ECOLOGICAL ANALYSIS OF THE TROTUS BASIN (CASE STUDY BACAU COUNTY)

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Abstract The authors analyze the causes which generated the disastrous events in the summer of year 2005 in the hydrographic basin of the Trotus River, stressing those generated by ecological dysfunctions, due to the brutal intervention of people through extensive deforestation of the slopes of the Trotus River's tributaries and of the mountainous area the river flows through in Bacau County.

Keywords: hydrographic basin, precipitations, floods, deforestation, ecological dysfunctions.

1. INTRODUCTION

The Trotus River is a tributary of the international river Siriu, part of the catchment area of the Siret. The length of the hydrographic network of the Siret basin is 15,836 km, of which 15,157 km are in Romania.

The Trotus River has only 162 km in length, i.e. about 1.1% of the total length of the hydrographic network of Romania. On the territory of Bacau County the Trotus basin covers an area of 2,948 km^2, i.e. about 90% of the agricultural area of the county and about 44% of the county's total area.

Taking into account that the Siret basin covers 42,890 km^2, its tributary the Trotus detains 10.4% of it, i.e. ten times the share of its length in the total length of the hydrographic network of the county.

Two main tributaries of the Siret in Bacau County – Trotus and Bistrita – together with the Siret, which flows for 90 km in the county, create a hydrographic triangle most unfavorable to current antropic changes, as it collects water flows from the largest and most uneven areas in the whole Siret basin. Moreover, there are another 15 tributaries that become active and overflow, during heavy rainfalls, due to extensive deforestation and slopes.

2. THE SPECIFIC SITUATION IN 2005

Albeit at world level year 2005 was the warmest in the planet's history and of Western Europe, Romania and a great part of the countries in Central and Eastern Europe were areas of decompensation at world and European levels, characterized by massive rainfalls and low temperatures.

From April to August 800 mm of rain had fallen in the studied area, i.e. over 240 mm/month or 2400 m^3/ha in average, which for a hydrographic basin of 445-600 km^2 represented 445x600 ha x 2400 m^3/ha = over 1 billion m^3 or tons of water This quantity of water could have been evacuated without causing flooding in the following conditions:

a) if the intensity of rains would not have exceeded a maximum of 25 l/day over a period of maximum two days and 15 ml/day over the remaining period;

b) if penetrability (infiltration index) would have been normal, i.e. at least 10mm/day;
c) if the vegetation coverage would have been intact in the area as it used to be 30 years ago.

This climate situation and the antropic behavior of the last 20 years are characterized by:

- The greenhouse effect over the territory of study increased ten times due to the important emissions generated years ago by the chemical plants (in the stratosphere at 20 km altitude there are also large quantities of perchlorocarbon which are 4,000 times more dangerous for climate instability then carbon dioxide – CO2 – and more than 20 times more dangerous than nitrogen oxides – NOx). The frosty winters of the last four years, that of year 2005 included, in particular February, induced a more rapid temperature inversion at regional level (fig.1).

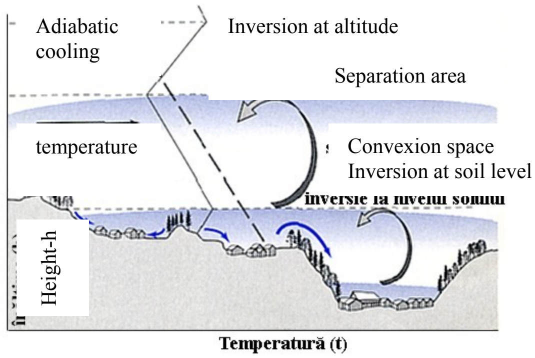


Fig. 1
Chart of regional temperature inversion with an additional inversion at ground level and local change of air (Source: Berca, M., 2006)

The relief featured in fig. 1 is similar to that of the Trotus Valley, therefore it is fairly certain that the phenomenon which took place was similar. Quantities of rainfalls exceeding maximums in April, May and June were registered at several meteo-stations over the country, the Trotus hydrographic basin included, creating an unprecedented pluviometric and hydrodynamic tension along the valley, as confirmed by the oldest inhabitants.

An elderly inhabitant from Ciobanas village (to the North of Comanesti) made the following description of the situation on July 1st 2005: “All of a sudden it went dark and the rain poured down so heavily that we feared to be drowned immediately. We felt as if the mountains full of water started towards us”.

The usually dry Ciobanas brook became a huge water carrying large quantities of water and rocks. During our research in the Trotus Valley there were numerous such accounts.

3. HYDROMETRIC REGISTERING

The maximum flow registered at Vranceni on 13th July 2005 reached 2,800 m^3/sec being the highest in the recorded history of the river. It is comparable with that registered on the Tazlau brook when the Belci Dam broke down in 1991 (3,100 m^3/sec). The volume of the high flood on the Trotus had been of 550 million cubic meters. The average flow of the river is about 10-30 m^3/sec.

At the hydrometric station Lungoci the maximum flow of the Siret was registered a day later on 14th July 2005, it being 4,860 m^3/sec. The total volume of the high flood was 970 million cubic meters, of which 60% poured down on the Trotus. For comparison, the average flow of the Danube is about 7,000 m^3/sec.

4. DAMAGES AND ECOLOGICAL DYSFUNCTIONS

In the circumstances there have been large material and human losses at Bacau County level: from spring to end August 2005 a number of 71 settlements were affected, five people lost their lives and various material damages amounted to about 100 million Euros, of which 60% have been imputable to the Trotus River.

However, we should mention that the most important damages that cannot presently be estimated, being difficult to quantify, are the ecological ones:

a) Until the disaster there were 15,000 ha meadow forests along the Trotus flood plain with species dominated by poplar trees, alder trees, willows and numerous annual and perennial herbs. At least 120,000 tons/year of biomass were lost this way, the energy equivalent of 70,000 tons of petrol, i.e. 350,000 kW/h of electricity. Biodiversity, genotypes and the specific genetic fund of the meadow was lost (fig.2).

b) By the enlargement of the riverbed an additional 4,500 ha of fertile meadow land was lost (fig.3 and fig.4).

Fig. 2
Ecologically devastated area near Urechesti. Of a large meadow forest but a small group of more resistant trees are still in place.

Fig. 3
Eroded soil lost for the productive circuit with poor economically useless vegetation (Slobozia – Urechesti area)

Fig. 4
A year after the floods, an area wholly compromised ecologically, needing over 10,000 Euros in investments for reconstruction

c) The loss of a large volume of soil and vegetation was correlated with the expansion of the riverbed and the creation of several files of water flow in the same riverbed. The riverbed of 60 m width before the floods reached 800 m after that.

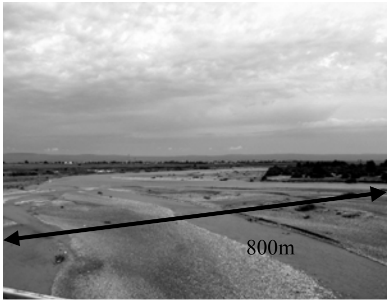


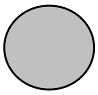
Fig. 5
The water bed of Trotus at the Bacau County's border with Vrancea County. The riverbed is 800 m wide and the river flows through three courses.

Fig. 6
Two of the courses of Trotus River and large quantities of rocks transported by rivers and brooks from the high mountains.

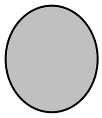
Fig.5 features the riverbed of Trotus at the border with Vrancea County. The riverbed has a width of over 800 m and the river flows along no less than three courses: to the North of Comanesti several flows can be noticed in the new riverbed of the river (fig.6). Though embedded in rock, the river managed to create two flows and between those there are huge deposits of rock transported by brooks from the high mountains.

d) Erosion, transport, clogging

The Trotus River is but the final instrument of water and solid material dynamics transported through erosion from the mostly uneven hydrographic basin (multi-segmented mountains and deeply furrowed hills). There are a number of factors that create the specific dynamics of the river's waters:
d 1) A very high kinetic energy which hit the soil and then accumulating in brooks generate a great kinetic energy from the smallest brooks to the river proper. The rain drops are spherical (the small ones) or slightly aero-dynamic (the big ones).



a) Spherical drops
Strength index = 0.2



b) Large aero-dynamic drops 0.5-0.7 mm
Strength index = 0.05

Fig. 7
Raindrop forms that influence the kinetic energy and the erosion

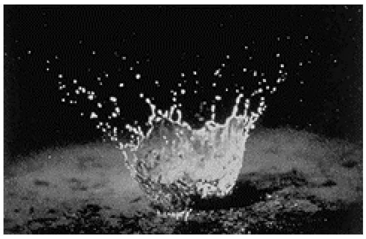
d 2) Types of rain
- Drizzle – homogenous rain of drops smaller than 0.5 mm and downfall speed of 0.3-2.0 m/sec.
- Light rain – drops of 2-3 mm and downfall speed of 4-5 m/sec
- Moderate rain – drops of 3-4 mm and downfall speed of 4-5 m/sec.
- Heavy, abundant rain with drops of 3-7 mm and downfall speed of 4-8 m/sec.

By heavy rain Richter (1965) means the following:
- In 5 minutes fall down 5 mm pp; in 30 minutes fall down 17.1 mm pp; in 90 minutes fall down 24.0 mm pp.

It is to be retained that the rains which fell down in the Trotus basin exceeded two to three times the standard of "heavy rains", which increased the process of ecological decay up to unprecedented values. Large drops attain higher speeds (figure 7 b) due to their aero-dynamic shape and earth gravitation, and to the high speed of 8 m/sec. with which they hit the unprotected soil, dislocating and carry away. In year 2005 heavy, abundant rains made up 90% of the total and in the Trotus basin they reached intensities of 70-80 mm in 24 hours.

When each drop of 7 mm impacts the uncovered and unprotected soil (figure 7b) it creates a micro-crater as in fig. 9 dislocating at a speed of al least 8 m/sec. a quantity of 500 gr/m^2 = 10,000 x 500 = 50,000 kg = 5 t/ha, which it caries right away on a slope of 30 degrees. The possibility of infiltration on such uncovered soils is near "0".In situation 'B" of figure 8 the soil is partially covered by vegetation and the fall of raindrops has a lesser impact on the soil. The same rain of 20 mm dislocates only 200 gr/m^2 = 2 t/ha.

However, both situations "A" and "B" are influenced by situation "C" where the land is freshly cleared, the slope milder and the infiltration index higher. Water infiltrated in such a land represent 50% of the fallen rain, the remainder flowing down the steeper slopes, contributing to the acceleration of the process and to the increase of the quantity carries away by about 30% in case A and 20% in case B (the results were computed according to the erosion model 3D – Geoplace. Com – 2006).



Micro-crater formed by large raindrops (7 mm) at a speed of 8m/s during torrential rain

Fig. 8
Three situations illustrating the creation of catastrophes due to rainfall and erosion

Water infiltrated in point "C" enters deeply the rock down to the base of the slope and contributes to the dislocation of the front of the slope, facilitating occasionally severe land slides (figure 10 and figure 11).

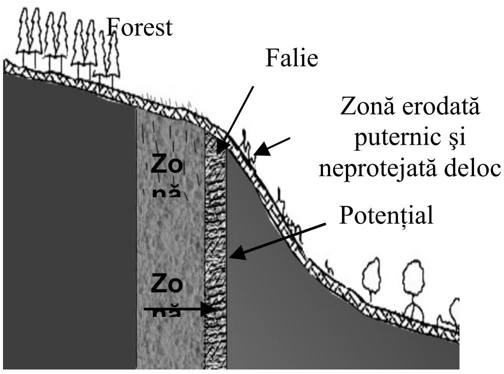


Fig. 10
Chart of an area in Ciuc Mountains subject to a complex, high intensity, surface-erosion process and to deep erosion

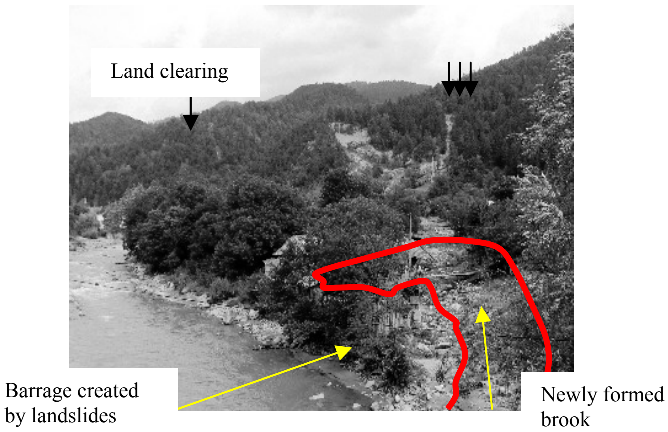


Fig. 11
Landslides on the left bank of Trotus that blocked the river in July 2005 making it to create a new waterbed. Since the waterbed was reestablished but the risk remained

It is to be mentioned that in the mountains and hills of Trotus land clearing occurred in two stages:

- **1994-2000** – the first restitutions of forests behind houses situated on the slopes; at the slope's base you can still find the house; after the clearing primary erosions have appeared on about 10% of the forested area, later evaluating to landslides.
- **After year 2000** – forests situated on the back of slopes or behind the peak; infiltrations have facilitated important landslides, millions of tons of rocks being carried down the slopes of mountains and high hills.

The large quantities of rocks and deposits are estimated, for year 2005 only, at over 150 million tons. They blocked the riverbed, modified its course, affected localities, crops and infrastructure (fig. 12). It is to be noticed that due to infiltrations even the slopes covered with perennial and annual plants started showing some forms of landslides, in areas that were formerly stable (fig. 13).

Fig. 12
Tens of thousands of tons of materials dislocated from the mountains were carried by 20 brooks towards the

Fig. 13
Landslides appear on well kept surfaces too if the surrounding areas became unstable

5. CONCLUSIONS

It was demonstrated lately that one of the specific characteristics of the current situation in the Trotus basin is related to the fact that "the environment changes are more rapid than the methods of prognosis, control and reconstruction" which can be devised. We could also state that sometimes they are more rapid than our capacity of monitoring them.

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