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THE ANALYSIS OF THE FLASH FLOOD PRODUCED DURING 02-04.06.2016 IN THE TROTUȘ RIVER BASIN (ROMANIA)

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Key words: maximum flow, defence levels, flash flood, damage

Abstract: This paper concentrates information on the flash flood produced during 02-04.06.2016 in the Trotuș River basin. Maximum flows have been analyzed by reference to the thresholds corresponding to the Defense Levels. In order to show in a suggestive way the amplitude of the event, the characteristics of the flood were highlighted as well as a series of morphometric and hydrological data on the maximum flow of the Trotuș River. The hydrometric stations in the basin area, to which reference was made, were: Lunca de Sus, Goioasa, Tg. Ocna, Onești and Vrânceni. The flow series were represented graphically to be able to easily observe the evolution of the flood over time. The analysis showed that the flood produced on the Trotuș River had a great magnitude causing significant damages.

Introduction

The topic of water flow in general and flash floods in particular has been extesively debated in studies both at national level (Petru et al., 1989; Diaconu et al., 1994; Stănescu et al., 2002; Drobot et al, 2014; Sorocovschi et al,. 2008) and international level (Redmond et al., 1991; Milly et al., 2005; Borga et al., 2007; Marchi et al., 2010).

The maximum flow is of major interest in the forecasting activity, knowing it is first of all important for the establishment of the flood defence measures (Diaconu, 1988). Flash floods represent peak moments in the evolution of the river

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water flow. In the last decades, these phenomena occur with increasing frequency and severity both worldwide and in our country. In the future, it is also planned to maintain the same trend, the main cause remaining the global climate change which manifested more pronounced after 1970 and altered the river flow regime in many regions of the Globe (Wijkman, Rockstrom, 2013). Between 2 and 4 June 2016, wide areas of Bacău County reported torrential rain and significant flows from the slopes, which caused many damages and the loss of human lives. In order to diminish the negative effects caused by floods, an important activity is represented by forecasting and warning in case of dangerous hydrological phenomena, hydrological warning messages being emitted with a certain anticipation time, in order to reduce the risk of floods and flash floods.

General geographic features of the Trotuș River basin

Trotuș is a river in the eastern part of Romania, which springs from the Ciuc Mountains, at an altitude of 1380 m, and flows into the Siret River crossing the Bacău and Vrancea counties. The hydrographical basin (Fig.1) overlaps the central-eastern part of the Eastern Carpathians and the Sub-Carpathians of Moldova. Table no. 1 presents some main morphometric data on the analyzed river basin.

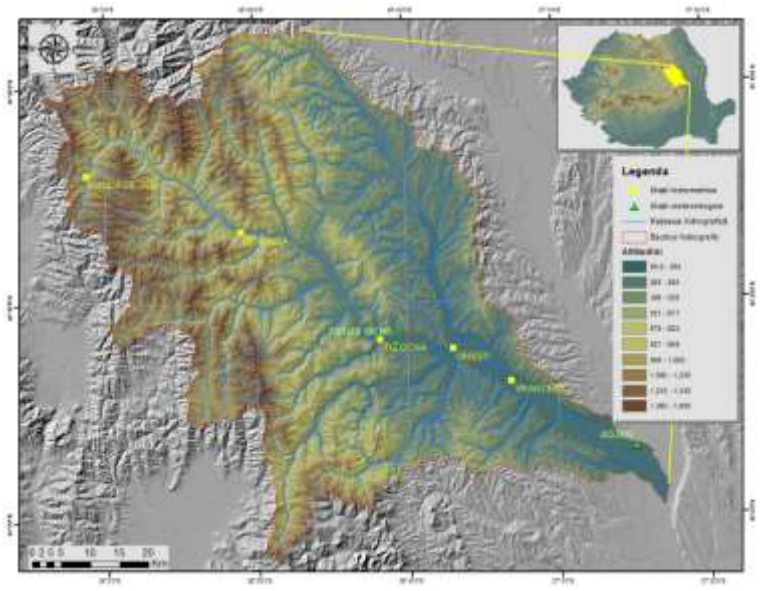

Fig. 1 – Location of the study area – Trotuș River hydrographic basin

Data and methods

This paper presents an analysis of the dangerous hydrological event recorded between 02 to 04 June 2016, within the Trotuș hydrological basin. Some morphometric data are shown in the next table (Tab.1):

Tab. 1 – Morphometric data, Trotuș River

Lenght (km	Altitude (m)			Average slope (%)	Sinuosity coefficient	F (Km^2)	Forest found area (ha)
	Upstream	Downstream	Average				
162	1380	79	706	8	1.54	4456	241737

F = surface (Source: Atlasul Cadastrului Apelor din România, 1992)

Data from five representative hydrometric stations within the basin: Lunca de Sus, Goioasa, Tg. Ocna, Onești, Vrânceni (Tab. 3) were analyzed, as well as data on the precipitations recorded during the analyzed period (Tab. 2). The montly amount of precipitations in Romania, in Jume is shown in the map below (Fig,2).

Tab. 2 – 24 hour rainfall in Siret basin (Bacău County), 2-3.06.2016 period

Hydrometric station	24 hours precipitations l/sqm	Recording date	Mean precipitation in Siret basin – Bacau county (l/sqm)
Lunca de sus	38,2	2-3.06.2016	60
Goioasa	93.5		
Tg. Ocna	59.6		
Onești	78.2		
Vrânceni	42.2		

Data source: INHGA

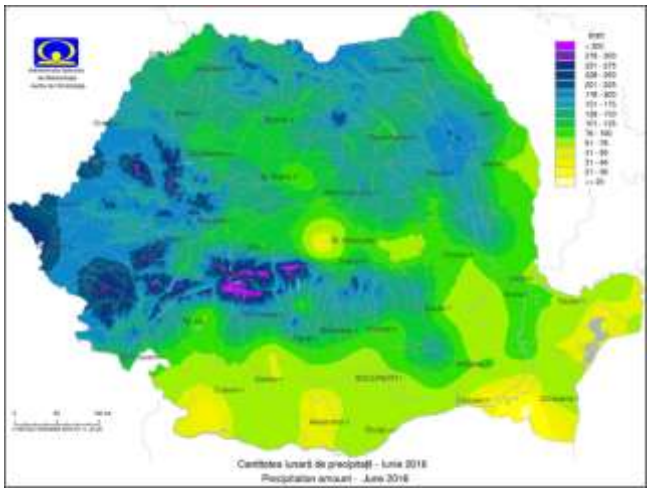

Fig. 2 – Precipitation amount in Romania – June 2016

Maximum flows have been analyzed by reference to the respective thresholds for the Defence Levels, respectively the maximum flows that lead to the overrun of the Flood and Danger Levels. The current limnimetric key (Tab. 3) was used to determine the corresponding flows.

Also in the paper the situation of damages produced, the objectives affected (Fig. 9) and the causes of these phenomena will be presented. The following software packages were used for data processing: EXCEL, CAVIS and GIS.

Tab. 3 – Morphometric and hydrological data on the maximum flow of the Trotuș River at the hydrometric stations Lunca de Sus, Goioasa, Tg. Ocna, Onești și Vrânceni

River	Hydrometric station	F Km^2	H med m	Q.A. m^3/s	Q.I. m^3/s	Q.P. m^3/s	Q max 2-4.06. 2016	Hmax 24.06. 2016	Obs.	C.A. cm	C.I. cm	C.P. cm
Trotuș	Lunca de Sus	89.2	1140	6	15.6	34	23.46	146	+26 C.I.	80	120	200
	Goioasa	765	1052	168	246	416	241.2	247	+47 C.A.	200	250	350
	Tg. Ocna	2091	924	305	590	740	686	382	+32 C.I.	250	350	400
	Onești	2836	830	457	641	1256	945.5	455	+55 C.I.	350	400	500
	Vrânceni	4077	734	797	1175	2220	2524	525	+25 C.P.	350	400	500

F = surface b.h.; H med = the average altitude of the river basin; Q.A. = flow of attention; Q.I. = flood flow; Q.P. = risk flow; Q max = maximum flow; H max = maximum level; C.A. = attention level; C.I. = flooding level; C.P. = danger level.

Data source: INHGA

Results

As a result of the significant rainfall that occured in short intervals and due to the significant water flow from the slopes, during the analyzed period there were important increases in flow rates on the watercourses in the upper and middle basin of the Trotuș River (Fig. 3,4,5,6 and 7). The following precipitations were recorded at the analyzed hydrometric stations: 38,2 l/sqm Lunca de Sus; 93,5 l/sqm Goioasa; 59,6 l/sqm Tg. Ocna; 78,2 l/sqm Onești and 42,2 l/sqm Vrânceni, and the average precipitation in the entire Siret basin in the Bacău County area was 60l/sqm. The highest recorded flow (2524 sqm/s) was the one from Vrânceni downstream station (03.06.2016, 02:00), with a level of 525 cm, thus exceeding by 25 cm the Danger Level. At Lunca de Sus, Tg. Ocna and Onești hydrometrical station, the levels exceeded the specific Flood Levels by more than 20 cm. The characteristic

elements of the flood waves and the date of the maximum flow recording are shown in the next table (Tab. 4):

Tab. 4 – Characteristic elements of flood waves, Trotuș River, 02-04-06.2016

River	Hydrometric station	Date	Characteristic elements of the flood waves										
			Qb m^3/s	Qmax m^3/s	Recording date	Wc mil. m^3	Wd mil. m^3	Wt mil. m^3	Hs mm	Shape coef.	Tc hours	Td hours	Tt hours
Trotuș	Lunca de Sus	06/2016	1.71	23.46	02.06.2016 21:00	0.56	0.92	1.48	0.34	0.53	15	18	33
	Goioasa		19.9	241.2	02.06.2016 21:00	7.55	9.43	16.98	3.9	0.59	15	18	33
	Tg. Ocna		49.2	686	02.06.2016 20:00	20.5	33.1	53.6	12.3	0.45	14	34	48
	Onești		66.5	945.5	03.06.2016 01:00	36.2	24	60.2	13.8	0.49	19	17	36
	Vrânceni		131.4	2524	02.06.2016 02:00	69.1	69.3	138.4	31.8	0.54	12	16	28

Qb = base flow (m^3/s); Q max = maximum flow (m^3/s); Wc = growth volume (mil. m^3); Wd = decrease volume (mil. m^3); Wt = total volume (mil. m^3); Hs = drained water layer (mm); Shape coef. = shape coefficient; Tc = growth time (hours); Td = decreasing time (hours); Tt = total time (hours);

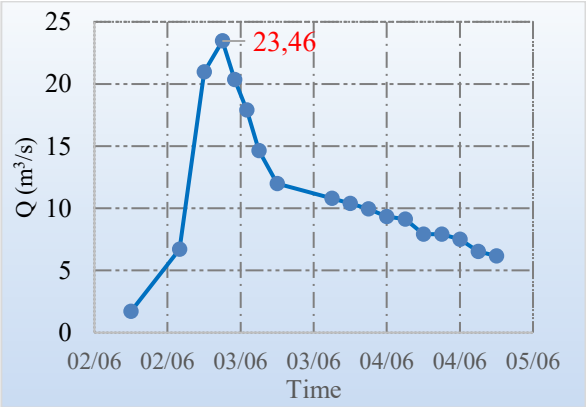

Fig.3 - Flood hydrographer, Trotuș River, Lunca de Sus hydrometric station, 02-04.06.2016

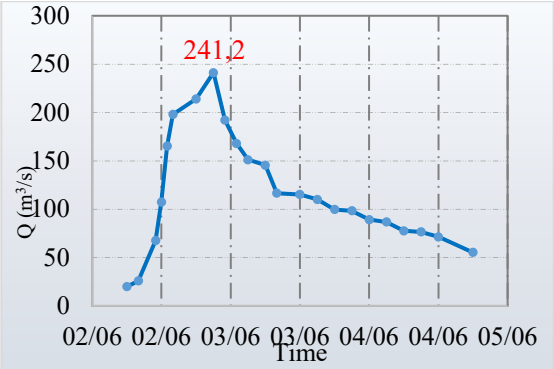

Fig.4 - Flood hydrographer, Trotuș River, Goioasa hydrometric station, 02-04.06.2016

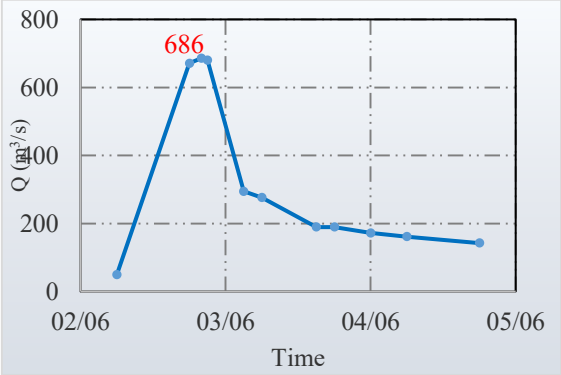

Fig.5 - Flood hydrographer, Trotuș River, Tg. Ocna hydrometric station, 02-04.06.2016

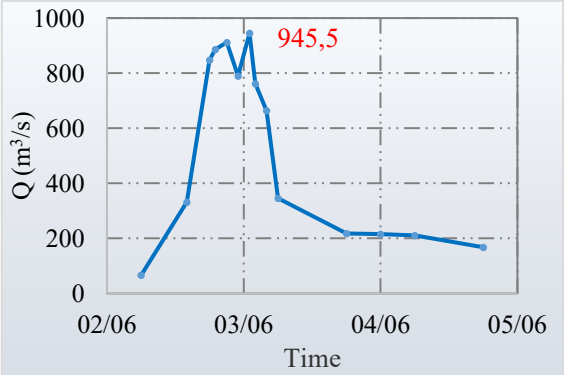

Fig.6 - Flood hydrographer, Trotuș River, Onești hydrometric station, 02-04.06.2016

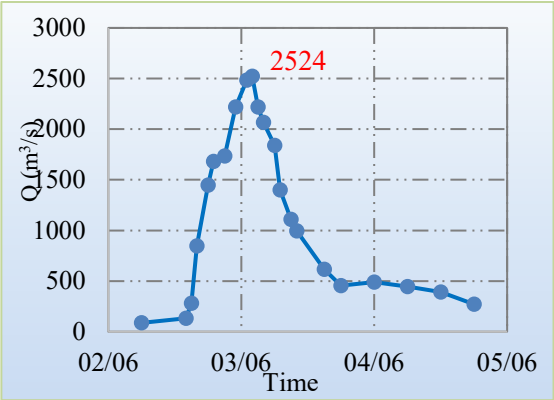

Fig.7 - Flood hydrographer, Trotuș River, Vrânceni hydrometric station, 02-04.06.2016

Conclusions

The maximum flow is the consequence of the rich supply from snow meting and abundant rainfall. This is influenced by the climatic factors, the surface and shape of the hydrographic basin, the wetting degree, the temperature and the permeability of the soil, the vegetation etc.

The analyzed region, where the four hydrometric stations are located, presents a mixed (snow and rain) hydrological regime characterized by high levels of water at the end of spring and low water levels in winter.

On the basis of the operational report on the effects of the dangerous hydrometeorological phenomena produced during the analyzed period, a total of 23 UAT`s with 61 affected villages resulted in 32 flooded houses, 442 flooded house holds, 16 isolated households, over 100 km of affected roads, 4 km of sewerage network, 26 bridges, 87 culverts, 9 decks, 1060 ha of agricultural land, 200 ha of pasture land, 0.69 km of shoreline, 3 socio-economic objectives, 0.3 km CF, a damaged gas pipe, 3 damaged salt water pipelines, one car and a deceased person. The flood affected also the hydrotechnical constructions, namely: 1 concrete pile and destroyed gabions.

Among the causes that have led to these phenomena are mainly included torrential rainfall (90 l / mp in 30 min), flow increases, leakage on the slopes, overflowing of tributaries and significant accumulations of water with sediments. During this interval, 4 orange and red code warnings were issued, of which 2 for immediate phenomena (Fig.8). Regarding the actions and interventions for diminishing the effects of the dangerous hydrometeorological phenomena

undertaken by SGA Bacau during 3.06.2016 we mention: removing obstacles by workers and unlocking of the clogged river bed, to ensure the drainage section, as well as the evacuation of the water from the flooded area.

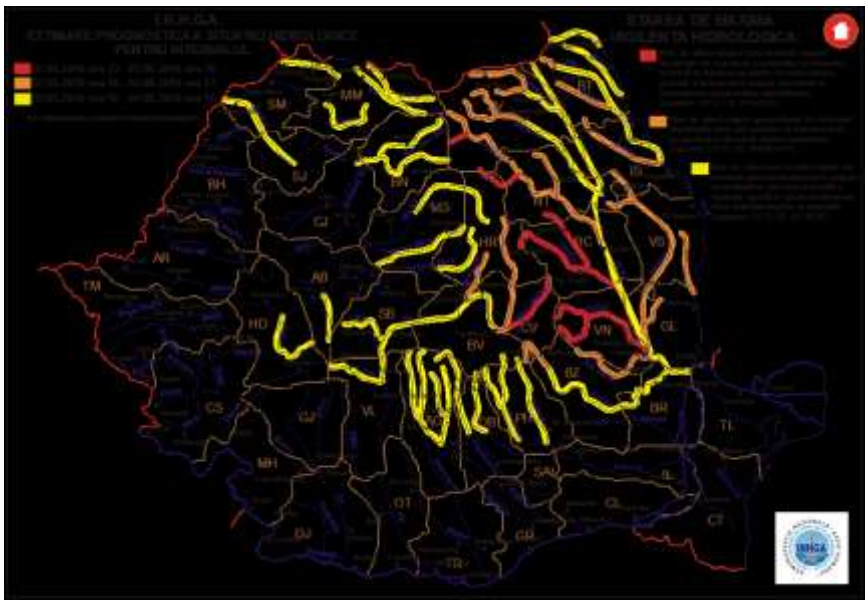

Fig. 8 – Hydrological warning map of the event (02.06.2016). Source: INHGA

Fig.9 – Damage caused by the flash flood, Trotuş River, June 2016. Source: www.bacău.net

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