THE SUSPENDED LOAD FLOW ON SIRET RIVER FROM THE NORTH SIDE OF MOLDAVIA DURING THE 2010 FLOOD

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Key words: flood, suspended load, anthropogenic impact, erosion, clogging.

ABSTRACT:

In 2010, an exceptional flood occurred on Siret River, with liquid flow rates so high that it exceeded the maximum values so far known in many of the monitoring sections (Siret, Huțani, Lespezi). The suspended load flows produced during this flood were uncommonly high on various sections of the river.

This paper presents several aspects concerning the conditions in which solid flows are formed and how they evolve, as well as maximum rates recorded during this flood.

Statistical processing of the instantaneous values allowed realization of an association of suspended load flows taking into account the liquid flow. There have also been realized a few very suggestive diagrams regarding special characteristics of the suspended load flow on Siret River.

Following the analysis of the data, we have seen that anthropogenic impact proves to have the greatest influence on suspended load transportation.

1. Introduction

Suspended load formation is realized through the water erosion activity on the surface of the earth where vegetation and anthropogenic factor have a certain importance. Thus, water flow is the main determinant of the suspended load flow which may be influenced one way or another by the geographical circumstances in which it takes place.

Concerning the activity of water courses and water basins management, the problem of knowing and exploiting suspended load flows is particularly important. Suspended load is the main element that leads to clogging up the reservoirs, reducing the operational water reserves, and along with the growing vegetation, leads to eutrophication and erasing them from the functional circuit.

On the other hand, in the context of logical chaining of natural phenomena regarding cause-effect relationships, it is necessary to acknowledge direct and indirect implications, closer or further to the impact of human activities on the geographical environment.

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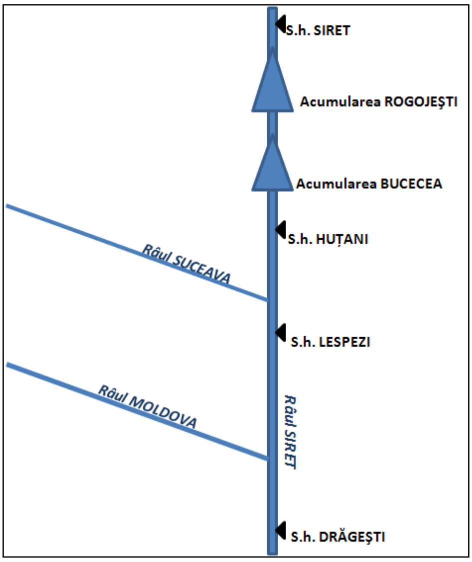


Fig. 1. Position of the hydrometrical stations on Siret river.

In 2010, an exceptional flood occurred on Siret River, with liquid flow rates so high that it exceeded the maximum values so far known in many of the monitoring sections (Siret, Huțani, Lespezi).

This paper presents several aspects concerning the conditions in which solid flows are formed and how they evolve, as well as maximum rates recorded during the 2010 flood on Siret River. The study area covers the Siret River flow from the Northern part of Moldavia, to Lespezi locality, which has a control section for this river, downstream of the confluence with Suceava River.

2. Database used. Working methods

The paper is based on long-term monitoring data, as well as on instantaneous data from hydrometrical stations on Siret River, North side of Moldavia (Siret, Huțani, Lespezi – Figure no. 1).

The database used can be found in the archives of the Hydrology Service from “SIRET” Water Branch Administration, and it contains:

-average multiannual suspended load flows;
-instantaneous liquid flows measured during the flood;
-instantaneous suspended load flows measured during the flood.

The average flows used concern a longer monitoring period (50-60 years) and offer an insight into Siret River suspended load transportation up until the year of 2010. The data are representative for the study area, taking into account that during this period the river flows have reached minimum values as well as historical highs.

Instantaneous values are obtained through measurements realized during the flood (27/06-12/08/2010) with the use of the current-meter and by getting samples of suspended load using special equipment. Where measurements were not possible at certain times of the flooding, flow values (liquid, solid) were correlated with limnimetrical keys from hydrometrical stations and other floods produced in the past, similar cases in terms of formation and evolution.

The processing of materials was realized by using Microsoft Excel, and a few diagrams resulted, very suggestive on the suspended load flow particularities for the study area on Siret River.

The statistical processing of the data on instantaneous values also allowed the realization of correlations of flows of suspended load according to the liquid flow.

3. Aspects regarding formation and suspended load flow in the study area

Control factors of suspended load flow are numerous and they are all in a continuous relationship. The liquid outflow can be considered the main and indispensable element of the formation and regime of the solid flow.

Precipitation and rainfall conditions in source areas, temperature, geological structure and composition (especially hardness and cohesion of rocks), altitude, massiveness, orientation and fragmentation of terrain, vegetation coverage (including forestry), use of land, existence of artificial lakes, intensity of gravel layer exploitation, are all of special importance.

The study area is located in the North-East side of Romania, and it overlaps Bucovina Hills and Moldavian Plateau. A very special role concerning suspended load transportation through this area is represented by the upper basin of Siret River, located in the North border of Romania and Ukraine. Considering these aspects, we find them as an indicator that there is a great variety of genetic factors for the liquid and solid suspended load flow.

As for the anthropogenic component, suspended load flow in the study area presents a series of particularities that need be mentioned:

- the presence of accumulation lakes (Rogojeşti, Bucecea) which have a very big influence in the multiannual suspended load flow regime; the above mentioned reservoirs have been put to use in 1970 – Ac. Bucecea and 1980 – Ac. Rogojeşti.

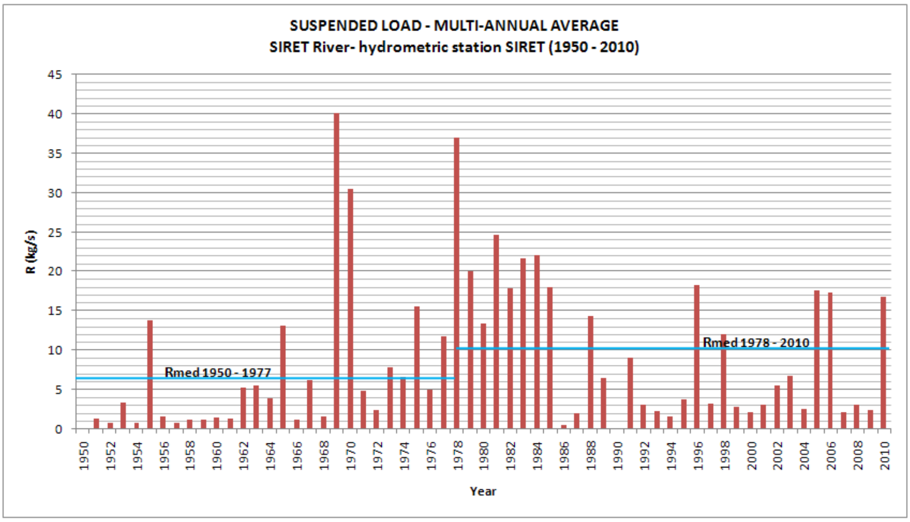
- the presence of a high number of gravel plants in Siret water meadow, in Suceava county.

Through statistical processing of multiannual average flow of suspended load from hydrometrical stations in study area (Siret, Huțani, Lespezi), we realized three diagrams that present multiannual values of suspended load flow, as well as a comparison between average values before and after Bucecea accumulation has been put to use.

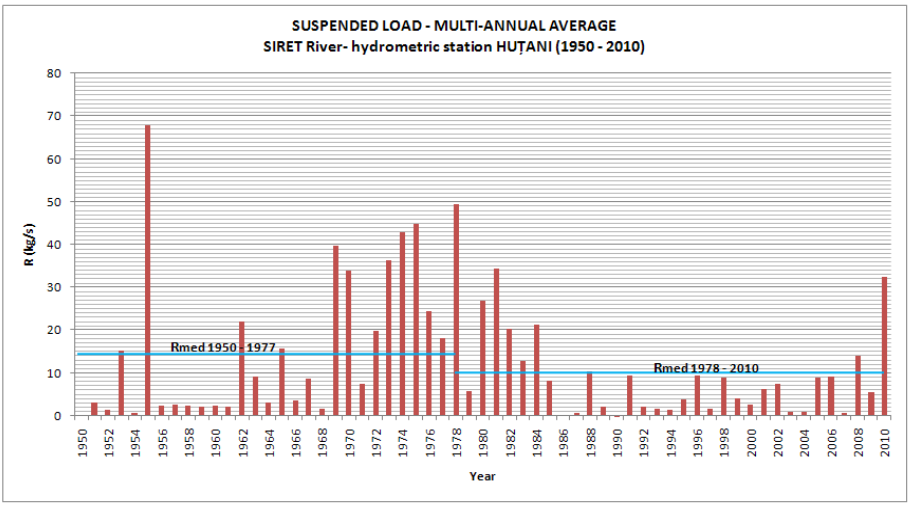
By analyzing the above presented graphics, one can observe that for hydrometrical stations located downstream from the lake complex Rogojeşti – Bucecea, there are lower values for the period after Bucecea accumulation has been put to use (1970). However comparing it to Huțani hydrometrical station, the difference is more obvious, yet for Lespezi hydrometrical station we can see a smaller difference which we can correlate with the suspended load flow recovery trend, downstream from accumulations, and also with the suspended load intake from Suceava River, whose confluence with Siret River is about 30 km upstream.

For Siret hydrometrical station, located upstream of the lake complex Rogojeşti – Bucecea, we can observe higher values of suspended load flow for the period after accumulation Bucecea has been put to use, in comparison with the other two stations located downstream.

What might have caused this could be the lack of a large accumulation in Ukraine able to hold some quantities of suspended load, but another cause could be the massive deforestation in Forested Carpathian Mountains. All this combined with climatic changes recorded in the last years, is having a noticeable influence on the suspended load flow on Siret River.



a.



b.

Fig. 2. Suspended load on Siret river.

Following the above presented graphics for Huțani and Lespezi one could also notice an enhancement of the suspended load flow in the last 15-20 years, a fact which may occur due to the anthropogenic impact (deforestation, poor agricultural work) and to the obvious climatic changes (more and more frequent periods of droughts followed by heavy rain).

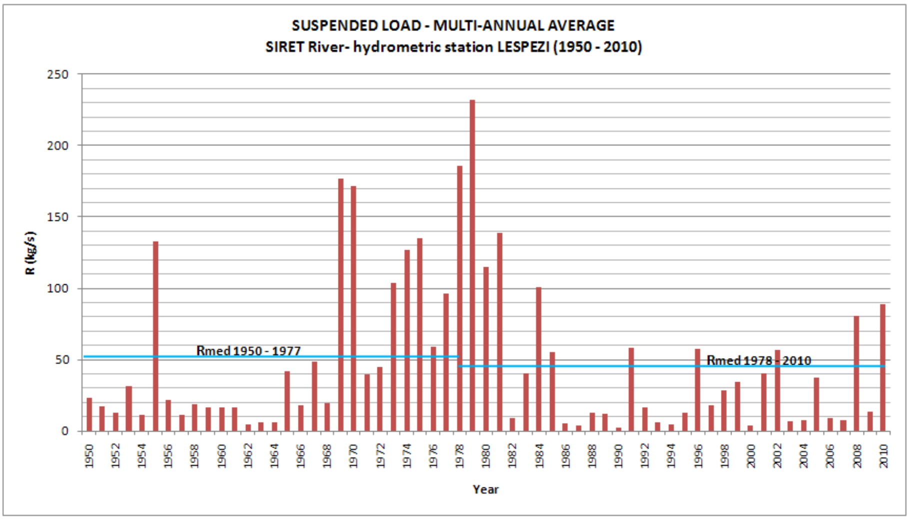


Fig. 3. Suspended load on Siret river.

4. Results. Discussions

The 2010 flood on Siret River was an exceptional flood with liquid flow rates so high that they exceeded the maximum values so far known in many of the monitoring sections (Siret, Huţani, Lespezi).

The suspended load flows produced during this flood were also uncommonly high on various sections of the river.

The flood was caused by the rainfall that occurred during this period: 29.06 – 01.07.2010.

The flood and the rainfall that produced it had been closely monitored. The table below (table 1) shows the most representative amounts of precipitation recorded during the period 29.06.2010 – 1.07.2010:

Table 1. Precipitations recorded during the period 29.06.2010 – 1.07.2010 in the study area.

No. crt.	***River***	***Hydrometrical Station***	***Precipitations (l/m^2)***
1	Siret	Siret	133,4
2		Zvoriştea	202,5
3	Suceava	Brodina	109,1
4		Ţibeni	209,7
5		Iţcani	32,8
6	Pozen	Horodnic	115,2
8	Soloneţ	Părhăuţi	120,3

The table presented above includes only data from hydrometrical stations which are considered to be representative for the study area, and which have had an impact on the suspended load flow on Siret River.

The highest flood values are presented below:

Table 2. Highest liquid flow recorded in the study area during the flood.

No. crt.	River	Hydrometrical station	First peak		Second peak	
			Q (m^3/s)	Date/Hour	Q (m^3/s)	Date/Hour
1	Siret	Siret	1115	29/13		
2		Zvorîştea	766	29-30/23-3		
3		Huțani	815	30/8-11		
4		Lespezi	1678	29/21-23	2049	1/5-8
5	Suceava	Brodina	151	29/4	136	30/15
6		Țibeni	973	29/8	747	30/20
7		Ițcani	883	29/3	1050	30-20
8	Soloneț	Părhăuți	346	29/0		

It is important to mention that a noticeable role in reducing flood waves in the upper section of Siret River was undertaken by the maneuvers conducted in Rogojeşti and Bucecea accumulations.

Through statistical processing of data gathered during the flood, correlations were made between the flow of suspended load (R) and the liquid flow (Q).

The form of the curves of these correlations can take the form of a loop when the reservoir presents favorable conditions for erosion development (lack of vegetation, easily eroded soil, large hillside slopes, etc.) or a unique curve when certain factors interfere (increased deforestation in the reservoir, accumulation lakes present downstream of monitoring section).

Analyzing the following charts (figure 4) one can see that for Siret hydrometrical station we have a unique curve due to the afflux phenomenon which takes place in the bottom section of Rogojeşti accumulation reducing the flood wave and preventing the development of a $R = f(Q)$ relationship in the form of a loop.

As for the hydrometrical stations Huțani and Lespezi correlations take the form of a loop with a maximum R in Q’s growth phase and a maximum Q in R’s decrease phase.

Maximum R registered in Huțani indicates the influence accumulations have when detaining a high quantity of suspended load (R max. Huțani= 2370 kg/s) compared to Siret hydrometrical station (R max. Siret= 6030 kg/s).

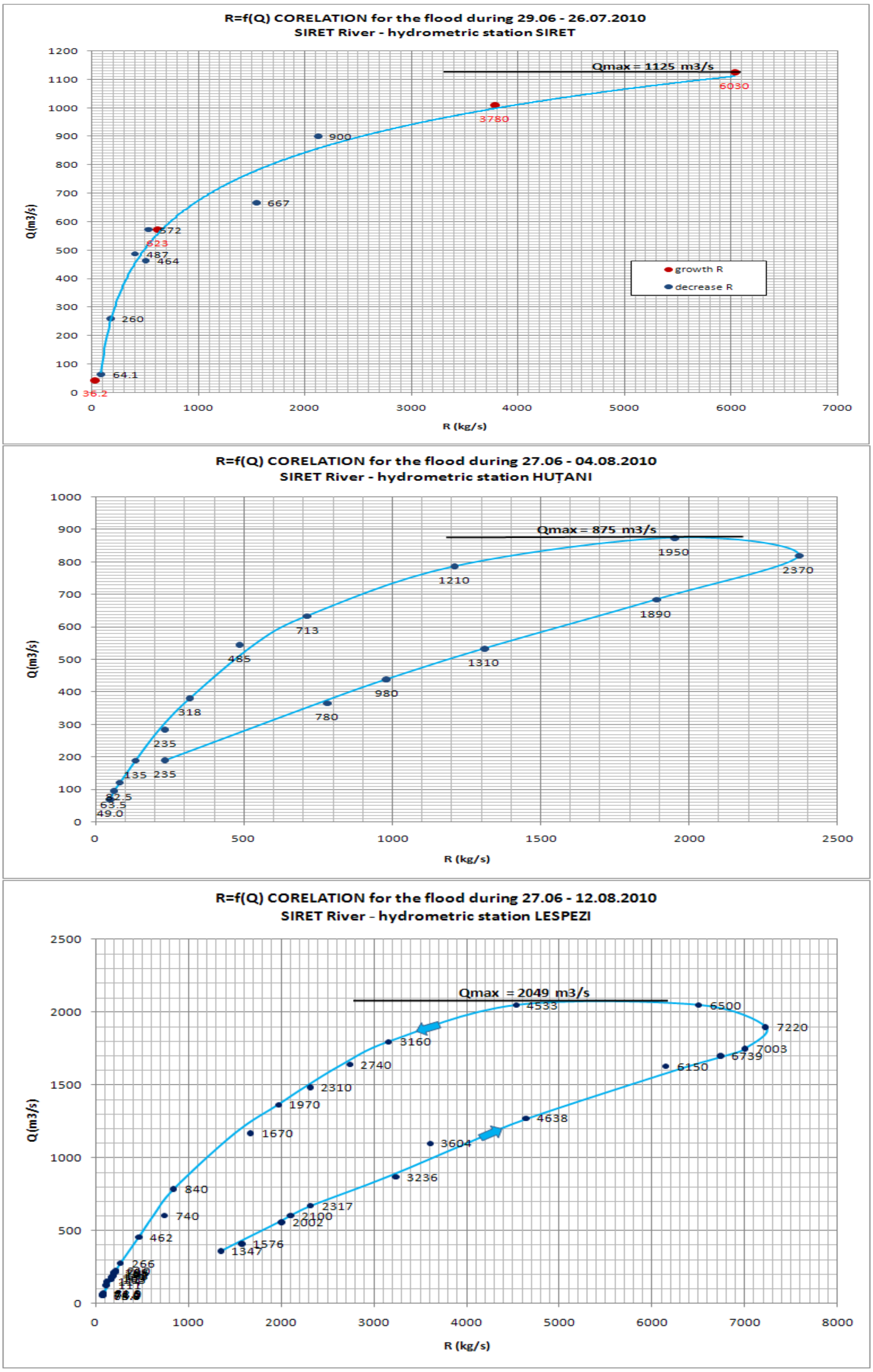


Fig. 4. R=f(Q) correlations for the flood on Siret river.

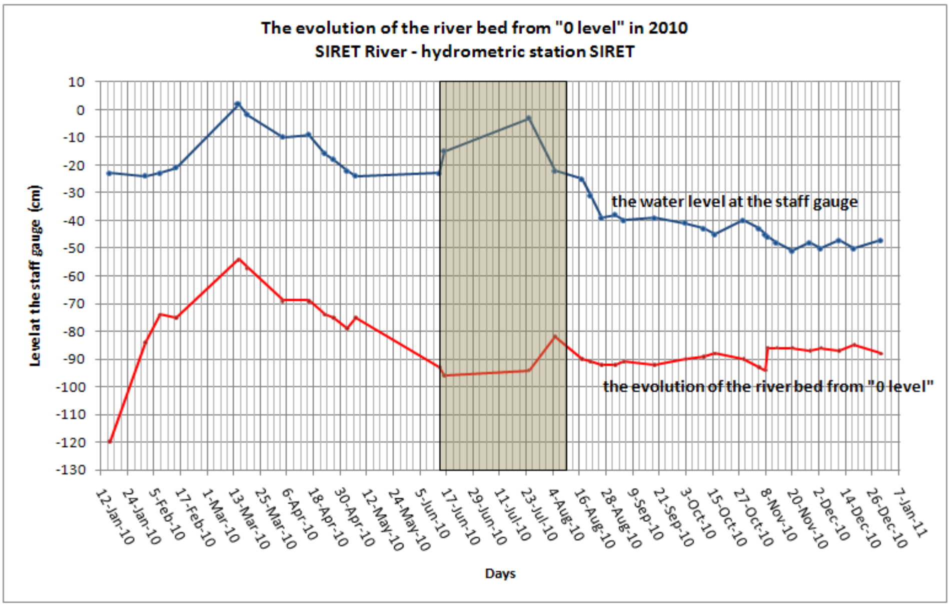


Fig. 5. The evolution of the Siret river bed in 2010.

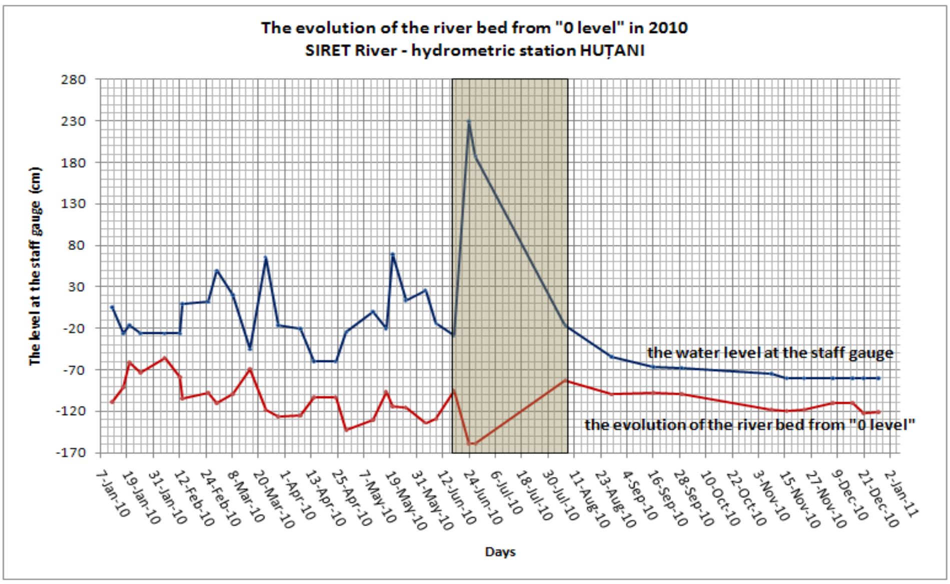


Fig. 6. The evolution of the Siret river bed in 2010.

In Lespezi hydrometrical station the charge of suspended load is recovered (R max. Lespezi= 7220 kg/s) because of the above mentioned characteristics (suspended load intake of Suceava). Yet, comparing the reception basin surfaces on Siret, and Lespezi respectively (B.s.Siret= 1637 km^2, B.s.Lespezi= 5888 km^2), we can notice a very big difference between the two stations. However, this difference cannot be seen in the flow of suspended load, having 6030 kg/s for Siret and 7220 kg/s for Lespezi, and this because significant suspended load quantities are detained in the accumulation lakes.

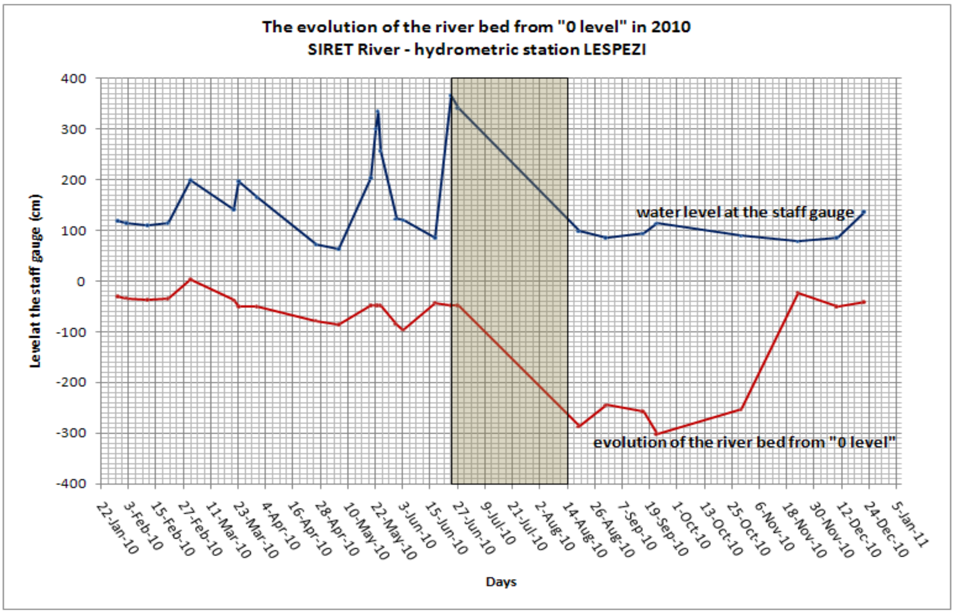


Fig. 7. The evolution of the Siret river bed in 2010.

For the analysis of Siret River suspended load flow, it is also very important to observe the evolution of the riverbed thalweg in the monitoring sections during the flood. This analysis was performed using flow charts in hydrological stations, charts in which maximum depth values, leveling rods, speed of water flow, etc., are recorded.

Some diagrams resulted from the statistical processing of data from these charts which indicate the evolution of the riverbed thalweg. So, after analyzing the graphics in figures 5,6 and 7, we can state the following:

- for Siret hydrometrical station we can see a rather stationary evolution of the thalweg during the flood, then followed by its growth during the decreasing phase of the water level. The slight tendency of the riverbed thalweg increase during the flood growth phase is assumed to the presence of Rogojeşti accumulation downstream, which attenuates the flood flow and also leads to the production of afflux phenomenon.

- for Huțani hydrometrical station the riverbed thalweg evolution is a typical one for a riverbed during the flood – depth in the growth phase and growth in the decrease phase of the flood. The riverbed thalweg growth in this hydrometrical station is also assumed to the immediate presence of a very big gravel plant upstream.

- the evolution tendency of the riverbed thalweg is of decrease in the case of Lespezi hydrometrical station. This uncommon thing happens in the monitoring section because there are extensive channel works for the Paşcani accumulation regulation, a reservoir which should be put to use the following two years. Thus, the riverbed is strongly affected by the activity of the equipment. During the flood there was a very strong washing off of the alluvial material, which had already been disturbed by the working equipment.

5. Conclusions

All previous studies, so far, have indicated that the problem of the sediment flow on water channels is as much as complex, as consequential.

The undergoing analysis made us observe that, as far as the study area is concerned, a noticeable influence is due to the anthropogenic impact on sediment flow. This is a consequence of the Rogojeşti – Bucecea lake complex presence, as well as of the impressive number of gravel plants in Siret meadow.

The highest flow recorded on Huțani and which is approximately 3 times smaller than the one on Siret, located upstream, offers a pretty clear view concerning the suspended load retention potential on the above mentioned lake complex.

The sudden deepening of the thalweg in the decrease phase of the flood on Huțani, as well as the one on Lespezi during the entire period of the flood, also prove that gravel plants and activities that take place in the stream (in Paşcani accumulation mostly) have a very strong influence on riverbed erosion and suspended load flow, and thus increasing these values.

Climate change marks, through obvious droughty periods, make water and suspended load flow rate to become more and more torrential, with strong implications in the sediment flow.

The powerful and irreversible anthropogenic impact on hydrographical network and landscape in reception reservoirs cause large imbalances (high erosion rate, frequent accumulation clogging, longer periods for gravel resources regeneration).

Considering the study area, we must take into account all these aspects, especially since the accumulation lakes mentioned here have an accelerated clogging rate, which might produce a negative effect on their capacity of efficiently reducing flood waves, and thus on their functionality.

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REFERENCES

Diaconu C., Şerban P. (1994), *Sinteze şi regionalizări hidrologice / Hydrological Synthesis and Regionalization*, Ed. Tehnica, Bucharest;

Olariu P. (1990), *Controlul producției de aluviuni în bazinul hidrografic Bistrița / Suspended load Production Control on Bistrita River*, Third Symposium on "Suspended load Origin and Effluence", Piatra Neamț;

Olariu P. (1997), *Gospodărirea tranzitului de aluviuni în spațiul hidrografic Siret / Suspended load Flow Management in Siret Hydrographical Area*, in vol. "Non-structural measures in water management", Ed. H.G.A. Bucharest;

Olariu P., Gheorghe D. (1998), *The Effects of Human Activity on Land Erosion and suspended Sediment Transport in the Siret Hydrographic Basin*, in vol. "Vegetation Land Use and Erosion Processes", Bucharest;

Olariu P., Vamanu E. (2001), *„La surveillance du transit des alluvions de l'espace hydrographique Siret"*, Geography Seminar „Dimitrie Cantemir", no. 19 –20, Iaşi;

Vladimirescu I (1978), *Hidrologie / Hydrology*, Ed. Didactică şi Pedagogică, Bucharest;

Pişotă I, Buta I. (1975), Hidrologie / *Hidrology*, Ed. Didactică şi Pedagogică, Bucharest;

Serviciul de Hidrologie – ABA „SIRET" Bacău (2010), *Raport tehnic privind producerea unor fenomene hidrologice periculoase pentru anul 2010 / Technical Report on the production of dangerous hydrological phenomena for 2010;*

Ujvari I. (1974), *Geografia Apelor României / Geography of Romanian Waters*, Ed. Tehnica, Bucharest.