erosion on rivers	12,6	10,0	0,54	6,8	15,3
<b>Total</b>	<b>126,0</b>	<b>100,0</b>	<b>0,35</b>	<b>44,6</b>	<b>100,0</b>
Erosion forms (generating processes)					
Sheet erosion	61,8	49,0	0,26	16,1	36,2
Gully erosion	29,8	23,6	0,46	13,8	31,0
Landslides	15,0	12,0	0,35	5,2	11,6
Gully erosion and landslides on forestry area	6,8	5,4	0,40	2,7	5,9
Bank and riverbeds erosion on rivers	12,6	10,0	0,50	6,8	15,3
<b>Total</b>	<b>126,0</b>	<b>100,0</b>	<b>0,35</b>	<b>44,6</b>	<b>100,0</b>

Hill lakes, in present conception, is an gather up reservoir of rainfall letting out from agriculture area formed by an earth dam from 8 to 20 m who closed a secondary valley, and their purpose are from agriculture – irrigation, fish and water bird growing, water from animals, regularized of rainfall letting out from the crop slope, sports and traveling in village area. (*Evanghelisti, 1959*). In Romania these kind of reservoir have an active role in to attenuate the high flood through buffer volume accumulate when are produced these kind of events. Also from the village and town community from hill area, in Romania, these reservoirs are an important source of drink water.

In the context presented the protection of hill lakes is an necessity objective because the erosion phenomena through this consequences guide to degradation of these reservoirs, physical – sedimentation and chemical – degradation of water quality, and finally the eutrophisation.

## Research location

The Cuibul Vulturilor reservoir, located in Eastern Romania in the watershed of the Tutova River, flowing through the Tutova Hills, at 34.5 km from the source, provides a part of the water necessary for the population of Bârlad city. The reservoir was formed along with the erection of an earth dam (17 m in height and 843 m long at crest) with a central weir and a laterally spillway on the right bank. In 1978 it was taken into exploitation, with the following planned characteristics (from Normal Retention Level): available water volume – 9,500,000 m<sup>3</sup>, dead storage capacity – 300,000 m<sup>3</sup>, annual sedimentation ratio – 10,000 m<sup>3</sup>.

In 1978, with the help of synthesis hydrological data offered by the National Institute of Meteorology and Hydrology, the National Research and Project Institute for Water Management – Bucharest where made a study regarding the sedimentation of this reservoir who show as:

The affluent flow (in the Tutova control section of the Tutova river – annual mean value) is – 0.86 m<sup>3</sup> per seconds: the alluvial discharge is 0.6 kg per seconds (19.000 to/year) – which corresponds to a specific rate of 0.28 to per hectare and year.

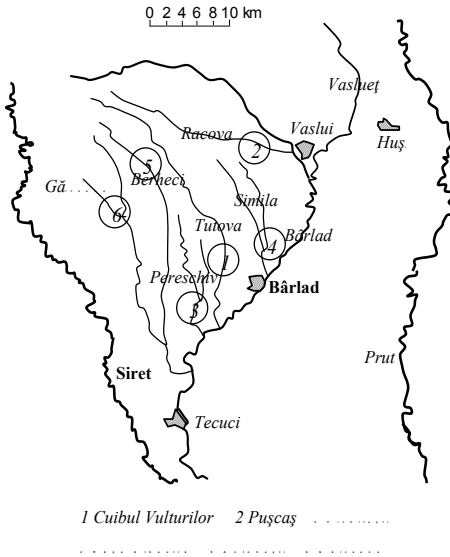
There are two possible sediment deposit area at 3 – 5 km and 7 – 9 km from the dam, whose thickness after 50 years could reach an average value of 1 to 1.5 m<sup>3</sup>s.

The average volume of these deposits area could reach 1000000 m<sup>3</sup>, fifty percent of which would be situated under the permanent water area. This study shows that the dead storage capacity of the reservoir - 300000 m<sup>3</sup>, will be reached in 30 years of exploitation.

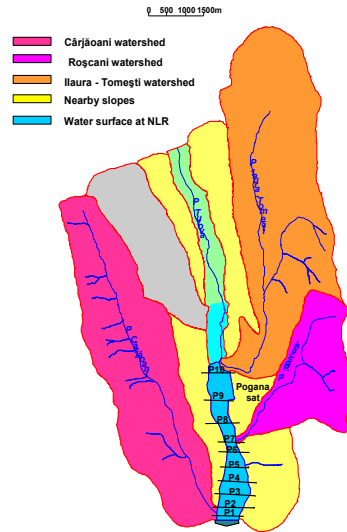
According to annual mean sedimentation ratio in this reservoir yearly enter about 221.430 m<sup>3</sup> sediments but from the area located in the vicinity of the reservoir enter about 98.755 m<sup>3</sup> sediments that mean 65 percent from all sediments step in the reservoir in one year. From these volume of sediments that provide from the area located in vicinity of the reservoir 13.1 percent provide from the hill slopes and 86.9 percent provide from the watersheds. This value show that the contribution of the watersheds located in vicinity of reservoir direct overflow in the reservoir is the most important quantitative in comparative with the hill slopes (Purnavel, 1999).

In the vicinity of Cuibul Vulturilor reservoir there is the watershed Cârjăoani a valley gully. From this watershed about 1872 hectares it was proposed to appropriate an erosion control works, with ought changing the land use (table 1), through an adequate crop structure, erosion control measure and erosion control works on the outlet network for showing the effect of these works on the sedimentation process.

Studied reservoir from Bârlad watershed



Cuibul Vulturilor Reservoir excessive influence area



Before reclamation: **Crop structure** - straw cereals 38 % / cultivator plants 62%; non erosion measure up and down cultivating; the outlet network with ought erosion control works

After reclamation: **Crop structure** - straw cereals 68 % / cultivator plants 24 % / yearly leguminous plants 8 %; **erosion measure** – contour, split and strip farming, banquet terraces; the outlet network (three zone from the upstream to downstream) first zone 7 working (earth dam 4-5 m in height), second zone 6 working (earth dam 5-6 m in height), third zone without working.

Table 1

Land use and homogenous calculation area ring from Cârjăoani watershed from the excessive influence area according sediment transport into Cuibul Vulturilor reservoir

Land use	Area (ha)				Homogenous calculation area (no.)
	Before reclamation		After reclamation		
	ha	%	ha	%	
Arable	1237,44	66,10	1237,44	66,10	51
Pasture	302,60	16,16	302,60	16,16	24
<b>Agriculture</b>	<b>1540,04</b>	<b>82,27</b>	<b>1540,04</b>	<b>82,27</b>	<b>75</b>
Forest	207,90	11,11	207,90	11,11	27
Constructions	62,65	3,35	62,65	3,35	1
Unproductive	61,75	3,30	61,75	3,30	3
<b>Total</b>	<b>1872,00</b>	<b>100,00</b>	<b>1872,00</b>	<b>100,00</b>	<b>106</b>

For show the effect of erosion appropriate it was determinate the erosion and sediment effluence in both tow case with and non erosion control works.

Total erosion it was determinate with the relationship:

$$E_T = E_s + E_{ad} + E_{al} + E_{nep} + E_{d.ex.} \text{ (to / year) from whom:}$$

$E_T$  - total erosion;  $E_s$  - sheet erosion;  $E_{ad}$  - gully erosion  $E_{al}$  - erosion from landslides;  $E_{nep}$  - erosion from unproductive area;  $E_{d.ex}$  - erosion from exploitation roads;

Sediment effluence it was determinate with the relationship:

$$E_a = E_T * C_{efl. aluv} \text{ (to/an) from whom:}$$

$E_T$  - total erosion;  $C_{efl. aluv}$  - sediment effluence coefficient

We use the fallow relationship to transform value from  $m^3/an$  in to/an:

$$E(m^3 / an) = \frac{E(to / an)}{\gamma(to / m^3)} \text{ where:}$$

$$\gamma = 1.7 \text{ to}/m^3 \text{ for the studded area.}$$

For erosion calculation, in both cases, it was establishing homogenous area (sheet erosion) and homogenous sectors (gully erosion) determination relationship it where:

$E_s = K * S * C * C_s * L^{0.3} * I^{1.4}$  (to/ha/an) where:  $K$  - rainfall aggressivity,  $S$  - soil erodability coefficient,  $C$  - crop structure coefficient,  $C_s$  - crop cultivating system efficiently coefficient,  $L$  - slope length,  $I$  - slope land;

$E_{ad} = V_s * S_{ad}$  ( $m^3/an$ ) where:  $V_s$  - sediment volume transported in active sector,  $S_{ad}$  - stretched active area;

$E_{al} = E_{al} * S_{al}$ ; where:  $E_{al}$  was calculated with USLE equation consider that the surface of landslide like an area with ought vegetation,  $S_{al}$  - stretched active area;

$E_{nep} = E_{nep} * S_{nep}$  unproductive area are considered like an area with ought vegetation;

$E_{d.ex} = E_{d.ex} * S_{d.ex}$  road area are considered like an area with ought vegetation (at road on level curve it was applied an coefficient of 0.5);

Sediment effluence coefficient it was estimated at 41% in proportion with the watershed area.

Results are presented in table 2, the value show as in percent the diminish of the erosion and sediment effluence, considering situation of non erosion control works like witness so 100% percentage.

For hydrological efficiency of erosion control works it was determinate the highest flow capacity in the outdoor section of watershed, entrance in the reservoir, through balance method. At the base of this method is the idea that in every moment of the letting out it must be satisfy the following balance equation:

$$W = 1000 \cdot h \cdot F = W_v + W_a + W_i \text{ where:}$$

W – total volume of the letting out until the moment considerate, h – the higher of letting out formed in watershed until that moment, F – watershed area,  $W_v$  – letting out volume find on slope that moment,  $W_a$  - letting out volume find in channel that moment,  $W_i$  - letting out volume who are passed from the section that moment

Table 2

Erosion and sediment effluence from Cârjăoani watershed

Erosion forms	Erosion						Sediment effluence					
	Before reclamation			After reclamation			Before reclamation			After reclamation		
	to	to/ha	%	to	to/ha	%	to	to/ha	%	to	to/ha	%
Sheet erosion witch:	30581	17.5	100	6729	3.8	22	12538	7.2	100	2759	1.6	22
from arable	27562	22.3	100	5606	4.5	20	11300	9.1	100	2298	1.9	20
from pasture	3008	9.9	100	1112	3.7	37	1233	4.1	100	456	1.5	37
from forest	11	0.1	100	11	0.1	100	4.4	0.0	100	4.4	0.0	100
from gully	541	8.8	100	324	5.3	60	222	3.6	100	133	2.2	60
from roads	0.3	0.1	100	0.3	0.1	100	0.1	0.0	100	0.1	0.0	100
TOTAL	31123	17.2	100	7054	3.9	23	12760	7.0	100	2892	1.6	23

Through application of an adequate culture structure and of a good reclamation works realized a diminuated of letting out layer of watershed and implicitly a better capitalization of rainfall (table 3).

Table 3

Values of sheet letting out layer for 10% assurance in Cârjăoani watershed

t(min)	10	20	30	40	50	60	70	80	90	100	110	120
Before reclamation												
$h_s$ (mm)	6.5	10.0	11.5	12.5	12.75	12.75	12.25	11.75	10.0	8.5	8.25	8.0
After reclamation												
$h_s$ (mm)	5.75	6.5	9.5	9.75	10.0	9.5	9.0	8.25	7.0	6.5	6.5	6.0
Reducing (%)	11.6	35.0	17.4	22.0	21.6	25.5	26.6	29.8	30.0	21.2	21.2	25.0

Table 4

The flow capacity in the outdoor section of Cârjăoani watershed

Time	10		20		30		40		50		60		70		80	
Case	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$	$t \leq t_c$	$t < t_c$
Moment	t	t+Δt	t	t+Δt	t	t+Δt	t	t+Δt	t	t+Δt	t	t+Δt	t	t+Δt	t	t+Δt
$Q_n$ with ought reclamation works	0.10	4.54	1.00	12.59	2.28	16.64	3.72	19.39	4.62	19.76	5.18	19.33	5.05	17.48	4.81	15.78
$Q_a$ with reclamation works	0.05	3.09	0.17	4.04	0.87	9.20	1.23	9.60	1.61	9.99	1.59	8.84	1.51	7.78	1.28	6.38

The highest flow capacity in the outdoor section of watershed entrance in the reservoir it was made for a number of eight moment's  $t_i$  - 10. 20. 30. 40. 50. 60. 70. 80 minutes for who the higher flow capacity in the section it was  $h_{(i)}$  - 6.25; 10.0; 11.5; 12.5; 12.75; 12.75; 12.25; 11.75 mm. in tow cases ( $t \leq t_c$  and  $t < t_c$  where  $t$  is rainfall time.  $t_c$  is concentration time) and tow specific moments for every case ( $t$  and  $t+\Delta t$ ) (table 4).

**Conclusions**

The comparative analyze of these tow situation, with erosion control works and same watershed without erosion control works. set of some conclusions:

The erosion are reduced under acceptable limits (17.2 m<sup>3</sup>/ha without erosion control works relative to 3.9 m<sup>3</sup>/ha with erosion control works);

A proper cultivation structure mixed with erosion crop system reduced erosion and sediment effluence with 20%;

A good erosion control works capitalized efficiently rainfall. surface runoff is reduced with 11-30%;

An adequate reclamation of outlet network reduces gully erosion with 60%;

Ensemble of land reclamation (cultivation structure. erosion crop system. erosion control works on outlet network) reduces erosion and sediment effluence with 23%.

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# IMPACTUL PIERDERILOR DE ELEMENTE FERTILIZANTE DE PE TERENURILE AGRICOLE ÎN PANTĂ, PRIN EROZIUNE, ASUPRA FERTILITAȚII SOLURILOR

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## Abstrct:

Solul, considerat ca resursă naturală strategică unică, poate fi distrus rapid, fertilitatea lui putând fi refăcută prin măsuri adecvate, într-o perioadă de ani sau decenii, iar reconstrucția ecologică a solului distrus poate dura secole sau chiar milenii.

Principalele elemente cu rol important în nutriția plantelor sunt: humusul, azotul, fosforul și potasiul.

Modalitățile prin care se pierd aceste elemente sunt:

- prin intermediul solului erodat, care contribuie la deplasarea acestor elemente pe versanți și depunerea la baza versantului, în lunci sau în acumulări, în funcție de puterea de transport a agenților erozivi, odată cu materialul solid transportat;
- pierderi de elemente odată cu apa scursă la suprafața solului, aceste pierderi fiind direct proporționale cu solubilitatea și cantitatea elementului din sol;
- deplasarea acestor elemente pe profilul solului prin intermediul apei infiltrate în sol.;

Pierderile maxime de elemente nutritive, la parcelele pentru controlul scurgerilor, s-au înregistrat după trei averse succesive ce au totalizat 103 mm din data de 22.06.1999 (între orle 16-24) exceptie făcând parcela cultivată cu grâu

La păioase, pierderile de nutrienți prin apa scursă oscilează între 12 și 83 %, în timp ce la prășitoare (porumb) apei revin 3 până la 31% din pierderile totale înregistrate, iar la legumioase anuale (soia, fasole) acestea oscilează între 9 și 50%

De remarcat faptul că la parcela cultivată cu bromus, pierderile cele mai mari s-au înregistrat când cultura era în anul întâi, nefiind suficient de bine dezvoltată

Raportând pierderile de elemente fertilizante înregistrate la parcelele pentru controlul scurgerilor la pierderile calculate pentru eroziunea admisibilă de 8 to/ha/an, constatăm că:

- la păioase, pierderile de nutrienți reprezintă 0,2-15 % din pierderile calculate, la prășitoare, pierderile de nutrienți reprezintă 99-138 % din pierderile calculate
- la leguminoase anuale, pierderile de nutrienți reprezintă 71-126 % din pierderile calculate

**Key words:** *soil, lost nutrients, runoff, erosion*

## Introducere

Solul, considerat ca resursa naturala strategica unica, poate fi distrus rapid, fertilitatea lui putand fi refacuta prin masuri adecvate, într-o perioad de ani sau decenii, iar reconstrucția ecologica a solului distrus poate dura secole sau chiar milenii.

Modificările proprietăților chimice ale solurilor, ca urmare a proceselor de eroziune sunt mai puternice decât cele produse asupra însușirilor fizice. Cele mai importante modificări apar în ceea ce privește conținutul în substanțe nutritive pentru plante: humus, azot, fosfor și potasiu.

Modalitățile prin care se pierd aceste elemente sunt:

- prin intermediul solului erodat, care contribuie la deplasarea acestor elemente pe versanți și depunerea la baza versantului, în lunci sau în acumulări, în funcție de puterea de transport a agenților erozivi, odată cu materialul solid transportat;

- pierderi de elemente odată cu apa scursă la suprafața solului, aceste pierderi fiind direct proporționale cu solubilitatea și cantitatea elementului din sol;

- deplasarea acestor elemente pe profilul solului prin intermediul apei infiltrate în sol.;

Pierderile de elemente nutritive prin intermediul scurgerilor lichide sunt strâns legate de solubilitatea în apă a fiecărui element și de capacitatea de reținere în complexul adsorbiv al solului.

Din acest punct de vedere, comportamentul fiecărui ion cu rol în nutriția plantelor este următoarea:

- azotul, sub forma de anion nitrata din îngrășăminte, este forma cea mai ușor deplasată, atât prin levigare, cât și prin percolare pe profil;

- azotul sub forma de cation amoniu, este mai greu deplasat fiind reținut de complexul argilo-humic;

- fosforul din îngrășămintele chimice mai ușor levigabil (superfosfații) este antrenat mai rapid prin intermediul scurgerilor lichide;

- potasiu este un cation cu o solubilitate ridicată în apă fiind ușor antrenat prin scurgerile de suprafață, în timp ce percolarea pe profil este mai anevoioasă datorită reținerii în complexul adsorbiv al solului.

Este important de știut dacă aceste pierderi pot fi recuperate în condiții naturale sau cât trebuie intervenit pentru menținerea fertilității solului.

### **Material și metoda**

Lucrarea prezintă cercetările efectuate timp de 9 ani, privind pierderile de elemente fertilizante, la suprafața solului, prin intermediul scurgerilor solide și lichide și raportarea acestora la pierderile calculate pentru eroziunea admisibilă stabilită pentru zona C.C.DC.E.S.Perieni. Experiențele s-au efectuat la parcelele standard pentru controlul scurgerilor, amplasate în bazinul hidrografic Valea Tarinei, bazin amenajat antierozional. Aceste parcele permit reținerea volumului de apă și sol în bazine acoperite pentru a nu induce erori în aprecierea volumului de apă scurs. Fiecare parcelă este

echipata cu 3 bazine de 1000, 200 și 50 litri, primele bazine fiind prevazute cu un dispozitiv de reducere 1:5 a volumului de apa scurs. Parcelele sunt lucrate în sistem convențional, în privința lucrărilor solului, fiind cultivate cu: porumb, grau, bromus, fasole și soia, respectându-se principiul rotației culturilor Pe baza volumului de apa colectat și a “turbidității” se estimează pierderile lichide și solide la hectar. În urma analizelor efectuate pe probele de apa și sol prelevate din bazine se stabilește nivelul pierderilor de elemente fertilizante, raportate la hectar.

Pentru estimarea conținutului de humus s-a folosit varianta oxidării umede și dozării titrimetrice (după Walkley – Black în modificarea Gogoasa),

Determinarea azotului total din sol s-a făcut prin metoda Kjeldahl.

Pentru determinarea concentrației de fosfor și potasiu din probele recoltate s-a folosit metoda de extracție în acetat-lactat de amoniu la, pH 3,75 după metoda Egner – Riehm – Domingo. Varianta de colorimetrie utilizată pentru determinarea fosforului a fost cea de dozare prin reducere cu acid ascorbic, după Murphy – Riley, iar potasiul s-a dozat prin fotometrie în flacăra atât pentru probele de sol, cât și pentru probele de apă.

Determinarea azotului amoniacal din probele de apă s-a făcut colorimetric, cu reactiv Nessler (tetraiodo - mercuriat de potasiu), iar a nitraților, colorimetric, cu acid fenol 2-4 disulfonic.

Metoda de determinare a anionului fosfat constă în dozarea colorimetrică a complexului de culoare albastră, rezultat în urma reacției dintre molibdatul de amoniu și anionul fosfat, în prezența unui reductor ( $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ ), la o lungime de undă de 830 nm.

Calcularea pierderilor de nutrienți pentru eroziunea admisibilă de 8 t/ha/an s-a făcut luând în considerare concentrațiile medii ale acestor elemente din zona de experimentare

### **Rezultate și discuții.**

Analiza numărului de evenimente și a precipitațiilor lunare care au provocat pierderi de apă și sol (*tabelul nr.1*) precum și repartitia procentuală lunară a acestora (*tabelul nr. 3*) arată că nivelul cel mai ridicat, cu implicații asupra fenomenului erozional, se înregistrează în luna iunie când sunt consemnate și cele mai mari scurgeri lichide și de sol erodat (*tabelul nr.2 și 4*) cu excepția parcelei cultivată cu grau, când pierderile maxime sunt în luna iulie.

Din tabelul nr. 1, reiese faptul că la parcelele cultivate, în luna iunie s-au înregistrat între 2 și 12 evenimente pluviale ce au înregistrat ploi ce au totalizat între 136,5 și 337 mm. cu excepția parcelei cultivate cu grau, unde maximile se situau în luna iulie (7 evenimente ce au totalizat 138.5 mm.),

luna in care parcela este ramasa o perioada ca miriste. Parcela ramasa ca ogor negru permanent inregistreaza intre 13-18 evenimente lunare ce totalizeaza 291,5-322,8 mm. cu repartitie aproximativ uniforma in lunile iunie, iulie si august.

Analiza datelor privind volumul scurgerilor lichide si solide lunare (*tabelul nr. 2*) si repartitia procentuala din totalul pierderilor din perioada luata in studiu (*tabelul nr.4*), reliefeaza faptul ca:

- la bromus, pierderile cele mai mari se inregistreaza in luna iunie, 165 mc/ha respectiv 0,23 to/ha, reprezentand intre 93,75 si 86,79 % din pierderile totale din aceasta perioada. De remarcat faptul ca pierderile cele mai marim s-au inregistrat dupa doua averse succesive ce au totalizat 136,5 mm. cand cultura era in primul an de la infiintare;

- la cultura graului, volumul scurgerilor lichide (243,5 mc/ha, reprezentand 74,46 %) si al celor solide (2,812 to/ha, cu un coeficient de 84,8 %), se inregistreaza in luna iulie;

- la culturile slab protectoare se inregistreaza pierderi lichide intre 729,1 si 844 mc/ha, in timp ce solul erodat oscileaza intre 34,27 si 51,19 to/ha, pierderi inregistrate tot in iunie;

- parcela ramasa ca ogor negru permanent are pierderi lichide cuprinse intre 1116,5 si 1147,2 mc/ha si de sol erodat de 192,2 – 86,85 to ha in lunile iunie si iulie.

Studiul pierderilor de elemente fertilizante din aceasta perioada si repartitia acestora prin solul erodat si apa scursa, (*tabelul nr. 5*), arata ca:

Pierderile de humus:

- la culturile bune protectoare( bromus, grau), ascileaza intre 8,85 si 110,71 kg/ha;

- culturile slab protectoare din punct de vedere erozional se înregistrează cu pierderi de 1523,4-2128,51kg/ha:

- la parcela martor sunt deplasate prin solul erodat : 8367,9 kg/ha

Pierderile de azot:

- la grau si bromus au valori cuprinse intre 1,2 si 6,44 kg/ha din care prin apa 62,46% la bromus;

- culturile slab protectoare au pierderi de 82,17-111,07 kg/ha prin apa pierzandu-se 3,95-4,06%:

- la ogor s-au pierdut 423,73 kg/ha, reprezentand 1,46% deplasari prin apa scursa.

Potasiu, calculat sub forma de oxid, are pierderi intre 1,072 si 66,603 kg/ha, cu procente cuprinse intre 65,74-94,22% la culturile bune protectoare, 30,71-35,51% la cele slab protectoare si 16,69 % la ogor, deplasari prin apa scursa.

Fosforul se înregistrează cu pierderi de 0,146-15,877 kg/ha, din care prin apă între 83,78 și 13,6%.

Pierderilor de nutrienți, la diferite culturi, ca urmare a fenomenului erozional, raportate la eroziunea admisibilă de maxim 8 to/ha/an stabilită pentru zona de experimentare sunt prezentate în tabelul nr.6, din care rezultă ca:

- față de eroziunea admisibilă de 8 to/ha/an, se înregistrează depășiri de 5,921 to /ha la porumb și de 276,177 to /ha la ogor pe o perioadă de 9 ani, cu procente de 108,3 – 483,58; - la humus, față de calculul estimat, pierderile sunt sub 99,54% la parcelele cultivate, iar la ogor sunt depășiri de 391,23%;

- azotul și fosforul înregistrează depășiri la ogor și porumb, în timp ce potasiul depășește limitele estimate cu 100,67-412,05% la culturile slab protectoare și la ogor.

### **Concluzii**

Referitor la pierderile de elemente fertilizante

- culturile bune protectoare din punct de vedere antierozional, cum sunt bromusul și graul, reduc impactul picăturilor de ploaie asupra solului, deci micșorează posibilitatea desprinderii și transportului particulelor de sol. Totodată, o mare cantitate de apă patrunde în adâncime astfel încât pierderile de sol prin eroziune și volumul scurgerilor lichide sunt mult mai mici față de culturile slab protectoare și ogorul negru permanent.

- pierderile scăzute de elemente fertilizante și sol justifică utilizarea bromusului la înierbarea taluzelor și a benzilor ;

- pierderile maxime de elemente nutritive, la parcelele pentru controlul scurgerilor, s-au înregistrat după trei averse succesive ce au totalizat 136,5 mm din data de 22.06.1999 (între orele 16-24) excepție făcând parcela cultivată cu graul

De remarcat faptul că la parcela cultivată cu bromus, pierderile cele mai mari s-au înregistrat când cultura era în anul întâi, nefiind suficient de bine dezvoltată.

Raportat pierderile de elemente fertilizante înregistrate la parcelele pentru controlul scurgerilor la pierderile calculate pentru eroziunea admisibilă de 8 to/ha/an, constatăm ca:

- la păioase, pierderile de nutrienți reprezintă 0,41-14,81 % din pierderile calculate;

- la prăsitoare, pierderile de nutrienți oscilează între 99,54-137,97 % din pierderile calculate;

- la leguminoase anuale, pierderile de nutrienți se situează între 67,7-106,67 % din pierderile calculate;

- la ogorul negru permanent sunt depasiri de 2 – 4 ori fata de pierderile estimat;

Referitor la eroziune, se constata ca:

- la paioase se situiaza sub 4,61%, fata de estimat;
- la leguminoase sub 78,76%;
- la porumb, aproape de calculele estimate (108,23);
- ogorul permanent ajunge la 483,58% din estimat.

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Tabel 1

Nivelul precipitatiilor lunare , totale si numarul evenimentelor pluviale care au produs scurgeri pe o perioada de 9 ani

Luna	Aprilie		Mai		Iunie		Iulie		August		Septembrie		Octombrie		Total	
	mm	Nr. ev.	mm	Nr. ev.	mm	Nr. ev.	mm	Nr. ev.	mm	Nr. ev.	mm	Nr. ev.	mm	Nr. ev.	mm	Nr. ev.
Bromus	6.2	1	0.0	0	136.5	2	0.0	0	0.0	0	60.2	1	0.0	0	202.9	4
Grau	0.0	0	0.0	0	0.0	0	135.9	7	101.8	3	0.0	0	0.0	0	237.7	10
Soia	0.0	0	0.0	0	295.8	11	158.7	8	142.3	5	35.7	2	0.0	0	632.5	26
Fasole	0.0	0	0.0	0	268.4	9	153.2	8	142.3	5	19.2	1	91.4	1	674.5	24
Porumb	0.0	0	9.5	1	337.4	12	222.2	12	237.4	9	136.7	5	14.4	1	957.6	40
Ogor 100	0.0	0	9.5	1	315.3	13	322.8	18	291.5	15	138.9	6	32.3	2	1110.3	55

Tabel 2

Volumul scurgerilor lichide si solide lunare si totale pe 9 ani

Luna	Aprilie		Mai		Iunie		Iulie		August		Septembrie		Octombrie		Total	
	Sl	E	mc/ ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha
Cultura	mc/ha	to/ha	mc/ ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha	mc/ha	to/ha
Bromus	5.5	0.024	0.0	0.000	165.0	0.230	0.0	0.000	0.0	0.000	5.5	0.011	0.0	0.000	176.0	0.265
Grau	0.0	0.000	0.0	0.000	0.00	0.000	243.5	2.812	83.5	0.504	0.0	0.000	0.0	0.000	327.0	3.316
Soia	0.0	0.000	0.0	0.000	831.2	36.584	277.5	4.883	498.0	15.456	66.5	0.781	0.0	0.000	1673.2	57.704
Fasole	0.0	0.000	0.0	0.000	844.0	34.271	231.5	3.321	341.5	4.310	30.5	0.179	46.0	0.159	1493.5	42.240
Porumb	0.0	0.000	10.0	0.066	729.1	51.191	572.5	17.080	477.0	8.856	104.0	0.640	12.0	0.088	1904.6	77.921
Ogor 100	0.0	0.000	3.8	4.840	1116.5	192.201	1147.2	86.850	797.5	57.960	284.0	5.590	47.0	0.736	3396.0	348.177

Tabel 3

## Repartitia procentuala lunara a precipitatiilor si evenimentelor

Luna	Aprilie		Mai		Iunie		Iulie		August		Septembrie		Octombrie	
	Prec. %	Ev. %	Prec. %	Ev. %	Prec. %	Ev. %	Prec. %	Ev. %	Prec. %	Ev. %	Prec. %	Ev. %	Prec. %	Ev. %
Bromus	3.1	25.0	0.0	0.0	67.3	50.0	0.0	0.0	0.0	0.0	29.7	25.0	0.0	0.0
Grau	0.0	0.0	0.0	0.0	0.0	0.0	57.2	70.0	42.8	30.0	0.0	0.0	0.0	0.0
Soia	0.0	0.0	0.0	0.0	46.8	42.3	25.1	30.8	22.5	19.2	5.6	7.7	0.0	0.0
Fasole	0.0	0.0	0.0	0.0	39.8	37.5	22.7	33.3	21.1	20.8	2.8	4.2	13.6	4.2
Porumb	0.0	0.0	1.0	2.5	35.2	30.0	23.2	30.0	24.8	22.5	14.3	12.5	1.5	2.5
Ogor 100	0.0	0.0	0.9	1.8	28.4	23.6	29.1	32.7	26.3	27.3	12.5	10.9	2.9	3.6

Tabel 4

## Repartitia procentuala lunara a scurgerilor lichide si eroziunii

Luna	Aprilie		Mai		Iunie		Iulie		August		Septembrie		Octombrie	
	SI %	E %	SI %	E %	SI %	E %	SI %	E %	SI %	E %	SI %	E %	SI %	E %
Bromus	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Grau	3.13	9.06	0.00	0.00	93.75	86.79	0.00	0.00	0.00	0.00	3.13	4.15	0.00	0.00
Soia	0.00	0.00	0.00	0.00	0.00	0.00	74.46	84.80	25.54	15.20	0.00	0.00	0.00	0.00
Fasole	0.00	0.00	0.00	0.00	49.68	63.40	16.58	8.46	29.76	26.78	3.97	1.38	0.00	0.00
Porumb	0.00	0.00	0.00	0.00	56.51	81.13	15.50	7.86	22.87	10.20	2.04	0.42	3.08	0.38
Ogor 100	0.00	0.00	0.53	0.08	38.28	65.70	30.06	21.92	25.04	11.37	5.46	0.82	0.63	0.11
Bromus	0.00	0.00	0.11	1.39	32.88	55.20	33.78	24.94	23.48	16.65	8.36	1.61	1.38	0.21

Tabel 5

Repartitia procentuala a pierderilor de elemente fertilizante prin apa si sol in perioada 1995-2003 la parcelele pentru controlul scurgerilor

Cultura	Scurgerea lichida mc/ha	Eroziunea to/ha	Humus kg/ha	Azot			K2O			P2O5		
				Total	Apa	Sol	Total	Apa	Sol	Total	Apa	Sol
				kg/ha	%	%	kg/ha	%	%	kg/ha	%	%
Bromus	176.0	0.265	8,85	1,20	62,46	37,54	1,072	94,22	5,78	0,148	83,78	16,22
Grau	327.0	3,316	110,71	6,44	12,13	87,87	2,407	65,79	34,21	0,571	39,48	60,52
Soia	1673.2	56.704	1902,68	101,35	3,95	96,05	20,367	35,13	64,87	6,625	13,60	86,40
Fasole	1493.5	42.240	1523,40	82,17	4,06	95,94	16,273	35,54	64,46	5,079	14,39	85,61
Porumb	1904.6	77.921	2128,51	111,07	3,96	96,04	22,302	30,71	69,29	7,855	16,56	83,44
Ogor 100	3396.0	348.177	8367,90	423,73	1,46	98,54	66,603	19,69	80,31	15,877	15,25	84,75

Tabel 6

Raportarea pierderilor de elemente fertilizante inregistrate la parcele fata de pierderile estimate la eroziunea admisibila de 8 to/ha/an

Cultura	Eroziunea		Humus		Azot total		K2O		P2O5	
	to / ha	% din estimat	kg / ha	% din estimat	kg / ha	% din estimat	kg / ha	% din estimat	Kg / ha	% din estimat
Estimat	72,00		2138,40		108,00		16,16		7,50	
Bromus	0.265	0.37	8,85	0,41	1,20	1,11	1,07	6,63	0,15	1,97
Grau	3,316	4,61	110,71	5,18	6,44	5,97	2,41	14,89	0,57	7,61
Soia	56.704	78,76	1902,68	88,98	101,35	93,84	20,37	126,00	6,63	88,31
Fasole	42.240	58.67	1523,40	71,24	82,17	76,09	16,27	100,67	5,08	67,70
Porumb	77.921	108.23	2128,51	99,54	111,07	102,84	22,30	137,97	7,85	104,70
Ogor 100	348.177	483,58	8367,90	391,32	423,73	392,34	66,60	412,05	15,88	211,63

# <sup>137</sup>Cs USE IN SEDIMENTATION RATE ASSESSMENT IN GULLIES AND RESERVOIRS IN ROMANIA

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## **Abstract.**

The acceleration of erosion processes, associated with land degradation represents, for a long term, a major problem for the sustainable agriculture. Beyond the protection, the reservoirs have also other functions like: drinking water sources for neighbouring towns and villages; irrigation water sources for agricultural land; fishing; recreational areas. The use of <sup>137</sup>Cs as an environmental tracer is a very good alternative option to classical methods due to the following reasons: <sup>137</sup>Cs half-time is  $T_{1/2} = 30.14$  years, long enough to average the environmental processes over decades; <sup>137</sup>Cs is present in environment in enough quantities due to nuclear tests, but mainly after the Chernobyl accident (it is not necessary to introduce it voluntarily); <sup>137</sup>Cs is strongly fixed on clays. For this study, a number of samples taken from Gaiceana and Antohesti reservoirs were taken up to 100-110 cm depth, with an increment of 10 cm. The samples were conditioned and <sup>137</sup>Cs was measured in laboratory using a high-resolution gamma-spectrometer. The total inventory and the initial deposition of <sup>137</sup>Cs were derived. The sedimentation rate can be measured, considering the depth distribution of <sup>137</sup>Cs. The Chernobyl maximum deposition in Antohesti reservoir is about 75 cm depth. The sedimentation rate is about  $4.2 \pm 0.4$  cm/year. The accumulation of sediments in the flood plain reaches  $63.0 \pm 6.3$  t/ha per year. The Chernobyl maximum deposition lies between 50 and 60 cm depth. The sedimentation rate is about  $3 \pm 0.3$  cm/year. The accumulation of sediments in the flood plain of Gaiceana reservoir reaches about  $45.0 \pm 4.5$  t/ha per year. The erosion and sedimentation processes contribute to the secondary pollution of environment by the redistribution of pollutants in watersheds.

**Keywords:** sedimentation rate, <sup>137</sup>-Cs, gullies, environmental tracer.

## **Aims and background**

The Moldavian plateau, located in the Eastern Romania and extending about 25 000 km<sup>2</sup> is considered as the broadest and most typical plateau of the country (Fig. 1). As moving from the north to the south a regular, systematic decrease in clay content with increasing in sand percentage can be regarded. This plateau is situated between 32 and 564 m a.s.l. Man drastically changed the native vegetation cover; two natural zones have been distinguished: the forestry area that occupies the higher parts of the plateau and the area under silvosteppe (forest-grassland transition) and steppe (short grasslands). Slopes within the plateau are mantled by mollisols and forestry soils.

This area is characterised by a high potential of land degradation being subjected to surface soil erosion and landslides.

The proper study area has focused mostly between the Prut and Siret rivers on three major units of the Moldavian plateau:

- the Moldavian plain, drained mainly by Jijia catchments occupies the northern part of the plateau, which is rich in clayey Miocene layers.
- the Central Moldavian tableland that is well known by some structural plateaus bounded by north-looking cuestas.
- the Tutova rolling hills, which are situated in the southern area, being surrounded by the Racova, Barlad and Siret rivers.

The radioactive fallout, which has occurred after the Chernobyl accident<sup>1</sup> in April 26 1986, was characterised by complex meteorological conditions. Consequently, the contamination of the soil surface was highly non-uniform. In special situation like those arising in the gully-heads, floodplain and reservoirs, from the total inventory of <sup>137</sup>Cs, the initial deposition due to the Chernobyl accident can be derived<sup>2,3</sup>.



**Figure 1** Romanian Moldavian Tableland

The soil erosion processes<sup>3,4</sup>, associated with land degradation represents, for long term, a major problem for the environment. Beyond the protection against floods, the reservoirs have also other functions like:

- drinking water sources for neighbouring towns and villages;
- irrigation water sources for agricultural land;
- fishing;
- recreational areas.

The sediments accumulated in surface waters affect water quality, biological activity and produce the loosing of water storage capacity of reservoirs.

### **Experimental**

The investigated area is placed on the Moldavian-Romanian tableland. For this study, a number of samples from reservoir and gullies were taken as the total inventory and the initial deposition of <sup>137</sup>Cs were derived<sup>2</sup>. Images of Antohesti reservoir and the sampling site are given in Photos 1 and 2.



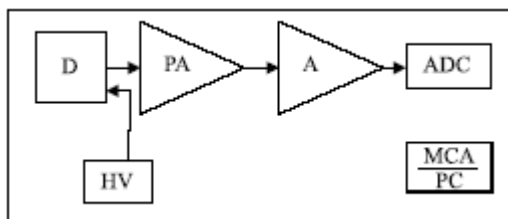
**Photo 1** Antohesti reservoir



### Photo 1 Pit profile in sediment

*Measurement system.* The semiconductor detectors are frequently used in nuclear physics due to their advantages such as high resolution for energy, linear response with energy, and good detection efficiency.

In this work the following system was used (Fig. 2).



**Figure 2** Measuring system scheme

D – detector; PA – preamplifier; A – amplifier; ADC – analog to digital converter; HV – high voltage; MCA – multichannel analyser; PC – personal computer

*Sample taken and conditioning.* The sediments samples were taken up to 230 cm depth, with an increment of 10 cm. A label with the following data was attached to each sample:

- sample place and depth;
- sampling date;
- sample type.

A minimum of 2.5 kg of sediment per sample were taken.

The samples were conditioned as follows:

- impurities removal (small stones, vegetation. etc.);
- drying at 60°C minimum 6 h;
- soft milling (for avoiding the crush of soil particles);
- sieved with a 2-mm mesh;
- drying at 90°C about 2-4 h;
- soft milling;
- sieved with a 2-mm mesh;
- sample weighting.

*Sources of sediment.* The sediments in the investigated reservoirs come from the associated watershed, due to erosion processes. In the investigated area, the soil erosion represents a major risk in land degradation. All forms of water erosion are present in the region: surface, rill, inter-rill and gully erosion. The effects of erosion are illustrated in Photos 3 and 4.



**Photo 3** Gully erosion in the Moldavian Tableland



**Photo 4** Gully erosion in the Moldavian Tableland

### **Results and discussion**

The samples were measured using the Marinelli geometry, with a 500 cm<sup>3</sup> volume. The collecting time ranges from 5000 to 80 000 s, depending on the sample activity. The <sup>137</sup>Cs activity was calculated as follows:

$$A = \frac{A_n}{t_c y E_f m} \text{ Bq/kg} \quad (1)$$

where  $A_n$  is the net area;  $y$  – yield;  $m$  – sample weight (kg);  $E_f$  – detector efficiency at 661.6 keV for the Marinelli geometry.

The uncertainty (in %) for a confidence level 90% is given by:

$$E.P. = 165 \frac{\sqrt{A_t + \left(\frac{N}{2}\right)^2 (B_1 + B_2)}}{A_t - \frac{N}{2} (B_1 + B_2)}. \quad (2)$$

The minimum detectable activity is:

$$AMD = \frac{2.73 + 4.65 \sqrt{A_t}}{t_c I E_f m} \quad (3)$$

where AMD is the minimum detectable activity (Bq/kg);  $A_t$  – gross area in the region of interest.

**Table 1.** Chernobyl depth of  $^{137}\text{Cs}$  activity in sediment in reservoirs and sedimentation rates

Reservoir	River basin	Chernobyl depth (cm)	Sedimentation rate (cm/year)
Bibiresti	Racatau	69.9	5.8
Antohesti	Berheci	57.3	4.8
Hutu-Gaiceana	Berheci	70.5	5.9
Puscasi	Racova	142.7	11.9
Pungesti-Garceni	Racova	30.9	2.6
Ras-Craesti	Barlad	35.0	2.9
Solesti	Vaslui	81.3	6.8
Popesti	Scobalteni	9.6	0.8
Doroscani	Scobalteni	23.0	1.9
Podul Iloaiei	Bahluiet	38.0	3.2
Ichimeni	Baseu	26.3	2.2

**Table 2.** Chernobyl depth of  $^{137}\text{Cs}$  activity in gullies and sedimentation rates

Gully	Chernobyl depth (cm)	Sedimentation rate (cm/year)
Scranghita	8.4	0.8
Rapa Albastra	34.7	2.9
Gomei	12.1	1.1
Valea Timbrului	24.6	2.1

The maximum activity of  $^{137}\text{Cs}$ , due to Chernobyl direct deposition,