SOME PARTICULARITIES OF RIVERS' HIGH FLOW PERIODS FROM SUCEAVA HYDROGRAPHIC BASIN

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ABSTRACT. – Some particularities of rivers' high flow periods from Suceava hydrographic basin. High flow periods represent an important phase in river's water regime. These periods are represented by high waters and floods. The most important and visible are the floods, because they may have negative effects when they reach water levels that threaten the human life and everything close to it. The analyse of these periods inside Suceava hydrographic basin was made using discharge and level data from the 9 stations inside the basin, 3 on the main river (Brodina 2, Țibeni and Ițcani), and 6 on the main tributaries (Brodina 2 – Brodina River, Putna – Putna River, Horodnic – Pozen River, Bădeuți – Sucevița River, Pârhăuți – Soloneț River, and Șcheia – Șcheia River).These data were processed using programs such as Microsoft Excel and CAVIS, that gave us a better look over the particularities of high flow periods in this basin. The results bring into attention some rivers that need to be better controlled to prevent further floods and their effects.

Keywords: Flood, flooding, high waters, Suceava basin, water levels.

1. INTRODUCTION

The maximum flow represents one of the water regime phase. Knowing the maximum flow values is important for hydro technical constructions exploitation and for other defences against flooding, and also for its role in floods effects reduction (Sorocovschi, V., 2002).

This paper represents an analyse of high flow periods (floods and high waters) over an average period of 16 years (See Table 1) from the rivers from Suceava River Basin. The analysed data are taken from SGA Bacău, for 9 stations inside the basin, 3 on the main river (Brodina 2, Țibeni and Ițcani), and 6 on the most important tributaries (Brodina 2 – Brodina River, Putna – Putna River, Horodnic – Pozen River, Bădeuți – Sucevița River, Pârhăuți – Soloneț River, and Șcheia – Șcheia River).

Using programs like Microsoft Excel and CAVIS, we analysed and calculated hydrograph's elements, such as maximum discharges, seasonal and monthly discharges, total, increasing and decreasing times, etc. Also, using these programs, we obtained high

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water diagrams (Excel) and floods hydrographs (CAVIS) (see, Corbus, 2010), and used them to show the evolution in time of floods and high waters.

Table 1. ***Hydrological stations from Suceava river basin***

River	Station	Analyzed period	F (km^2)	Hm (m)	Q_m (m^3/s)
Suceava	**Brodina 2**	1981-2003	366	990	4,30
Suceava	**Tibeni**	1981-2003	1288	730	12,05
Suceava	**Iţcani**	1987-2003	2334	629	16,990
Brodina	**Brodina 1**	1973-2003	142	989	1,715
Putna	**Putna**	1973-2003	53	847	0,631
Pozen	**Horodnic**	1973-2003	67	488	0,533
Soloneţ	**Pârhăuţi**	1987-2003	204	467	1,250
Scheia	**Scheia**	1973-2003	33	388	0,163
Suceviţa	**Bădeuţi**	1981-2003	-	-	-

The Suceava River Basin has a surface of 2616 km^2, from which 13% belong to the Ukrainian territory (340 km^2). On the Romanian territory, it ranges between 47° 31'and 47° 59' N, and 25° 05' and 26° 33' E. The basin's limits are represented by basin's watershed, except for the northern limit, which is represented by the Romania – Ukraine Border. In west its neighbours are the Bistriţa and Moldova basins, in south - Moldova, Şomuzul Mare and Şomuzul Mic basins, and at east – Siret River Basin (Barbu, 1987).

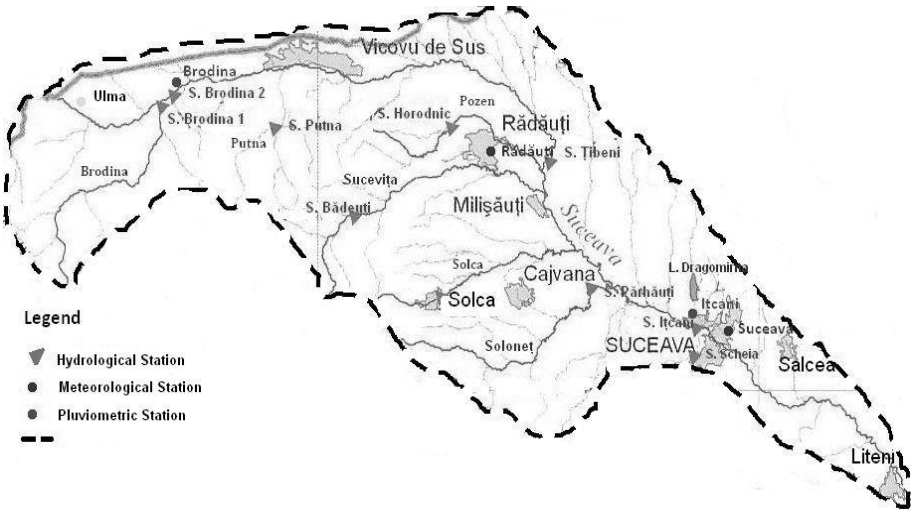

Fig. 1. ***Hydrological, meteorological and pluviometric stations from Suceava river basin (reworked after Cocerhan, 2012)***

The monthly and annual average rainfalls values registered at basin's meteorogical station (Rădăuți, Suceava) and pluviometric posts (Brodina, Ițcani) (Fig. 1) presents an irregular distribution, with increasing values (Ițcani – 570,24 mm, Brodina – 828,24 mm)from the plateau area (lower basin) to the basin's upper, mountainous sector (from north - west). The most rainy years registered in the period 1970 – 2010 at the basin's meteorological stations and posts were 1970 (upper basin), 1974 (lower basin), 1978 (entire basin), 1981 (Suceava and Brodina stations), 1989 (Brodina Station), 1991 (entire basin), 1995, 1996 (Brodina Station), 2001 (Brodina and Rădăuți stations), 2005, 2006, 2008, 2010 (entire basin).

2. SOME PARTICULARITIES OF FLOODS AND HIGH WATERS FROM SUCEAVA RIVER BASIN

The flood represents the significant increase and decrease of flow values in a river basin (Mustățea, 2005). Usually, the increase time is shorter than the decreasing one.

Flood waves are characterised by some elements: flood duration (total time - Tt, increasing time - Tc, decreasing time - Td), flood volume (total - Wt, increasing - Wc, decreasing volume - Wd), maximum discharge (Qmax), maximum runoff (q_{max}), depth of surface runoff (h_v), shape coefficient of the hydrographs surface (Gamma), etc..

Floods can be analysed using many criteria, such as: genesis (triggered by rainfalls, snowmelts, glaciers, mixed, accidents), hydrographs form and forming conditions (with one peak, with more peaks), duration, location (riverine, estuarine, costal, urban), recurrence period, etc.

High waters represent the flow phase when the daily, ten-day or even monthly values are high, exceeding the multiannual average discharge values (Sorocovschi, 2002). They appear especially after periods of slow snow melting, long low intensity rainfalls, or the combination of the two.

The factors that intensify floods can be separated in three categories: basin's characteristics, river network characteristics and river bed characteristics. The most important are basin's surface and form, which correlated with the network's disposing, can affect the flood volume and duration. The soil's water storage capacity can also affect the floods duration and amplitude. The river network framing influences the floods formation and evolution.

The most important particularities of these high flow periods are: their frequency, duration and intensity.

2.1. Frequency

High flow period inside Suceava River Basin varies between 5 (May - September) at Brodina 2 Station (from the upper mountainous basin sector) 8

months (March - October) at Ițcani, Horodnic and Bădeuți stations. At the other stations, this period lasts 5 – 6 months.

The margins of these intervals generally overlay on the high waters periods, caused by quick snow melts. Sometimes, also appear on these periods high floods that cause flooding (especially during spring time at Brodina 1, Brodina 2 and Putna stations).

These periods from Suceava River Basin concentrate especially in summer months – June and July (at all stations) (Table 2). In these months, the percentage values exceed 25% from the multiannual values. The highest values (above 30%) appear in June at Țibeni (32,65%) and Brodina 1 stations (37,04%), and July at Brodina 2 (32,35%) and Pârhăuți stations (30,56%). High values (above 20%) appear in these months, too - May (Putna Station– 22,58%) and September (Ițcani Station – 21,62%). These months present the highest flow values after June and July.

Table 2. ***Flood's monthly frequency at the stations from Suceava river basin (%)***

River	Station	Month											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Suceava	**Brodina 2**	0.0	0.0	0.0	0.00	11.76	26.47	**32.35**	11.76	17.65	0.0	0.0	0.0
Suceava	**Țibeni**	0.0	0.0	0.0	6.12	14.29	**32.65**	20.41	8.16	18.37	0.0	0.0	0.0
Suceava	**Ițcani**	0.0	0.0	2.70	5.41	10.81	21.62	**27.03**	8.11	21.62	2.703	0.0	0.0
Brodina	**Brodina 1**	0.0	0.0	0.0	3.70	12.96	**37.04**	20.37	11.11	14.81	0.0	0.0	0.0
Putna	**Putna**	0.0	0.0	0.00	4.84	22.58	**29.03**	20.97	11.29	11.29	0.0	0.0	0.0
Pozen	**Horodnic**	0.0	0.0	6.15	12.31	16.92	**26.15**	18.46	7.69	9.231	3.077	0.0	0.0
Suceviţa	**Bădeuţi**	0.0	0.0	2.78	19.44	5.56	19.44	**25.00**	11.11	13.89	2.778	0.0	0.0
Soloneţ	**Pârhăuţi**	0.0	0.0	2.78	2.78	16.67	19.44	**30.56**	8.33	19.44	0.0	0.0	0.0
Şcheia	**Şcheia**	0.0	0.0	5.13	7.69	15.38	**28.21**	25.64	12.82	5.128	0.0	0.0	0.0

The other months present low percentage values, hardly exceeding 10% (exception - Bădeuți Station on Sucevița River – 19,44 % in April).

Values between 0 and 6% appear between October and March, when the flow is very low in the entire basin. Higher values appear only in October and March at the stations from the middle and lower Suceava River Basin (Ițcani, Horodnic, Bădeuți, Pârhăuți, Şcheia). This thing is determined by the much faster snow melting in the plateau than in the mountainous area, where the snow melts appear later in April.

At seasonal level, summer represents the season with the highest values, slightly below 60% at all stations from Suceava Plateau, followed by spring (Fig. 2). This thing is caused high intensity frontal rainfalls that fall during this time of the years.

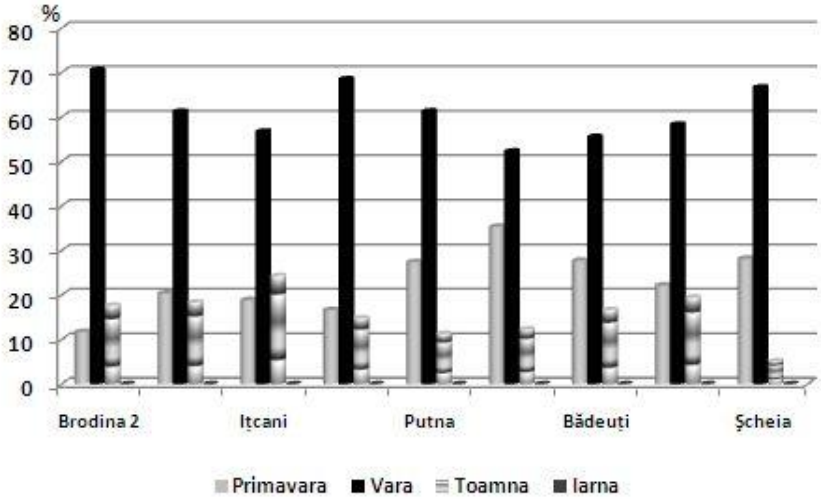

Fig. 2. Seasonal maximum flow percentage variation from Suceava river basin

In the opposite place is situated winter, with 0%, which shows how low the flow is during winter time, due to very low air temperatures and long period water freezing.

2.2. Duration

The floods duration is represented by the floods time characteristics: total, increase and decrease time. These values make the difference between a flood and high water period. When the total time becomes too big, there appear high waters.

The duration of high waters may vary between a few days to almost a month (Fig. 3). Sometimes, the floods from the basin overlap on these high waters, especially at the beginning of spring (March – April) and at the beginning of autumn (August – September), determining higher values for total flood time and volume.

The total flood time from Suceava Basin varies from a station to another. At the mountainous stations, the total time tends to be shorter than at the plateau stations, showing the faster passing of water in these areas. In the upper basin section, the average values are: increase time - 12 hours, decrease time -120 hours, total time - 132 hours. In the middle and lower basin section, these values increase, with an average of: increase time - 50 hours, decrease time -105 hours, total time - 155 hours.

The total flood time may increase also if we have floods with two or more peaks. In these cases, the total time summarises the total times of the individual floods.

In Fig. 3 we present some examples of flood and high water hydrographs from Suceava river basin that present floods from upper and middle basin, high waters and a flood with multiple peaks.

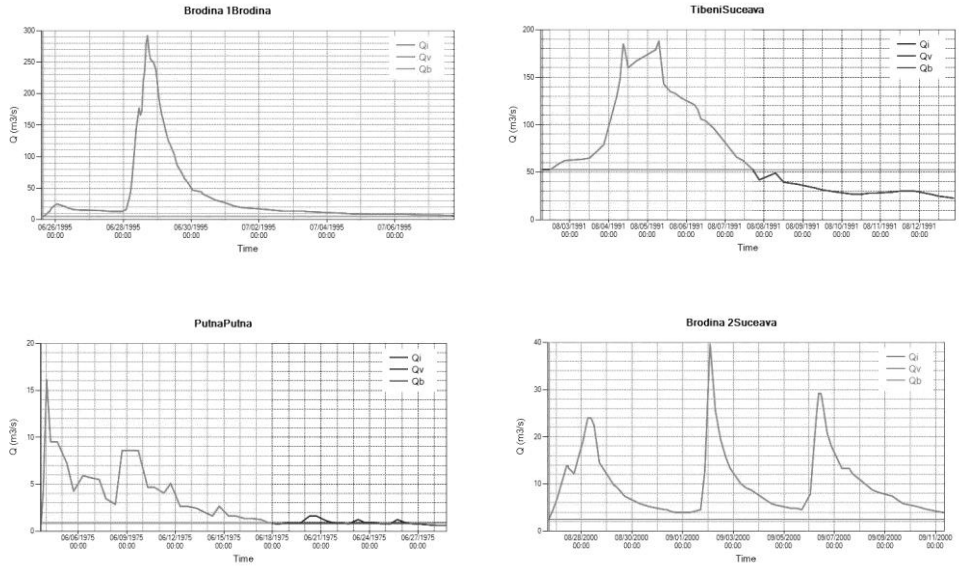

Fig. 3. ***Examples of floods hydrographs from Suceava River Basin (upper basin flood, middle basin flood, high waters, multiple peaks flood)***

2.3. Intensity

The floods intensity is determined by the combination of the values of floods increasing time, maximum discharge and the water levels they reach or exceed, and by their effects (flooding, etc.).

When these values reach their highest, we get the biggest intensity. It is not enough that the time to be short, the discharge values must be great and the water levels be high.

When the discharge and level values are not extremely high, but the total time is big, we obtain a high intensity high water.

To analyse the intensity of floods and their destructiveness, we must look at the water levels they reach. These water levels are represented by: safety, flooding and danger levels. They are different from a river to another, according to their basin surface, river bed size, local aspects, etc.

As seen in Table 4, some rivers from Suceava hydrographic basin have not registered in the analysed period floods that exceeded these levels (Iţcani and Horodnic). Some reached only the safety levels, at Brodina 2 (on Suceava River), Putna (on Putna River) and Şcheia (on Şcheia River) stations. This means that these rivers do not present a real danger for flooding, reaching only lower water

levels. A special attention must be set to Putna Station, where safety levels have 74,19 % from the total values. That means that in this mountainous area there may appear one day cases of high floods.

Table 4. ***Frequency of floods that defense (DL), flooding (FL) and danger level (DL) (% of cases)***

River	Hydrometric Station	SL	FL	DL
Suceava	**Brodina 2**	**10.53**	2.63	0.00
Suceava	**Țibeni**	6.12	**34.69**	**59.18**
Suceava	**Iețcani**	1.00	1.00	0.00
Brodina	**Brodina 1**	**29.85**	**20.90**	**29.85**
Putna	**Putna**	**74.19**	1.61	1.61
Pozen	**Horodnic**	3.08	0.00	4.62
Soloneț	**Părhăuți**	**22.22**	**33.33**	**44.44**
Şcheia	**Şcheia**	**43.59**	5.13	0.00

The stations with the highest level percentages are Țibeni on Suceava River (34,69% FE and 59,18% DE), Brodina 1 on Brodina River (at all three levels, the values vary between 20 – 30%), and Părhăuți on Soloneț River (with increasing values at all elevations, getting close to 50% for danger levels). This means that at this stations appears the highest flooding risk, such as seen in the flooding from June 1995 Brodina River, July 2008 and June 2010 on all rivers, when historical levels have been reached in the entire basin.

3. CONCLUSIONS

The floods from the Suceava River Basin maintain the characteristics of the eastern Carpathian and Peri-Carpathian water regime, with very low and low winter flow, and high flow values during summer. Also in spring and autumn, floods are rarer than in summer, they can produce flash floods of high intensity, especially during high waters period.

After analysing the floods, it can be observed that some station separate from the others, with a high frequency of flooding and danger levels exceed. These stations and their surroundings (Brodina 1, Țibeni and Părhăuți) are the more vulnerable to flooding with high effects on humans, being areas with a large number of inhabitants and many kettles and agricultural crops. These are the places (situated especially at the border between mountainous and plateau areas) from the basin where the authorities must the highest efforts in flood control and damage reduction. Without proper measures, flash floods like those from 1995, 2008 and 2010 (Anghel, 2010) will appear again.

Acknowledgements

This paper is a result of a research made possible by the financial support of the Sectoral Operational Program for Human Resources Development 2007-2013, co-financed by the European Social Fund, under the project POSDRU/159/1.5/S/132400 - "Young successful researchers – professional development in an international and interdisciplinary environment".

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