DEGREE OF THE RIPARIAN ENVIRONMENT IN THE TROTUS HYDROGRAPHIC BASIN AFTER THE FLODS IN THE YEARS 2016

DEGRADAREA MEDIULUI RIVERAN ÎN BAZINUL HIDROGRAFIC AL RÂULUI TROTUŞ ÎN URMA VIITURILOR DIN ANUL 2016

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Abstract. *The paper presents an analysis of the degradation phenomena of the riparian environment in the Trotuş river basin following the floods produced in the summer of 2016. The Trotuş River has been affected by many floods over the past 28 years, 2004, 2005, 2011 and 2016. The riverine environment was affected by the degradation of shore defence works, the morphological modification of the riverbed, the destruction of the roads, the erosion of the agricultural land, the deposition of pollutants on the land adjacent to the river, etc. The June 2016 flood in the Trotuş River basin resulted in the degradation to the total destruction of over 318 km of bank defence hydrotechnical works. The floods caused the degradation of 1337 ha of agricultural land, the degradation of 355 km of road and 180 bridges. The floods affected over 376 homes in the studied area, from which it destroyed 76.*
Key words: discharges, floods, defence banks works, roads, bridge

Rezumat. *Lucrarea prezintă o analiză a fenomenelor de degradare a mediului riveran în bazinul hidrografic al râului Trotuş în urma viiturilor produse în vara anului 2016. Bazinul hidrografic al râului Trotuş a fost afectat de multiple viituri în ultimii 28 ani, dintre care se remarcă cele din 1991, 2004, 2005, 2011 şi 2016. Mediul riveran a fost afectat prin degradarea lucrărilor de apărare de mal, modificarea morfologică a albiei râului, distrugerea drumurilor, eroziunea terenului agricol, depunerea de poluanţi pe terenul adiacent râului etc. Viitura din iunie 2016 în bazinul hidrografic al râului Trotuş a produs degradarea până la distrugerea totală a peste 318 km de lucrări hidrotehnice de apărare a malurilor. Viitura a produs degradarea a 1337 ha de teren agricol, degradarea a 355 km de drum şi 180 de poduri. Viitura a afectat peste 376 de locuinţe în zona studiată, din care a distrus 76.*
Cuvinte cheie: debite, inundaţie, apărare de mal, drum, pod

INTRODUCTION

Globally, a series of climatic changes have occurred over the past 30 years and have significantly influenced the environment. Climate change has affected Romania's territory by influencing the monthly distribution of temperatures and precipitation. The high value of changing meteorological parameters creates a hydroclimatic risk in the evolution of flows and river levels. Hydrological

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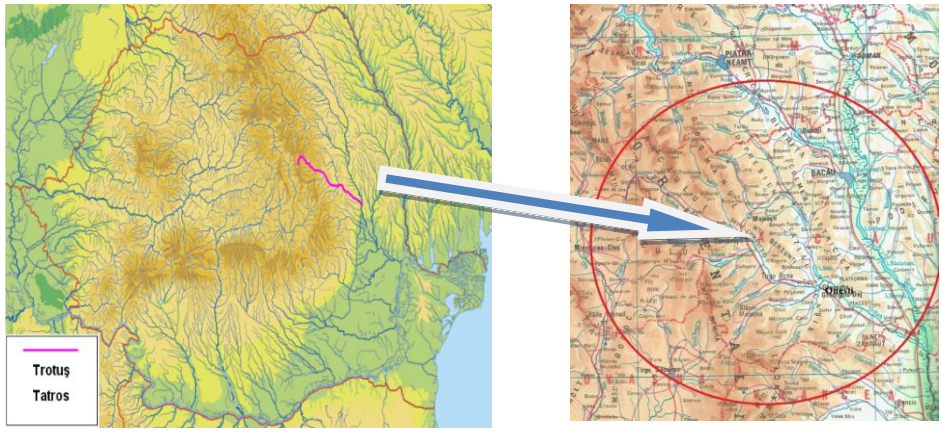
parameters directly influence the morphological evolution of the river and, implicitly, the stability of existing buildings in the riverbed and the riparian. The hydrological regime of the rivers in the Trotuş River Basin is characterized in the last period of time by the high frequency of the floods. Floods have caused major economic damage and human losses in recent years.

Elements of hydrological risk modify intensively the morphology of riverbed in cross-section and longitudinal section. The stability of bed constructions (bridges, adjustments) and shore (shore defence works, dikes) is influenced by the high frequency of floods. Hydrological risk elements affect the existing habitat in the minor and major river bed. The amount of flood damage has become very high, which has forced the allocation of significant investments to restore destroyed targets. Effects of changes in the riverbed are immediately detected, or may occur after a longer period of time.

STUDY AREA AND RESEARCH METHOD

The research was conducted in the Trotuş River basin. The hydrographic basin of the Trotuş River is located in the relief area of the Oriental Carpathians. The river passes through the geomorphological units of the Ciucului, Tarcăului, Comăneştii and Tazlău - Caşin depressions. The Trotuş River flows into the Siret River downstream of Adjud. The Trotuş River has the XII-1-69 cadastral code. The Trotuş River has its springs in the Ciuc Mountains at an altitude of 1360 m. The course of the river has a main north-south direction.



a b

Fig. 1 Framing of the study area in the Siret catchment area: a - location of the area on the territory of Romania; b - the location of the area in the East Carpathians.

The inhabitants of the Trotuş River on the sector considered are (Ujvari I., 1972):
- on the right: Ciugheş, Sulita, Ciobănuş, Uz, Dofteana, Slănic, Oituz, Caşin;
- on the left: Brusturoasa, Agăş, Ciungi, Asău, Urmeniş, Vâlcele, Tazlău.

The hydrographic basin of the Trotuş stream has an area of 4.440 km^2. The length of the river is 158 km. The average altitude of the river basin varies from springs to springs in the range 1140 - 734 m. The Trotuş River and the tributaries are

monitored by 21 hydrometric stations. Monitoring parameters have been determined flow parameters (liquid and solid flows, levels, ice, etc.) for a period of 40-60 years (table 1, ABA Bacau 2016).

Climatic, hydrological, hydraulic, topographic, geotechnical studies were collected and elaborated in the area of analysis. The state of exploitation of shore regulation and defence buildings was analyzed by technical expertise and field inspections. Research has included meteorological and hydrological data over a period of about 50 years. Several aspects have taken place over 10 to 25 years. The theoretical and experimental research was also based on a series of technical expertise produced after the floods.

Primary data was processed using the statistical calculation programs and the hydrological and hydraulic calculation programs applicable to this study.

RESULTS AND DISCUSSIONS

The study of the degradation of the buildings located in the riverbed and the riparian area was carried out on the watercourses in the Trotuş river basin.

Hydrological parameters were taken from hydrometric stations located in characteristic sections in the Trotuş River basin and its tributaries (tab. 1). The data from the hydroclimatic risk periods were analyzed by considering variable time periods (10-65 years). The analysis considered the average, maximum and minimum multiannual flows between 1950 and 2016 (Avram, 2016). The research analyzed the variation of the average and maximum annual flows from the multiannual average. The frequency of overflowing flows with the probability of calculation on the studied rivers was also analyzed.

Table 1

The hydrometric monitoring network of the Trotuş catchment area (A.B.A. Siret, 2016)

Nr. crt.	Hidrometric station	Area HB (km^2)	H_m (m)	Q_{med} (m^3/s)	Q_{max} (m^3/s)	$Q_{max, p}$ (m^3/s)			
						1%	2%	5%	10
1	Lunca de Sus	88	1140	0.805	23.2	210	165	113	77,5
2	Ghimeț-Făget	381	1116	3.65	127	500	410	300	220
3	Goioasa	781	1052	6.59	353[1]	750	625	460	340
4	Tg. Ocna	2091	924	17.5	1490[2]	1200	1025	795	625
5	Oneşti	2836	830	25.1	2294[3]	1620	1390	1075	840
6	Vrânceni	4092	734	35.0	2845[4]	2345	2095	1580	1255

H_m - Average altitude

From the analysis of the multi-annual average flow values, with a seasons distribution, the following aspects can be mentioned (Avram, 2016):

- the minimum flow takes place in winter and autumn, where the value of the winter flow is 8.7 - 11.6% of the annual volume and the autumn 12 - 15.5%; the two periods accumulate over 23% of the annual flow;

- the maximum flow occurs in spring and summer, where the value of the spring flow represents 39.9 - 49.3% of the annual volume and the summer season 27.1 - 34.7%; the two periods accumulate over 60% of the annual volume.

Flood from 02.06-05.06.2016 in B.H. Trotus was formed following the precipitations that fell on 02 and 03 06.2016. On 02.06.2016 there were precipitations with values above 80 L/m^2. Precipitation continued on 03.06.2016 and on the night of 3-4.06.2016, where the peak reached 40 L/m^2. The analysis on the studied area shows that large quantities of precipitation accumulated throughout the period 02.06.-03.06-04.06.2016. The measured values at the meteorological stations were 108 L/m^2 at Goioasa, 82.9 l/m^2 at Onesti, 68.1 L/m^2 in Sulta, 87.5 L/m^2 in Cremenea, 61.4 L/m^2 at Ciresoaia , 93.6 L/m^2 in Tazlau, 85.9 L/m^2 in Lucăceşti on the Tazlăul Sărat River, etc. (ABA Bacau, 2016).

Table 2

Parameters of floods formed in BT Trotuş in the period 02.06-04.06.2016

Nr. crt.	River	Hidrometric station	H_{max} (cm)	*p* (%)	*Pp.tot* l/m^2	*Q* (m^3/s)
1	Trotuş	Tg. Ocna	382	5-10	48,5	686
2		Oneşti	455	10	82,9	846
3		**Vrânceni**	525	**1**	58,3	**2525**
4	Asău	Asău	220	20	71,1	89,0
5	Slănic	Cireşoaia	260	5	61,4	118
6	Dofteana	Dofteana	285	5	64,6	134
7	Tazlău	**Helegiu**	410	**2**	69,6	**1280**
8	Tazlăul Sărat	**Lucăceşti**	360	**3**	85,9	**342**

H_{max}- Water share; p - probability; Pp.tot - Total rainfall

a b

Fig. 2 Degradation on the Asau River in June 2016: a - shore erosion; B- defense of damaged riverbank in the locality of the locality (A.B.A. Siret, 2005).

The analysis of the data results in the delimitation of an area with exceptional precipitation and flows located in the Tazlău Depression and on the Trotuş corridor downstream of the Tg Ocna section. The flood flows in this area have shown probabilities of exceeding the calculation values for defence constructions (tab. 3).

a b

Fig. 3 The evolution of the flood in June 2016 on the river Caşin in the commune of the Monastery of Caşin: a-shore erosions; b-degradation of roads and dwellings (Avram M., 2016)

Table 3

Shore defense works works degraded by floods in June 2016 in the Basin Hydrographic River Trotuş, Bacau county (selection Synthesis report - I.S.U Bacau, 2016)

Nr. crt.	Name of the work/county	**Location**	**Date[1]**	**EVD** (Tho. lei)	**Impaired capacities**
1	Regularization of Tazlău Sărat R. Zemes county	Zemes	02-04 .06.2016	27,00	Concrete support wall L=40m destroyed concrete pore L=60 m
2	Arrangement of the Slănic creek, Slănic Moldova and Tg. Ocna (PIF 2009)	Slanic Moldova	02-04. 06.2016	920,00	Wall damaged damage over a length of approx. 220 m
3	River Regularization Trotuş Palanca commune	Palanca	02-04. 06.2016	728,0	Defense of the left bank of gabons on L = 260 m
4	Landscaping of Trotuş and tributaries Object Brusturoasa, Camenca	Brusturosa	02-04. 06.2016	315,0	Defense of gabion shore on L = 80 m; 2 bottom thresholds
5	Arrangement of the Trotus river River and tributaries, Object Brusturoasa – Camenca river (PIF 2015)	Brusturosa	02-04 .06.2016	916,0	Gabion mattresses - 194 pcs. Gabions - 5 pcs. Reproduction of the whale-L = 1850m
6	Regularization river Helegiu in Helegiu commune (PIF 2005)	Helegiu	02-04 .06.2016	1069,0	Reprofilation of the bed l = 475 m, consolidation on L = 650 m; Shore consolidation L = 150 m

Date1 - the date the calamity occurred. EVD - Estimate value damage (impaired capacity)

The inventory of the July flood damages on the Trotuş River highlighted the large number of destroyed social and economic objectives. The works of regulating the Trotus river bed and the defences of the shore were partially and totally degraded on a large scale (synthesis, tab. 4) (Avram, 2016; ABA Siret, 2016).

Table 4

The main damages caused by floods in Trotuş Hydrographic Basin,in the years 1991-2016 (A.B.A. SIRET, 1991-2016, Avram M., 2017)

Nr. crt.	Object name	1991	2004	2005	2016
1	Impaired or destroyed hydrotechnical works (km)	5,64	13,4	35.46 out of which 28.61 in the area considered	318.14 in Bacău County
2	Dwellings and households affected / destroyed by floods (no)	2602	25/ 762	3149/922	376/64
3	Agricultural land flooded (ha)	11.460	280	5453,5	1337
4	Flooded / destroyed roads (km)	15	26	83,75	355
5	Flooded/destroyed bridges (pieces)	32	309	117	180
7	Flooded economic targets (no.)	11	9	51	4
8	Dead people (no.)	76	3	5	1

The hydrotechnical works were strongly affected by the 2016 floods in the Trotuş catchment area, where 318.14 km of partially and totally degraded works in Bacău County (ABA Siret, 2016) centralized.

CONCLUSIONS

1. The territory of the hydrographic basin Trotuş has been affected in the last 25 years by disastrous hydrological phenomena, which have greatly influenced the hydrotechnical regulation and shore defence.
2. The floods produced in June 2016 on the Trotuş River and its tributaries recorded flows with probabilities of 5 ... 1%, where the effects were extremely destructive on the riverbed and the riparian.
3. The degradation of shore regulation and defence works registered the highest value in the calendar period 1991-2016 (about 318 km in Bacău County).

REFERENCES

1. **Avram M., 2016** - *Cercetări privind impactul factorilor de risc hidroclimatic asupra proiectării, tehnologiilor de realizare şi exploatării lucrărilor de regularizare a râurilor - Studiu de caz. Raport 2 de cercetare.* Universitatea Tehnică „Gheorghe Asachi" din Iaşi.
2. **Luca M., Stoenescu, I.**, **2007** - *Current Issues Concerning Regularization Works Behavior under Disaster Conditions,* International Conference „Disaster and Pollution Monitoring – IC.DPM. 3". 1-2 nov. Iaşi, pp. 93-98.
3. **Luca M., Avram M., Lateş I., 2016** - *The influence of hidroclimatic risk factors on the evolution of natural sites*. Lucrări Ştiinţifice Seria Horticultură, An LIX, 59 (1)/2016, Universitatea de Ştiinţe Agricole şi Medicină Veterinară Iaşi, p. 207-212.
4. **Ujvari I.**, **1972** - *Geografia apelor României.* Edit. Ştiinţifică, Bucureşti.
5. **Vamanu E., Olariu P., 2002** - *Riscuri hidroclimatice în Spaţiul hidrografic Siret în contextul modificărilor geografice. Culegere de lucrări,* Ses. Ştiinţ. INMH Bucureşti.
6. ******* A.B.A. SIRET-Bacău - *Rapoartele de sinteză privind apărarea împotriva inundaţiilor, fenomenelor hidrometeorologice periculoase, accidentelor la construcţii hidrotehnice şi poluărilor accidentale din judeţul Bacău*, pentru anii 1991, 2004, 2005, 2010, 2012, 2016.