# FLOOD WAVES PARAMETERS – A COMPARATIVE ANALYSIS BETWEEN GALBENU AND TELEORMAN RIVERS

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**ABSTRACT. – Flood waves parameters – a comparative analysis between Galbenu and Teleorman Rivers.** The present study aims to be a comparative analysis of the main characteristics of flood waves from Galbenu River (located in the Gilort hydrographic basin) and Teleorman River (from Vedea hydrographic basin). Starting from the approximately the same multi-annual medium discharge (computed for the interval 1998-2007), the analysis is focused on the accentuation and explanation of the differences, dictated by the geographical position, relief characteristics (specially the slope), climate, size of the basin, length of the watercourse etc.

**Keywords**: duration, peak runoff, volume, shape coefficient, depth of the runoff, Galbenu River, Teleorman River.

## 1. INTRODUCTION

Galbenu River, also known with the names of Baia or Galben is the first important confluent of the Gilort on the left side, whose hydrographic basin is located entirely on Gorj county territory.

The Galbenu watercourse length is 32 km and the hydrographic basin has an average altitude of 1,230 m; this one totalizes a surface of 112 km$^2$. The studied basin is developed in altitude between 1,900 m (in the spring area, from Parâng massif) and 328 m (at the confluence with Gilort River, on the territory of Bălceşti locality).

Teleorman in the main confluent on the left side of Vedea River; the river has a total watercourse length of 169 km and a basin surface of 1,427 km$^2$. This river's hydrographic basin has as extreme altitudes the values of 390 m in the spring area (in the hilly region near Slătioara locality) and 29 m (at the confluence with Vedea River, on the territory of Ştorobăneasa commune).

For the present study were processed data coming from 2 hydrometric stations located on those 2 rivers, respectively Baia de Fier (Galbenu River) and Tătărăştii de Sus (Teleorman River) for a common period of running covering the interval 1998-2007 (10 years). For this studied interval were identified 20 flood cases at the hydrometric station from Galbenu River and 17 at the one from Teleorman.

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**Table 1.** ***Hydrographic basin parameters***

| River | Hydrometric station | Hydrographic basin parameters: | | | | | |
|---|---|---|---|---|---|---|---|
| | | at river level | | | at hydrometric station level | | |
| | | S ($km^2$) | L (km) | Mean alt. (m) | S ($km^2$) | L (km) | Mean alt. (m) |
| Galbenu | Baia de Fier | 112 | 32 | 923 | 57 | 26 | 1,230 |
| Teleorman | Tătărăştii de Sus | 1,427 | 169 | 148 | 415 | 71 | 242 |

For all the analyzed characteristics, the main procedure performed was the flood hydrograph delimitation, in order to identify the base flow. The operation assumes the identification of the inflexion points from the ascending and descending branches of the hydrograph. A major problem was the identification of the appropriate point from the descending branch; that step consisted in the correlation of the flood total duration with the river length or with the mean altitude and basin surface (Pandi, 2010).

The one exception from this procedure was made in the case of the paek discharges, which were handled including in the computations the base flow.

## 2. FLOODS DURATION

***<u>Total duration</u>*** of the floods is computed by summing up the rise period (or periods) and decrease period (or periods). For interpretation, at the 2 hydrometric stations analyzed floods were distributed in 5 categories, according to the resulted values, comprised between 0-24 hours and over 96 hours.

**Table 2.** ***Floods total duration (1998-2007)***

| Hydrometric station | No. of cases with total time (in hours) of: | | | | |
|---|---|---|---|---|---|
| | 0-24 | 25-48 | 49-72 | 73-96 | > 96 |
| Baia de Fier | 3 | 3 | 4 | 5 | 5 |
| Tătărăştii de Sus | 0 | 2 | 4 | 1 | 10 |

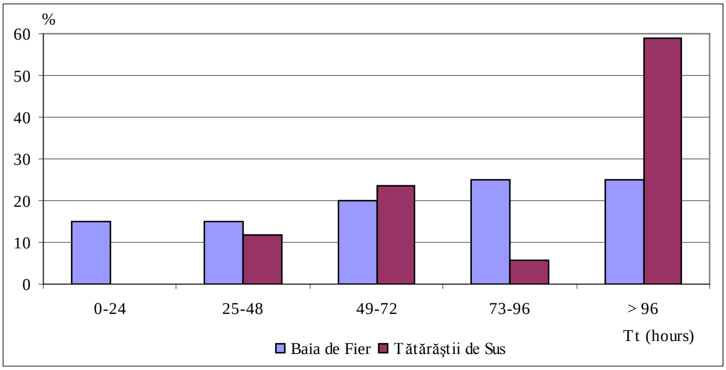


**Fig. 1.** ***Floods total duration (1998-2007 – in % from total)***

From the analysis of the data series referring to this parameter are resulting major differences between the 2 analyzed basins, at Tătărăştii de Sus hydrometric station prevailing visibly (50% of the total number of cases) the floods with a total duration of over 96 hours, while at Baia de Fier hydrometric station the 5 value classes taken into account have relatively equilibrated rates. Also, it was determined in the case of the hydrometric station from Teleorman River the lack of floods with a total time smaller than 24 hours (Table 2 and Fig. 1).

As extreme values from this point of view for the analyzed interval are highlighted as the longest floods the one from the interval 21-27 October 2003, (recorded at Baia de Fier – 149 hours), respectively the one from the period 16-26 January 2006 (at Tătărăştii de Sus – 239 hours). Regarding the floods with the shortest durations, at Baia de Fier it is the one from 11-12 July 2005 (15 hours), and at la Tătărăştii de Sus the one from 13-14 April 2006, with a total time summing up 30 hours.

***The increase duration*** for the analyzed period (Table 3 and Fig. 2.) varies between 4 hours and 45 minutes (flood from the interval 11-12 July 2005) and 56 hours (for the flood from the period 21-27 October 2003) in the case of Baia de Fier hydrometric station. Regarding Tătărăştii de Sus, the values of this parameter reached the extremes of 7 hours (flood from the interval 3-6 July 2005), respectively 68 hours (in the case of the flood from 10-15 January 1999).

**Table 3.** ***Floods increase duration (1998-2007)***

| Hydrometric station | No. of cases with increase time (in hours) of: | | | | |
|---|---|---|---|---|---|
| | 0-6 | 7-12 | 13-24 | 25-48 | > 48 |
| Baia de Fier | 1 | 7 | 7 | 4 | 1 |
| Tătărăştii de Sus | 0 | 3 | 5 | 5 | 4 |

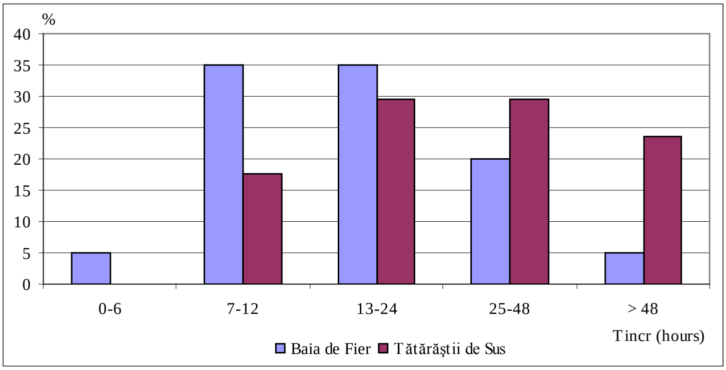


**Fig. 2.** ***Floods increase duration (1998-2007 – in % from total)***

A comparative analysis between the 2 hydrometric stations shows the lack of the category 0-6 hours at Tătărăştii de Sus, balanced by the high number of floods with increase duration higher than 48 hours. In percentages, in the case of Baia de Fier hydrometric station, the floods with an increase time between 7 and 24 hours have the highest value (70% from the total), and at Tătărăştii de Sus the ones with rates of this parameter comprised between 13-48 hours (58.8%).

Synthesizing the data regarding the floods duration, we can conclude that the total one has a mean value of 75 hours at Baia de Fier and 103 hours at Tătărăştii de Sus; the increase time reaches the value of approximately 21 hours at the station from Galbenu River and near 32 hours at the one from Teleorman River.

## 3. PEAK DISCHARGES

Peak discharges reached during the floods depend on various factors, the most important being: basin surface, particularities of the litho-edaphic substratum, vegetation cover and particularities of the vegetal associations, terrain and watercourses slope, presence of lakes or swamp areas etc.

The highest peak discharges (maxim maximorum) reached at the studied hydrometric stations (Table 4) are 72.3 $m^3/s$ at Baia de Fier hydrometric station (peak discharge recorded during the flood from the period 21-22 June 1999) and 88.4 $m^3/s$ at Tătărăştii de Sus, during the flood from the interval 20-25 September 2005 (figure 3).

**Table 4.** ***Absolute peak discharge, mean peak discharge, medium specific peak discharge and peak discharge power - 1998-2007 (after Minoniu, 2011; Toma, 2011)***

| Hydrometric station | $Q_{max}$ ($m^3/s$)/ *occurrence date* | $\overline{Q}_{max}$ ($m^3/s$) | $\overline{q}_{max}$ ($l/s.km^2$) | *A* |
|---|---|---|---|---|
| Baia de Fier | 72.3 – 22.06.1999 | 21.3 | 373.5 | 2.82 |
| Tătărăştii de Sus | 88.4 – 22.09.2005 | 27.8 | 69.5 | 1.39 |

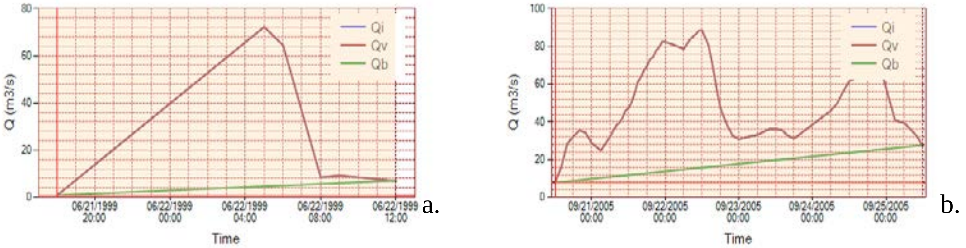


**Fig. 3.** ***Flood hydrographs form the interval 21-22 June 1999 at Baia de Fier (a) and 20-25 September 2005 at Tătărăştii de Sus (b)***

Regarding the mean peak discharge, it is obvious the fact that this one augments directly proportional with catchments surface.

On the maximum specific peak discharge base it was possible to determine the mean maximum specific peak discharge. By analyzing the obtained values it was determined that the general trend is the diminution of this parameter's value along with the augmentation of the catchment's surface.

The A parameter (also known as peak discharge power, flood power coefficient or Myer-Coutagne-Pardé coefficient) is given by the formula (Gob et al., 2003, Amat et al., 2008):

$$A = \frac{Q_{\max}}{\sqrt{F}}$$ , where:

- $Q_{max}$ – peak discharge;
- $F$ – basin surface.

Studying the values of A parameter, it was determined that those ones are situated in the frame of the normal values for the region where are located the 2 compared hydrographic basins, under 10. The highest annual values of this parameter were 9.58 at Baia de Fier hydrometric station (22 June 1999), respectively 4.42 at Tătărăştii de Sus (22 September 2005).

Hereinafter, were computed the peak discharges with different occurrence probabilities and the $C_s$ and $C_v$ parameters (Table 5). In order to perform this step, the data set was extended from 10 to 26 years (taking into consideration the fact that Baia de Fier hydrometric station was functional since 1982 and Tătărăştii de Sus since 1964).

The peak discharge with 1% occurrence probability has the value 78.4 $m^3/s$ at Baia de Fier hydrometric station and 224 $m^3/s$ at Tătărăştii de Sus hydrometric station, this parameter recording a growing trend directly proportional to the catchment's surface.

**Table 5.** ***Distribution curves parameters and peak discharges with different occurrence probabilities - 1982-2007 (after Minoniu, 2011; Toma, 2011)***

| River | Hydrometric station | $\overline{Q}_{\max}$ ($m^3/s$) | $C_v$ | Peak discharges with different occurrence probabilities ($m^3/s$) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.1 | 1 | 3 | 5 | 10 |
| Galben | Baia de Fier | 12.4 | 1.14 | 144 | 78.4 | 52.3 | 41.4 | 26.6 |
| Teleorman | Tătărăştii de Sus | 44.0 | 0.96 | 292 | 224 | 170 | 144 | 109 |

In order to compute the specific peak discharges ($q_{max}$), with different occurrence probabilities the values of the peak discharges with the same occurrence probabilities were related to the catchments surface (Table 6).

The values reached by the specific peak discharge with 1% occurrence probability are 1,156 $l/s.km^2$, at Baia de Fier hydrometric station, respectively 288 $l/s.km^2$ at Tătărăştii de Sus. The trend, strongly delineated as a matter of fact, is that this parameter's values are diminishing as the catchments surface grows.

**Table 6.** ***Distribution curves parameters and specific peak discharges with different occurrence probabilities - 1998-2007 (after Minoniu, 2011; Toma, 2011)***

| River | Hydrometric station | S ($km^2$) | $\overline{q}_{\max}$ (*$l/s.km^2$*) | Specific peak discharges with different occurrence probabilities ($l/s.km^2$) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.1 | 1 | 3 | 5 | 10 |
| Galben | Baia de Fier | 57 | 373.5 | 2,526 | 1,375 | 918 | 726 | 467 |
| Teleorman | Tătărăştii de Sus | 415 | 69.5 | 704 | 540 | 410 | 347 | 263 |

## 4. SHAPE COEFFICIENT AND DEPTH OF RUNOFF

Knowing the maximum volumes, it is possible to calculate the shape coefficient of the flood hydrograph, by comparing, in other words, the flood hydrograph surface to the surface of the rectangle that circumscribes it. This parameter has values between 0 and 1; in the present case, the obtained values were 0.39 for Baia de Fier hydrometric station and 0.31 for Tătărăştii de Sus. The differences are given by the higher value obtained for the total time at the station from Teleorman River, with the hydrographic basin developed in a plain region (Romanian Plain), while Galbenu hydrographic basin covers a mountain and hilly area (Parâng Massif and Subcarpathes).

In this context was also computed the medium depth of runoff, expressed in mm. It was observed that higher values of this parameter show up in the areas with more accentuated slopes, which favors the runoff, depending also on the degree of vegetation coverage and its composition (predominant species, their characteristics, density etc.) and on the soil type particularities.

Both shape coefficient and depth of the runoff were calculated as total values, for the whole amount of water transported in the analyzed interval during the flood event ($\gamma$ and $h_s$) and using the flood hydrograph delimitation method, (influencing the volume) – $\gamma_v$ and $h_{sv}$ (Table 7).

**Table 7.** ***Values for the shape coefficient and the depth of runoff - 1998-2007 (after Minoniu, 2011; Toma, 2011)***

| River | Hydrometric station | $\gamma$ | $h_s$ (mm) | $\gamma_v$ | $h_{sv}$ (mm) |
|---|---|---|---|---|---|
| Galben | Baia de Fier | 0.43 | 28.5 | 0.31 | 17.4 |
| Teleorman | Tătărăştii de Sus | 0.50 | 10.3 | 0.39 | 7.22 |

## 5. FLOODS VOLUME

In order to calculate floods volume for the analyzed hydrographic basins were selected the data sets for the most important 2 flood events from each year included in the analyzed interval; the goal consisted in the identification of the total volume leaded through the river bed during the flood manifestation.

A next step consisted in the delimitation of the base flow and of the volume associated and their omission from computations. In order to perform these operations was used CAVIS program (*CAracterizarea VIiturilor Singulare* – Singular Floods Characterization), version 1.0 (Corbuş, 2010), program created at INHGA (National Institute of Hydrology and Water Management), Bucharest. Were obtained floods volumes with mean values between 0.990 mil. $m^3$ at Baia de Fier hydrometric station and 2.99 mil. $m^3$ at Tătărăştii de Sus hydrometric station, this parameter revealing a directly proportional growth with the catchment's surface.

**Table 8.** ***Floods absolute maximum and minimum volumes and floods mean volume 1998-2007 (after Minoniu, 2011; Toma, 2011)***

| River | Hydrometric station | Mean volume (mil. m$^3$) | Absolute maximum volume (mil.m$^3$) | | Absolute minimum volume (mil.m$^3$) | |
|---|---|---|---|---|---|---|
| | | | vol. | period | vol. | period |
| Galben | Baia de Fier | 0.990 | 2.13 | 22-26.10.2007 | 0.122 | 11-13.09.2003 |
| Teleorman | Tătărăştii de Sus | 2.99 | 13.7 | 20-25.09.2005 | 0.220 | 28-30.03.2001 |

Next were calculated the floods volumes from the studied basins with different occurrence probabilities, the volume with 1% occurrence probability ($W_{1\%}$) reaching values between 2.99 mil. m$^3$ at Baia de Fier hydrometric station and 17.1 mil.m$^3$ at Tătărăştii de Sus (Table 9). In the computations, due to the mixed origin of the floods in both cases, it was adopted an asymmetry coefficient $C_s=3C_v$ (Mociorniţă et al., 1979, quoted by Drobot, 1997).

**Table 9.** ***Floods volumes with different occurrence probabilities - 1998-2007 (after Minoniu, 2011; Toma, 2011)***

| River | Hydrometric station | Floods volumes with different occurrence probabilities (mil. m$^3$) | | | | |
|---|---|---|---|---|---|---|
| | | 0.1 | 1 | 3 | 5 | 10 |
| Galben | Baia de Fier | 5.38 | 3.37 | 2.48 | 2.08 | 1.54 |
| Teleorman | Tătărăştii de Sus | 30.9 | 18.6 | 13.3 | 11.0 | 7.86 |

## 6. DISCUSSIONS AND CONCLUSIONS

Regarding the flood waves parameters are highlighted the following aspects: the total and increase durations, with higher values at Tătărăştii de Sus, show the dependence of this parameter mainly on the mean altitude of the hydrographic basin and slopes of the basin and of the water course. The whole hydrographic basin of Galbenu River has a mean altitude of 923 m, the mean altitude for Baia de Fier hydrometric station 1,240 m and a slope of the water course reaching 49 ‰, while Teleorman River has a mean altitude of the basin of 148 m, the mean altitude for Tătărăştii de Sus hydrometric station of 242 m and a mean slope of the watercourse of 2 ‰.

The peak discharges recorded at the 2 analyzed hydrometric stations reached comparable results of the absolute and mean values of this parameter; this fact is explainable by the fact that the larger basin surface of the Teleorman River is counterbalanced by the different rainfall amount in the 2 analyzed basins; thereby, the data recorded at Baia de Fier hydrometric station were compared with those coming from Videle meteorological station (which is located closest to Tătărăştii de Sus). The results showed a multi-annual mean of 63.6 mm at Baia de Fier and of 47.8 mm at Videle. At monthly level, the highest values are recorded in May-July at Videle and in July-September at Baia de Fier, fact that explains the different occurrence dates of the 2 most important floods from each year, that are not generated in the same meteorological and synoptically context in most cases.

Significant differences were recorded for the specific peak discharges and index of flood power, due to the fact that the computation formulas include basins surfaces (much larger in Teleorman River's case).

Regarding the floods volume, it was obvious the significant larger values obtained in the case of Teleorman River, fact due to the much longer total durations, plus the slightly higher peak discharge of the flood events.

If the shape coefficient shows only slightly higher values for Tătărăştii de Sus hydrometric station, the depth of runoff has significant higher values at Baia de Fier, due to the fact that the surface of the hydrographic basin is much smaller.

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