THE EVALUATION OF THE HYDROLOGICAL RISKS ASSOCIATED WITH THE MAXIMUM DISCHARGE IN THE UPPER WATER CATCHMENT OF THE RIVER BÂRLAD

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ABSTRACT. – The evaluation of the hydrological risks associated with the maximum discharge in the upper water catchment of the river Bârlad was realized based on the data respecting the maximum flows realized at two hydrometric stations Baceşti si Negreşti, between 1954-2006. The analysis had in mind both the evaluation of the maximum flows and the associated parameters and the implications of some extreme hydrological events as floods. An important component consists in the appreciation of the river safety levels based on the maximum debit obtained with different calcul formulas (rational or reductional) for the anticipation of the future hydrological events.

Keywords: hydrological riscks, maximum discharge, floods, river safety levels.

1. INTRODUCTION

An important characteristic in the regime of the river flows from Romania is the presence of some periods,during the year,with high debits induced, either by the atmospheric precipitations in impressive quantities, or by melting the snow or often by the overlap of these two phenomena. The intensity and the duration of the high debit periods is mainly influenced by the physical geographical conditions of an hydrographic basin. Of all these,the main element is the climatic one, being represented by the atmospheric precipitations in the forms described above. The other physical geographical factors which contribute to the formation of the maximum debits are: the geomorfometry of the draining basins,the type of the ground and its humidity level, the geological structure and the composition of the plant coating. An important role, especially in the case of the hydrographic basins arranged by hydrotehnical purposes (like in the case of the superior basin of the river Barlad), has the anthropic factor, by executions of the storage lakes, the evacuation areas of the maximum debits (polders), dams etc.

The hydrographic array developed in the central-southern part of the Moldavian Plateau, in the space Siret-Prut is represented, mainly, by the hydrographical basin Bârlad and then by a series of branches of the river Prut with a low hydrological importance (Elan, Chineja, etc.).

With the largest surface of all the branches of the river Siret, in which it blazes (over 7220 km^2), the hydrographic basin Bârlad represents over 45% of the

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surface of the Moldavian Plateau(between the rivers Siret and Prut). Although the hydrotehnical arrangement of this basin is quite extended, there are a series of hydrological situations which involve the production of some riscks events (floods) with destructive effects over the social and economical belongings and the geographical landscape.

Before realizing an thorough analysis of the processes and phoenomena related to the maximum leakage and risk phenomena related to this it, is necessary a theoretical approach of the difference between big waters and floods, thanks to the various definitions, many of them overlapped, appeared in specialized literature. High waters represent the leaking which is realized on the rivers of the Moldavian Plateau at the beginning of spring, determinated, generally by the melting of the snow due to the increased termperatures ,intensified by the falling of liquid precipitations in quite important quantities. The floods represent another characteristic form of producing the liquid leaking,mainly determined by the falling of the torrential rains(associated with the melting of the snow), with an effect in the increase in a short amount of time of the levels and debits of the waters. Sometimes,the increasing of the levels and debits is so significant,that it can cause floods in the major chanel, with negative effects on some social and economical objectives.

The statistic analysis of the maximum leaking was realized based on the data recorded between 1954-2006, on hydrometrical stations Baceşti and Negreşti. This analysis permitted us to extract some information of practical matters ,which will lead us to the adoption of measures which will be checked and consulted in the projecting, execution and exploitation phase of the hydrotehnical constructions in view of minimizing the effects produced by the hydrological hazards, especially in the areas which are vulnerable to this type of phoenomena.

In the maximum leaking, the most representative parameters analysed refer to the maximum levels and volumes associated to this, as well as to the floods.

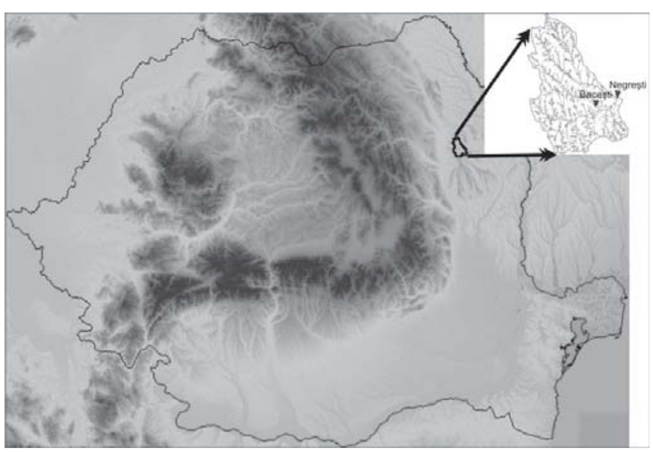

Fig. 1. ***The position of the upper basin of the river Barlad in Romania***

2. THE ANALYSIS OF THE MAXIMUM LEAKING: MAXIMUM DEBITS AND VOLUMES

The multiannual variation of the maximum debits knocks out that at the level of the upper basin of the river Bârlad, were registered a series of years in which were produced the biggest maximum debits (1969, 1970, 1971, 1979, 1985), and a series of years when this debits were more reduced(1991,1995)(table nr.1)

The highest debit registered between 1954-2006 (the maximum maximorum debit) was of 164,0 m^3/s, at the hydrometrical station Baceşti, registered on 17.VII.1970 and of 390 m^3/s, at the hydrometrical station Negreşti, registered on 19.VI.1985. These debits were produced based on the manifestations of downpours ,which had overdued at the meteorological stations and rainfall posts from the northern part of the basin Bârlad 120-150 l/m^2.

Tabel no. 1. ***The statistic of the monthly maximum debits in the hydrographical basin Bârlad***

Hydrometrical station	Băceşti	Negreşti
The maximum flow m^3/s (the maximum value)	164,0	390,0
Year	1970	1985
The maximum flow (the minimum value)	0,274	4,64
Year	1995	1959
The maximum flow m^3/s (the average value)	48,0	74,4
Cv*	0,96	1,64
Cs**	2,56	3,12
Cs/Cv	2,64	1,89
σ***	0.28	0,27

* values obtained by processing the hydrological data offered by the Basinal Association of water Prut-Bârlad
Cv – the coefficient of varriation of the data series of the minimal anual debits
Cs – the coefficient of assimetry of the data series of the minimal anual debits
σ – the medium square deviation

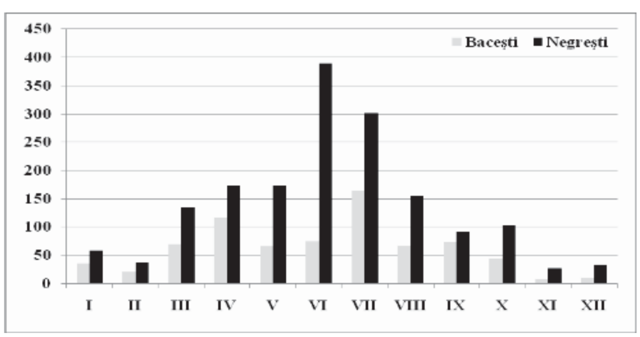

Fig. 2. ***Maximum monthly and instant debits in the upper basin of the river Bârlad***

An important aspect of the analysis of the maximum debits is the conditioning of the production of these by the achievement of some hydrotehnical constructions of the type of the dams and the storage lakes.those print a general tendance of reduction of the values of the maximum debits registered trough the regularisation of the leaking (Fig. 2).

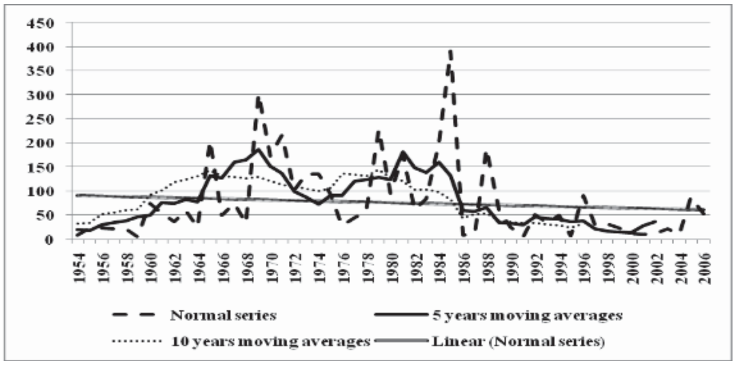

Fig. 3. ***The multianual variation of the maximum debits at the hydrometrical stations of the upper basin of river Bârlad***

During the year,the maximum debits present higher or lower variations, from a month to another,deppending on the rainfall features of every month.On the level of the upper basin of the river Barlad,the maximum debits produced more often in the perion june-july (over 55% from the cases), followed by period march –april (35% from the cases) and september (10% from the cases).

The lowest values of the maximum debits were registered in winter (december-february), and in the end of the summer and the beginning of autumn (august-october).

In order to project and realise the hydrotehnical construction as well as for an efficient management of the water resources from a hydrographical basin,is necesarry to calculate the maximum debits, with certain probabilities of overfloading.So,at the level of the upper basin of the Bârlad river were determined the maximum debits with different possibilities (0,01%, 0,1%, 0,5%, 1%, 5%, 10%) as well as the maximum debits speciffic and the maximum volumes corresponding to this debits for the natural regime of leaking ,using the curves of probability of the type *Pearson III*.

Table no. 2 ***The maximum anual debits (m^3/s) and speciffic maximum debits ($l/s/km^{2)}$ with different possibilities calculated at hydrometrical stations from the upper basin of the river Barlad***

Nr. crt.	Hydro. station	Q.max (m^3/s) for the probabilities						q.max (l/skm^2) for the probabilities					
		0,01%	0,1%	0,5%	1%	5%	10%	0,01%	0,1%	0,5%	1%	5%	10%
1	Băcești	329,0	254,2	178,1	123,2	99,0	74,1	2384.0	1842.0	1290.5	892.7	717.3	536.9
2	Negrești	588,7	445,6	301,8	202,3	158,7	115,7	720.5	545.4	369.4	247.6	194.2	141.6

The maximum debits registered at the hydrometrical stations,between 1954-2006, do fit in in the probabilities of production 5% and 10% in the case of both hydrometrical stations.

Also in practical purposes, for the design of hydrotechnical objectives, the maximum volumes with probability of exceeding have also been determinated (0,01%, 0,1%, 0,5%, 1%, 5% and 10%). In general, these fit between 23,0 mil. m^3, at the hydrometric station Baceşti, for the probability of production of 1% and 36,9 mil. m^3, at the hydrometric station Negreşti, for the same probability (table nr.3).

Reporting the maximum volume of water corresponding to each probability of exceeding at the surface of the sewn basin, in the right of each hydrometrical station the maximum layers of water equivalent drained to the volumes are obtained (hmax p%, mm).

Table no. 3. ***Maximum volumes and maximum layers of water equivalent to the maximum volumes (mm), with different probabilities of exceeding, determinated for hydrometrical station from the superior basin of Bârlad river***

Nr. crt.	Hydro. station	W.max ($10^6 m^3$) for probabilities						h_{max} (mm) for probabilities					
		0,01%	0,1%	0,5%	1%	5%	10%	0,01%	0,1%	0,5%	1%	5%	10%
1	Băceşti	23.0	17.3	12.3	10.1	7.4	3.5	382	269	206	178	95	61
2	Negreşti	36.9	28.2	19.8	16.3	10.5	5.6	207	148	113	92	53	35

3. THE EVALUATION OF THE HYDROLOGICAL RISKS INDUCED BY FLOODS

The genesis of floods is directly connected with the climatic conditions existent at a certain time in the analyzed basin and can be determinated by the superficial drainage from rains (pluvial floods), from the sudden melting of snows (nival floods), from the superposition of these two phenomenas (pluvial-nival floods) or as a result of accidents in the area of hydrotechnical constructions *(Zăvoianu*, 1999).

For the upper basin of Bârlad river, from the 26 hydrological events associated with flood waves, 14 have occured in the summer months, 10 in spring months and 2 in autumn months.

In hydrologic practice, of great importance is the knowledge of the flood waves characteristic features. These elements are determinated with the help of singular floods, registred at the hydrometrical stations and on the base of analysis of the most representative floods can be calculated, later, the average elements characteristics of the flood waves, which stay at the basis of building type hydrographers of singular floods, with different probabilities. For Bârlad river, for the probability of exceeding 1%, the medium time of manifestation of a flood is at Baceşti hydrometrical station of 38 hours, for increasing in the downstream at 95 hours, at hydrometrical station Negreşti. All the characteristic elements of the flood waves are influenced largely of the morphometric characteristics of basins (the lenght of water courses, the basins` medium altitude, the average slope of the courses and of the basins, the catchments` surface).

Another important aspect occurs from the random distributions of the hydrological phenomenas which are obtained from a limited set of datas, result of observations and recordings. The lack of monitoring stations of the hydroclimatic elements with a relatively high density (at least one such station at 25 km^2) thus leads to the impossibility of validating the obtained results. Given these elements, it is resorted at the division of the basins of large dimensions in a series of subbasins and interbasinal areas, each characterized by specific values of the used hydrological parameters. So can be realised an evaluation of the hydrological risks from certain portions of the basin through type-models rainfall-runnoff , in large basins; implies several steps :

- system decomposition (hydrographic basin) in a series of subsystems (subbasins and interbasinal areas)l
- the evaluation of the hydrological leakages within each system;
- the evaluation of the hydrological risks within each system;
- the realization of graphics and risk maps at the level of the hole basin.

Because at the level of each subsystem there are no measurements and continuous observations over the necessary hydrological parameters for the evaluation of the hydrological risk we used the genetic hydrological model input-output type for the small river basins, using the rational formula (STAS 4068/1-82):

$$q_{p\%}^{\max} = 16{,}7 \cdot \alpha \cdot I_{p\%} (m^3/s/km^2)$$

where: $q_{p\%}^{\max}$ - the maximum specific flow with probability of exceeding;

$I_{p\%}$ - the intensity of rain calculated based on standard STAS 940-73;

16,7 - size conversion factor.

α - is the coefficient of superficial leakage on homogeneous areas regarding the leakage (whose surface is noted with f), calculated with the formula:

$$\alpha = \frac{\sum_{i=1}^{n} \alpha_i \cdot f_i}{F},$$

where: α_i - the partially coefficients of superficial leakage which characterizes the homogeneous surfaces;

f_i - a surface considered homogenous if for a series of fields` elements (type of use, slope, texture etc) are homogeneous.

The partially coefficients of leakage α_1 are presented in the specialized literature (*Hâncu* et al., 1971, *Mustaţă* et.al, 1981), depending on using, slope, texture and permeability of the field

Regarding the intensity of the rain concretion Ip% is established for the lenght of the rain equal with the concentration time of the superficial leakage. An important aspect to be retained in the calculation method of the concretion rain is the fact that, in general, the concretion rain is considered to be uniformly distributed on the whole surface of the catchment afferent to the control section, so the lenght of the maximum intensity rain which is used in order to determine the maximum flow is equal with the time of concentration (tc) of the superficial leakage (and it is called concretion rain).

The time of concentration represents the time where the water coming from rainfall and which is leaking, gets from the farthest point of the basin to the concretion section of the maximum flow).

The reduction formula used in determination of the maximum flow with the probability of exceeding of 1%:

$$Q_{1\%} = \frac{K \cdot \alpha \cdot I_{60,\ 1\%} \cdot F}{(F + 1)^{m}}$$

where: K -0,28 transformation coefficient of rain`s intensity from mm/hour into m/s and surface from km^2 to square meters;

α - global coefficient of leakage;

$I_{60,1\%}$ - the maximum hourly intensity of rain with probability of exceeding of 1%;

Starting from the recorded values, a series of tipical values (characteristic) of the variable sections are calculated, such as : the average value, the dispersion, the deviation etc. Then is considered that these typical values or parameters of the empirical distribution are at the same time parameters of the theoretical distribution, used to adjust and extrapolate the empirical distribution (in other words, the parameters of the statistical population are estimated based on the selection which is decided by measurements), obviously, this habit is an approximation, which is a source of errors of the static concretion (*Giurma*, 2003). For the Bârlad basin, the value of the concretion rain intensity based on the dataset regarding intensity and average and maximum lenght of rains at some meteorological station and rainfall stations (Bârnova, Negrești, Vaslui).

For using the rational formula, first were determinated the average amd maximum intensity of torrential rains from this basin. In this way, there were determinated the maximum quantities of rainfall in 24 hours, with different probabilities (Table no. 4).

Table no. 4. ***Maximum quantities of rainfall (mm) in 24 hours with different probabilities (%) at meteorological station and the rainfall stations from Barlad basin and from adjacent area***

Nr. crt.	Meteo. station/ Pluvio. station	Pp max. abs. in 24 hours (mm) (value/date)	Max. quantities of pp (mm) in 24 hours with different probabilities (%)					
			0,1	1	5	10	20	50
1	Bârnova	167,9/7.08,1989	194,3	158,9	136,9	127,9	118,7	104,6
2	Negrești	91,4/20.08.1972	144,3	107,5	87,0	79,4	72,0	62,6
3	Vaslui	91,9/22.07.1980	112,3	93,9	82,4	77,8	72,9	66,4

In the next stage there were calculated the absolute maximum flows and the specific maximum with different probabilities at the main hydrometrical station within the basin,also identifying the relations from the maximum specific leakage with the 1% insurance and the average altitude of the basins (see table no. 2 , fig. no. 3).

Then, based on the dates from the rainfall stations ,regarding the share of attention of flood and danger, and considering the limnimetric keys specific to each station, the leakage coefficients were calculated and overcome situations of these shares at the two rainfall station were identified.

Table no. 5 ***The values of the maximum flows corespondent to the main shares at the rainfall stations from Bârlad basin***

Hydro. Station	Râul	Supr. (km^2)	C.A. (cm)	Q (m^3/s) coresp.	C.I. (cm)	Q (m^3/s) coresp.	C.P.	Q (m^3/s) coresp.
Băceşti	Bârlad	142,31	340	33.1	440	62.7	600	125.0
Negreşti	Bârlad	812,21	330	34,2	410	66,3	575	135,9

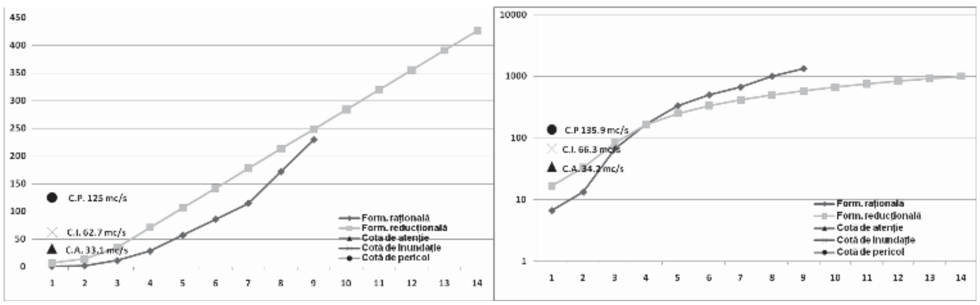

Fig. 5. ***The overcome situations of the main shares at some stations and hydrometric stations from the superior basion of Bârlad river (Baceşti on the left, Negreşti at the right) (remaking after Rusu C., 2009)***

CONCLUSIONS

The evaluation of the hydrological risks asociated to the maximum leakage in the superior basin of Barlad river highlighted a series of characteristics of these hydrological parameters. So, the maximum flows registred al the hydrometric stations from this area of the basin (Baceşti and Negreşti, in 1954-2006), fit between production probabilities 5% and 10%, which imparts to the leakage a strong torrential character. For the identification of the extreme values, it has resorted to the use of different formulas proposed by the specialised Romanian literature (rational and reduction), indicating a high risk of floods occurence in case of rainfall that exceeds 100-150 l/m^2, relatively frequently in the analyzed space.

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