TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

15

- special issue -

The Timiş River Basin

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

Sibiu - Romania
2013

TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

15

special issue

The Timiş River Basin

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

„Lucian Blaga” University of Sibiu,
Faculty of Sciences,
Department of Ecology and Environment Protection

International Association for Danube Research

“Lucian Blaga” University of Sibiu

West University of Timişoara

Ecotur Sibiu N.G.O.

Sibiu - Romania
2013

Editorial Office:

"Lucian Blaga" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Ion Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, Angela Curtean-Bănăduc (ad.banaduc@yahoo.com, angela.banaduc@ulbsibiu.ro)

IN MEMORIAM

Rodica (Teodorescu) Leonte
(1913 - 2002)

Rodica (Teodorescu) Leonte was a Romanian biologist.

She was born in Alexandria Commune in Teleorman County on 22 January 1913. She had her secondary education in the cosmopolitan atmosphere of Tulcea at that time, in the Highschool for girls, where she took her baccalaureate in 1930.

For higher education, she chose to attend the Faculty of Natural Sciences at Bucharest University (1930-1934). At this university, she later obtained a doctorate in biology, with the subject "Contribuţii la cunoaşterea dezvoltării embrionare şi postembrionare a speciilor de Percide din bălţile Deltei Dunării în comparaţie cu cele a câtorva specii de Ciprinide din aceleaşi bălţi / Contributions to the knowledge of embryonic and post-embryonic development of the Percidaes species of the Danube Delta wetlands in comparison with some Cyprinidae species from the same wetlands".

She specialised in hydrobiology, fish farming, fish anatomy and morphology. She worked for over 40 years in problems related to the hydrology and ichthyology of the Danube Delta flood plain. She was constantly interested by the equilibrium between the impact of reef exploitation and the fish populations of the Danube Delta.

She worked as a biology teacher at Principesa Ileana Highschool, and asa a university lecturer, but the longest period was as researcher in Tulcea Fish Research Institute, finally becoming its manager. Here she also worked with her husband Vasile Leonte, also a biologist. She won two important national awards for her scientific work.

Some of her most interesting scientific papers were: 1942 "Contributions à l'étude du developpement des larves de sander (*Lucioperca Sandra* C.V.). La nutrition et l'osification du système osseux", 1943 "Beitrag zur Kenntnis der Entwicklung, Nahrung und Bildung des Knochensystems bei der Larve von *Alburnus lucidus* Heckel", 1951 "Contribuții la cunoașterea dezvoltării embrionare și postembrionare a plăticii (*Abramis brama* L.) din bălțile Deltei Dunării/Contributions to the knowledge of the embryonico and post-embryo development of common bream (*Abramis brama* L.) from the Danube Delta wetlands, 1958 "Aspectul ihtiologic al Deltei Dunării/The ichthyological aspect of the Danube Delta", 1960 "Observații hidrobiologice asupra Complexului Razelm în perioada 1955-1956/Observations on the Razelm Complex in the period 1955-1956", 1961 "Observații asupra migrației peștilor effectuate în anul 1960 în unitățile experimentale Rusca (Delta Dunării)/Observations on the fish migration in 1960 in the Rusca experimental units (Danube Delta)", 1966 "Date privind hidrobiologia Deltei Dunării/Data regarding Danube Delta hydrobiology", 1969 "Considerații asupra structurii pe specii a actualei populații piscicole din Delta Dunării/Considerations regarding the present fish population structure of the Danube Delta present", 1971 "Modificarea biocenozelor acvatice ca urmare a populării cu pești fitofagi în amenajările piscicole din Delta Dunării/Modifications of the aquatic biocoenosis after the introduction of phitophagous carps in the fish farms of the Danube Delta", 1973 "Posibilitățile de sporire a productivității piscicole în crescătoriile intensive din Delta Dunării/Possibilities of the increasing fish productivity in intensive fish farma of the Danube Delta."

The relevance of the scientific themes approached by *Rodica (Teodorescu) Leonte*, the research methods she used, and the practical value of her assessments, make the work of this scientist, a life-time work of great significance for the development of Romanian hydrobiology, and an example to be followed.

The Editors

CONTENTS

SPATIAL AND TEMPORAL FEATURES OF THE TIMIŞ RIVER (BANAT, ROMANIA) LIQUID FLOW REGIME

Marioara COSTEA *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Ioan Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, marioara_costea@yahoo.com

DOI: 10.2478/trser-2013-0028

KEYWORDS: hydrological regime, maximum and minimum flow, Timiş River.

ABSTRACT

This paper presents an analysis of the flow regime of the Timiş River in Romania. The analysis was based on hydrological data provided by the National Institute of Hydrology and Water Management in specialized publications (hydrological yearbooks or online series). The data were supplemented by personal observations in the field. The following leakage parameters were analyzed: average flow (monthly, seasonal, annual), maximum flow (especially flash floods) and minimum leakage. This paper highlights the link between hydrological parameters and conditioning factors of spatial distribution (characteristics of the geological substratum, relief units, elevation, slope) and temporal variation of flow (in function of type of supply, and variability and variation of climatic conditions).

ZUSAMMENFASSUNG: Räumliche und zeitgebundene Eigenschaften im Abflussregime des Timiş-Flusses (Banat, Rumänien).

Vorliegender Beitrag umfasst eine Analyse des Abflussregimes des Flusses Timiş in Rumänien. Sie beruht auf hydrologischen Daten aus Fachveröffentlichungen des Nationalen Instituts für Hydrologie und Wasserwirtschaft (hydrologische Jahrbücher oder Online Reihe). Die Daten wurden durch eigene Beobachtungen im Gelände ergänzt. Als Parameter für das Abflussregime wurden der mittlere Durchfluss (monatlich, saisonal, jährlich), die maximale Durchflussmenge (insbesondere Überschwemmungen) und minimaler Durchfluss. Der Beitrag hebt die Verbindung zwischen hydrologischen Parametern und den Faktoren hervor, die räumliche Verteilung (Merkmale des geologischen Untergrunds, Reliefeinheit Entlastungseinheit, Höhe, Gefälle) sowie die zeitlichen Schwankungen im Abflussregime bedingen.

REZUMAT: Caracteristici spaţiale şi temporale ale scurgerii lichide pe râul Timiş (Banat, România).

Lucrarea prezintă o analiză a regimului de scurgere a râului Timiş pe teritoriul României. Analiza s-a realizat pe baza datelor hidrologice, furnizate de Institutul Naţional de Hidrologie şi Gospodărire a Apelor, prin publicaţii de specialitate (anuare hidrologice sau serii online). Datele au fost completate de observaţiile proprii din teren. Au fost analizaţi parametrii scurgerii lichide: scurgerea medie (lunară, sezonieră, anuală), scurgerea maximă şi scurgerea minimă. Lucrarea evidenţiază legătura dintre parametri hidrologici şi factorii care condiţionează repartiţia spaţială (caracteristicile substratului geologic, unitatea de relief, altitudinea, panta) şi variaţia temporală a scurgerii (tipul de alimentare, variabilitatea şi variaţia condiţiilor climatice).

INTRODUCTION

Timiş is the main river of the south-western part of Romania. The river has its origin on the eastern slope of Semenic Mountains, at an altitude of 1,135 m below the Piatra Goznei Peak (1,145 m). Timiş course exceeds the state border of Romania and flows into the Danube at Pančevo in Serbia, downstream from Belgrade. The total length of the river course is about 359 km, of which 241.2 km is in Romania (from spring and to the country border, at Grăniceri).

The Timiş River basin is a part of the Danube River basin and drains an area of 7319 km^2, of which 5795 km^2 is on the national territory (NIMH, 1971), as part of the Banat basin (Fig. 1), and is a large complex basin; its catchment area overlapping on distinct relief units: mountains, hills, plains.

The upper basin of the Timiş represents about 20% of the reception surfaces in Romania and includes the following mountain units: the eastern part of the Banat Mountains (to the left side of Timiş River), the western part of Ţarcu - Muntele Mic and Poiana Ruscă mountains (to the right side) and Timiş-Cerna corridor (along the river, including the Caransebeş Depression - an intra-Carpathian depression) (Oancea and Velcea, 1987).

Almost all mountain tributaries in this sector are short, with a strong torrential flow regime imposed by slope and supply regime. The declivity and the permanent flow on Timiş and on the main tributaries (Sebeş) confer to this sector's hydropower potential. In the north extremity of the upper basin, in the Caransebeş Depression, the significant decrease of declivity has generated changes of the river courses and a current active dynamic through meandering.

The middle basin of Timiş comprises of relief units with lower altitudes: Lugojului Hills to north-east of the city of Lugoj, the Pogănişului Hills to the south of this city, Lugoj Plain between the confluence with Bistra and Timişana rivers and Timiş Plain from Hitiaş due west to the state border of Romania (Badea and Bugă, 1992). From a morpho-hydrographic point of view this sector presents the following characteristics: active subsidence, meandering and stationary hydrodynamic processes due to the very low declivity.

The extreme Timiş lower basin is developed on the Serbian Banat territory. In morpho-hydrographic terms it retains the same characteristics similar to the middle sector. The river is arranged, channelled, and is part of the Danube - Timiş - Danube hydro graphic system.

The Timiş Basin shape is elongated from east to west, with an obvious asymmetry in the upper and middle sectors, due to the differences in the length of its tributaries.Thus, in the upper basin, it has an oval shape. The river has a general flowing direction from south to north, longer tributaries on the right part (Pârâul Rece, Sebeş, Bistra) and shorter tributaries on the left part. In the middle sector, the Timiş River has a general flow direction from east to west, and the basin has a trapezoidal shape with the basis to the north and an obvious left asymmetry due to numerous and longer tributaries (Pogăniş, Lanca-Barda, Barzava and Moraviţa) (Fig. 1).

From the entire basin surface developed in Romania, the right side occupies 47%, with an area of 2745 km^2 and the left side is of 53%, with an area of 3050 km^2. Morphometric elements of the Timiş River basin are cumulated in table 1.

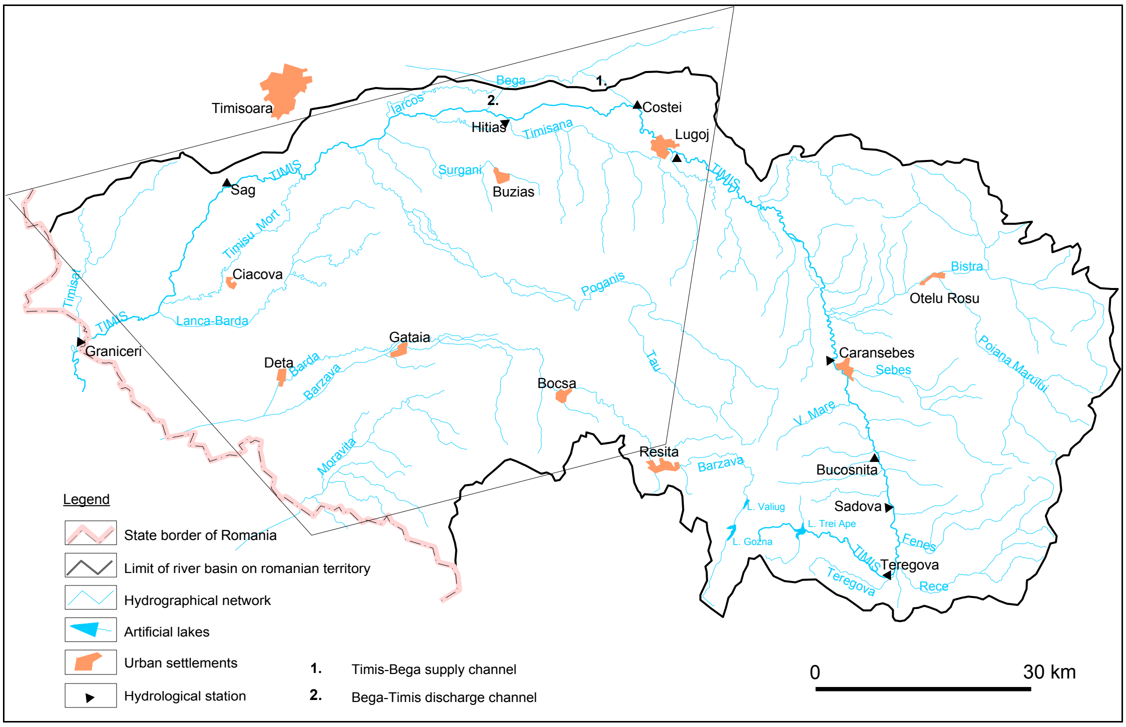


Figure 1: Hydrographic system of the Timiş River and its shape on sectors.

Table 1: Morphometric parameters of the Timiş River basin; Source: Ujvari I., 1972, verified in INMH sources and analytical on a topographic map, scale 1:25000; Hm - mean basin elevation, Im - mean basin slope, F - basin surface, H - section elevation, L - course length from sources to the hydrological station.

River	Section	L (km)	H (m)	River basin		
				F (km^2)	H m (m)	I m(m/km)
Timiş	source	0	1135	-	-	-
	Sadova	36.8	295	559	933	309
	Petroşniţa	47.7	245	740	847	293
	Caransebeş	60.0	200	1072	769	286
	Confluence with Bistra River	71.7	184	2032	782	299
	Lugoj	116.4	117	2706	665	258
	Confluence with Cheveres River	169.5	96	3614	533	201
	Confluence with Pogăniş River	174.0	95	4413	475	178
	Şag	194.1	82	4493	468	175
	at the border	241.2	72	5795	415	151

METHODS

The study was based on literary research, research in the field, collection, and mapping and interpreting of data and information provided by maps, and specialized institutions or locals. The characterization of the hydrological regime in the Timiş River basin was aimed to highlight the average, minimum and maximum flow. The hydrological analysis was based on data collected from the hydrological yearbooks and from the river's hydrological monograph developed by NIMH (1971). Data was updated based on personal field observations, online data from INHGA and recent works (Linc, 2002; Pantu, 2009). The liquid flow analysis was extended to the entire river basin through the correlation between the specific flow and mean elevation of the basin. We analyzed the specific average flow and its seasonal distribution. The hydrological risk phenomena were reported by analyzing maximum and minimum leakage.

RESULTS AND DISCUSSION

Liquid flow regime

Knowing the flow regime of the rivers, and implicitly of the Timiş River, is particularly important for sustainable management of water resources and for ensuring an ecological balance in minor riverbeds and floodplains of collector and tributaries, mostly in the conditions in which the human intervention in the Timiş Basin has been significant since historical times.

The average liquid flow

Average flow is directly influenced by the morphometric characteristics of the river basin (developing in altitude and surface, shape, slope), climatic elements (by rainfall, temperature, evaporation) and by the use of land etc. The Timiş River and its representative tributaries have a permanent drainage system, but first order courses from mountainous region and the I, II and III order courses of the hills and the plains have a temporary drainage system imposed by periodic variation of the non-periodic variability of rainfall (note that the river's order is established according to Horton-Strahler hierarchy).

In these conditions, the Timiş River reaches the hydrological parameters shown in table 3. It should be noted that the leakage regime is controlled by the hydro power stations systems on Timiş River or on its tributaries in mountainous areas, (accumulation of Trei Ape supplements by pumping on pressure pipes the water flow in the Bârzava Basin) (Pop, 1996) or the Pogăniş Hilly region (Badea and Bugă, 1992). The lateral arrangements from the Timiş Plain are also designed to regulate and reduce the risk of flooding in this area.

During the year the richest monthly leakage is achieved in the upper and middle basin between March to June, reaching the highest monthly flows in April at Teregova station and in May at Sadova, Caransebeş and Lugoj stations. The average flow during April at Teregova station is about 17% of the annual flow. The average flow in May is about 17% to Sadova, 15.6% at Caransebeş and 15.7% in Lugoj from the average annual of leakage. The highest values of the monthly average flow of April-May are not correlated with rainfall in these months, but are related to the water content of the snow layer from the Carpathian Basin. Hot air invasions from the Mediterranean induces the melting of snow, which cumulates to the amount of rainfall during these months.

Lowest monthly leakage occurs in autumn; in the months of September and October at Teregova (3.5% of annual flow), in November at Sadova (4.5% of annual flow), in October in Caransebeş (4.8% of annual flow) and in September in Lugoj (2.7% of annual flow). It is linked to the production of small amounts of rainfall in the second half of the year, water consumption in biological processes during the vegetation period and high evaporation in the warm season of the year that reduces underground water reserves.

The seasonal distribution of the liquid flow is determined by a combination of sources of supply and dominance, one of which is correlated with the deployment in the surface and elevation of the reception basin (Tab. 2, Fig. 2). Regarding the seasonal flow regime, the minimum value recorded in autumn both in the Carpathian Basin and in the Timiş Plain due to higher temperatures related to the establishment of an anticyclone regime in the Banat (Linc, 2002), is supplied mostly from underground consumption during the vegetation period and strong evaporation. The dynamics of air masses and Mediterranean cyclone activity, often acting in Banat, causes an accentuated instability during the cold season of the year. This explains the higher values of flow in winter, close to those of summer and in some years it exceeds even spring leakage.

The winter months contribute a proportion of 19 to 25% of the flow as a result of storing a large volume of water in solid form in the layer of snow and ice, the water supply being mainly accomplished from underground. Due to the increase of temperatures, melting snow, (especially in the lower basin) associated with rainfall from the months of March-April, leads as the equalizer; exceeding and even doubling the annual average values in this month, achieving approx. 40-45% of the annual flow (Tab. 2, Fig. 2). Highest monthly average flow occurs in the spring, in the months of April-May, when widespread melting of snow from the Carpathian Basin and rainfall are the main water supplies of the Timiş River and its tributaries. Thus, in the spring the richest leakage during the year (45% of the average annual flows) is done.

Table 2: Seasonal leakage in the Timiş Basin; data processed by Hydrological Yearbooks of the Institute of Hydrology and Water Management.

River/Station	F (km^2)	H m (m)	Distribution of flow %			
			Winter	Spring	Summer	Autumn
Timiş/Teregova	142	871	19.0	44.3	23.8	12.7
Timiş/Sadova	559	933	17.8	43.9	24.2	14.0
Timiş/Caransebeş	1072	769	20.2	41.4	24.2	14.4
Timiş/Lugoj	2706	665	25.6	42.3	22.1	10.0

In the summer, the values of average flow decrease; this causes a flow of approx. 22-24% of the average annual flow. The rising temperatures combined with the sensible decrease of rainfall amounts and strong evaporation in the middle basin causes a drastic decrease of flow in the plain sector. During autumn, flow values are maintained at about 10 - 15% of the annual flow, being the lowest share from the annual values (with the highest weight in the Carpathian Basin - 15% and the minimum weight - 10% in the plains).

Spatial representation and interpretation of data related to the multiannual average flow regime becomes very conclusive if the correlation between altitude basin and multiannual specific flow is made q ($l/s.km^2$) = f (Hm) (Tab. 3, Fig. 3). The figure shows a direct and strong correlation between specific average flow and average altitude of the basin. Considering the altitude as the main cause of differentiated distribution of leakage lies in synthesis of geographical conditions assembly that influence the flow: annual average amount of rainfall, the annual average of air temperature, the afforestation rate of the basin, the morphometric characteristics of landforms, and the hydro-physical features of geological substrata and soils etc.

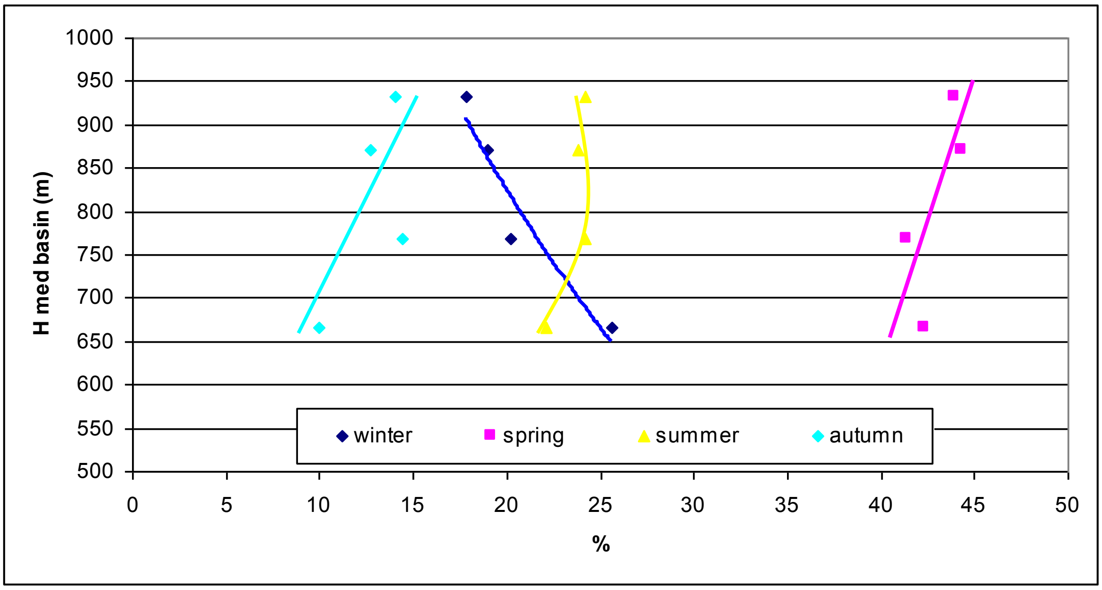


Figure 2: Seasonal average flow in the Timiş River basin.

Table 3: Hydrological parameters of Timiş River in some sections along the riverbed; source - INHGA, Q - average liquid flow; q - specific average flow.

River/section	F (km^2)	H m (m)	Q (m^2/s)	q (l/s.kmp)	Monthly discharge (m^3/s) - assured flow on probability levels		
					80%	90%	95%
Timiş/Teregova	142	871	2.4	16.9	1.70	1.60	1.41
Timiş/Sadova	559	933	10.9	19.50	1.80	1.70	1.53
Timiş/Caransebeş	1072	769	17.4	16.23	2.83	2.66	2.40
Timiş/Lugoj	2706	665	38.8	14.33	7.00	5.50	4.50
Timiş/Şag	4493	477	46.6	10.37	9.30	8.90	8.20
Timiş/Grăniceri	5795	415	49.8	8.59	9.20	8.80	8.10

Non-periodic variation of flow recorded on the Timiş River from year to year is subordinated to weather and climate conditions and also to local conditions that contribute to the flows formation (underground intake, changes in land use, or modification of forest areas). Annual average flows were recorded unevenly in time and space. Linc (2002) calculated the annual average flow for the Caransebeş station, based on data for the period 1976-1996 that the annual average flows with different insurance. The results are presented in the table below (Tab. 4).

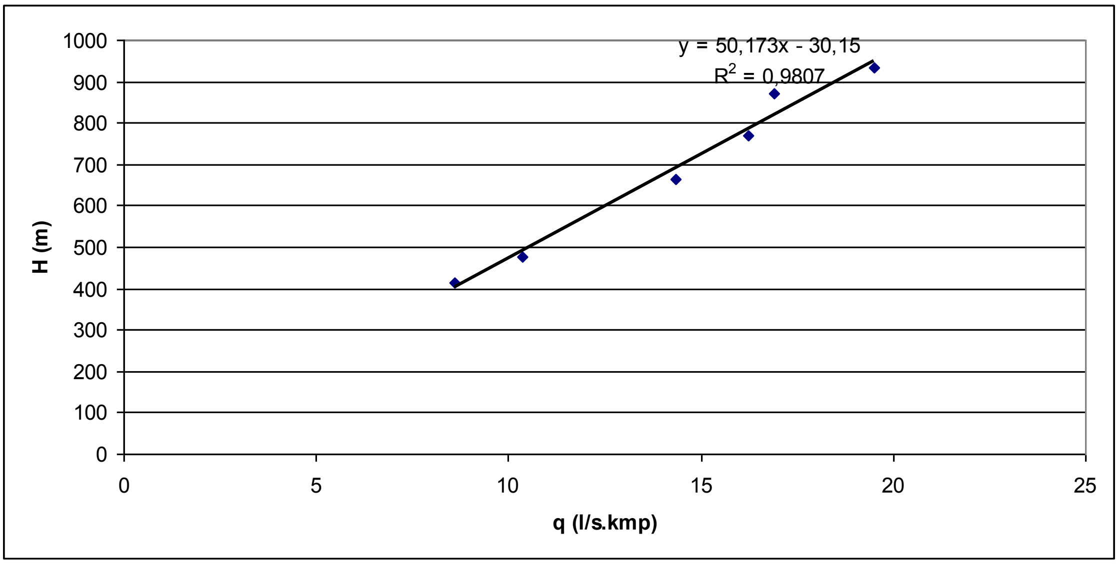


Figure 3: Specific average flow's correlation with mean elevation of the basin.

Table 4: Annual average flow rates with different insurances on the Timiş River; source: Linc, 2002, Cv - coefficient of variation of flow from average values, Cs - assymetry coefficient for characterization of insurance curve shape, Q - annual average flow (m^2/s).

Caransebeş hydrological station Cv = 0.28; Cs =0.49; Q =17.38							
Insurance %	0.10	1	3	5	10	20	30
Q	29.72	27.29	25.72	24.85	23.29	21.55	20.16
Insurance %	40	50	60	70	80	90	99
Q	18.94	17.73	16.51	15.12	13.38	10.94	4.69

The maximum flow

Maximum leakage raises the most important problems in the dynamic of riverbeds, aquatic ecosystems and wetlands. Flow phenomena, in most cases, are generating at large-scale, hydrological risks manifested in the short term, but with long term repercussions (Ştef and Costea, 2006). These risks are associated with geomorphologic risk (torrent, breaking the banks, landslides, and floods), economic risk (destruction of crops, damage of economic objectives and communication networks, etc.) and even social risk (endangerment or even loss of human life). Maximum leakage requires constant monitoring, especially because of the Timiş River basin arrangment. Knowledge of levels and corresponding maximum flow is particularly important in the maintenance and operation of hydraulic and hydropower systems (Pop, 1996; Costea, 2006).

Maximum leakage phenomenon is very complex, and is influenced by a series of factors which include: climatic factors (specially the amount and intensity of rainfall), basin shape and size, the slopes and riverbeds declivity, fragmentation, coverage and vegetation type, the physical and chemical properties of soil and geological substrata, the share of human intervention by deforestation, grazing, hydro exploitation etc., i.e. the ecologic state of the basin at the time of rainfall manifestation.

An important feature of flow in the upper basin of the Timiş River is the appearance with regularity of the annual flash floods, especially in the spring - summer season, from March to June (50%). The highest values of maximum flow occur in May after snowmelt and overlap with the rainfall of this month (Badea et al., 1983). Moreover, about 17% of the annual maximum discharges have a mixed provenance. However, as a result of the warm Mediterranean air invasion, neither of the big winter waters is missing. These are resulting into sudden melting of the snow or rainfall and high flow from December to January (44.0 mc/ s - 86 m^2/s).

Ujvari (1972) specified for the rivers of Banat that, compared to other regions, the maximum flow is higher for the same area of the basin due to the climatic regime, higher humidity and abundant rainfall. In the case of small basins size (100-500 km^2), specific maximum leakage is about 120-150 l/s.km^2 in the Banat Plain, about 300-500 l/s.km^2 in the Pogăniş Hills and about 1000 to 1600 l/s.km^2 in the Carpathian Basin of Timiş. Peak flow values with different insurance are shown in table 5.

Table 5: Maximum flow on Timiş River with different insurances; source: INMH/INHGA, 1970 recalculated data and updated hydrological study.

Hydrologicalstation	Maximum flow (m^2/s) - assured values			
	1%	2%	5%	10%
Teregova	230	176	125	90
Sadova	475	385	345	280
Caransebeş	700	475	320	210
Lugoj	1225	1055	840	675
Şag	1740	1500	1175	960

Flash floods can occur in any month of the year. They have a higher rate of production between February to May and a lower frequency from August to September. Their production depends directly on the synoptic conditions and also on the morphometric characteristics of the river basin and riverbeds. Flash floods of pluvial provenance prevail, and in winter flash floods with nival provenance can be produced. The highest frequency has the monowave flash floods, but can also create the multiwaves flash floods. Table 6 shows the characteristic elements of individual flash floods produced at different hydrometric stations on the Timiş River between 1952-1999.

These phenomena have contributed to the formation of maximum flow to the Timiş River. The most representative flash floods occurred between January to March 1957, between 1978-1980 (86.4 m^2/s in Caransebeş), in 1987 (397 m^2/s - the highest value recorded in April to Caransebeş) in May 1981, from 6 to 10 June 1989, from 20 to 23 April 1998, from 20 to 26 February 1999, 6-7 April 2000, 23 to 26 April 2001, from 15 to 30 April 2005 (Tabs. 7 and 8). The last was by far the most important for the registered of peak flows and of water volumes in transit (http://www.inhga.ro/).

Table 6: The characteristic elements of individual flash flood waves and layers drained volumes at the maximum flow with 1% insurance produced in the Timiş River; Source : INMH, update hydrological study 1970 - 1999; Ib - basin slope; Ir - riverbed slope; Tcr. - time of flow increase; Ttot. - total time of flashflood; W - volume of flasflood; h - the thickness of drained water layer; 1 % - insurance of flow.

Hydro station	F (km^2)	Hm (m)	L(km)	Ib ‰	Ir ‰	Tcr. hours	Ttot. hours	ϒ	$W_{1\%}$ mil.mc	$h_{1\%}$ mm
Teregova	167	906	26.1	187	28.7	19	90	0.28	20.9	125
Caransebeş	1072	769	60.0	286	15.6	33	135	0.30	102	95.2
Lugoj	2706	665	116	258	8.8	45	179	0.26	209	77.4
Şag	4493	468	194	175	5.4	54	210	0.27	356	79.2

Table 7*:* Two significant flash foods on the Timiş River; source: INMH/INHGA.

Date	Conditions	Hydrographic station	Total time hours	Maximum flow m^2/s	Observations
June 1989	In May the rainfall exceeded about 80 l/m^2 the annual average of the south-west Carpathians region; Between 20 May and June 6 - daily rainfall fell	Sadova	80	97.4	Overcoming attention quotas with about 60 cm. Peak quota of 133 cm.
		Caransebeş	98	123	Overcoming attention quotas with about 27 cm. Peak quota of 147 cm.
April 2005	Liquid precipitation occurred during April 14 to 28; The amount of rainfall in 15 days was 201.2 mm, exceeding the annual average of April (176.8 mm).	Lugoj	72	1135	The highest flow ever recorded on the Timiş River, this led to exceeding dam's defense quotas and to flooding interfluves' area between Timiş and Bega rivers.
		Şag		1083	

Table 8: Volumes and drained water layer on the Timiş River at flash flood from April 2005; source - INHGA 2005 quoted by Panţu, 2009; * = recorded values;** = reconstructed values by adding of volumes stored in permanent and non-permanent accumulations and of those lost by dykes breaking; Ws - drained volume;Wt = total volume; h_{p+z} = the thickness of the drained water layer on the basin surface, from rain and snowmelt.

Secţiunea	Q max (m^2/s)	Ws (10^3 mc)	Wt (10^3 mc)	h_{p+z} (mm)
Lugoj	1135	350^{*} 372^{**}	450^{*} 472^{**}	166
Şag	1083	598^{*} 715^{**}	796^{*} 913^{**}	171
Grăniceri	920	296^{*} 747^{**}	486^{*} 937^{**}	163

In the production condition of the above flow on the Timiş River in April 2005, the defense dikes which accompanies the river between Lugoj and the border, were exceeded (these dykes are classified as IVth class on the base of their importance) (http://www.rowater.ro/dabanat). Discharge areas were Lugoj - Coştei and Cebza - Grăniceri. Supplementation of the Timiş flow with debit transferred from the Bega River through the stack bypass of Topolovăţ (to avoid flooding of Timişoara) resulted in recording the largest flow that occurred on Timiş in the Banat Plain. The river overflows the embankment and has produced some breaches downstream to Crai Nou which led to flooding of the Timiş - Bega interfluve and to the calamity of the localities of Foeni, Cruceni, Giulvăz, Rudna, Crai Nou, Ivanda, Rudna, Peciu Nou, Diniaş, Sânmartinu Sârbesc, Gad, Uivar, Otelec and Ionel (Panţu, 2009).

The minimum flow

Minimum leakage is recorded over the entire basin of Timiş, but mainly characterizes the upper basin in the Caransebeş Depression and the lower basin in the Timiş Plains, where the flow is significantly reduced. This hydrological indicator is directly dependent on the groundwater supply, on the depletion degree of the underground water resources and on interception of these resources by riverbeds.

Minimum leakage occurs in two distinct periods of the year and presents differences along the river. Minimum flows recorded in the winter are characteristic to the upper basin and the summer - autumn minimum flows are characteristic to the depression and plain area. Minimum leakage between December to March is due to the winter meteorological phenomena such as: frost, snow falls, and average daily temperatures below 0°C, water storage in the snow layer and due to emergence and evolution of winter phenomena on rivers, especially ice bridge. The minimum, for the interval August-September coincides with the vegetation season, where the maximum water consumption is recorded; the evaporation increases due to the high temperature and the rainfall is also the lowest.

Due to the contribution of the permanent springs and almost uniformly distributed rainfall all year round in the Carpathian Basin of Timiş, the leakage is not totally reduced. There are situations where flows were greatly reduced; in the droughty years the flow reached the lower limit, about 85% probability of occurrence. Also, the minimum flow of the Carpathian Basin of Timiş is substantially influenced by reservoirs; downstream of the Trei Ape Dam the flow is reduced significantly in lengths of 500-1,000 m, being ensured only the flow of servitude.

The middle basin corresponding to the Banat Plain is facing a minimum leakage more pronounced in summer and autumn, when the Timiş River and its tributaries supply exclusively from groundwater sources and the high temperatures favour a large loss by evaporation. Added to these factors are the interception and the water consumption by spontaneous vegetation and crops. Moreover, the minimum flow values are significantly altered in the plain of water uses in agriculture and retentions along the Timiş River or the tributaries.

Rivers flowing is a common phenomenon in the Banat Plain, and is not only because of the climate condition like pluvial and thermal variability. Other causes are the geological substrate, high permeability and its composition of gravel and sands deposits (Geological Map, 1968) which favours rainwater infiltration under the riverbeds and very small slope that impedes the water drainage to the Timiş riverbed and tributaries. Table 9 cumulates the minimum flow data for different insurance on the Timiş River.

Table 9: Characteristic data regarding the minimum flow on the Timiş River (INHGA).

Hydrological section	Minimum flow with different insurance q (l/s.km^2) Q (m^2/s)			Minimum monthly average flow VI - VIII by various insurance companies q (l/s.km^2) Q (m^2/s)		
	80%	90%	95%	80%	90%	95%
Teregova	3.34 0.56	2.94 0.49	2.40 0.40	5.07 0.85	4.20 0.70	3.70 0.62
Lugoj	1.85 5.00	1.66 4.50	1.47 4.00	2.84 7.70	2.10 5.70	1.66 4.50

CONCLUSIONS

Considering that flow interacts with all environmental components, knowledge of its characteristic values has a great practical importance for determining water reserves from the Timiş River and the tributaries in order to satisfy the utilities, ensure ecological flow and avoid the hydrological risk. For the analysis of morphohydrographic and ecological systems along the Timiş and to preserve the ecological balance, it is necessary to know the hydrological regime of the river; especially knowing the degree of maximum and minimum flow rates at different times of the year and different durations. The Timiş River's hydrological regime has a great variability and variation in time and space. It depends on the altitude, by the climate conditions and by the peculiarities of geological substrate. The natural and anthropogenic conditions are different, depending on relief units (mountains, hills, plains) drained by Timiş.

Altitudinal variation of the flow regime for the upper basin is specific to the Western Carpathian type, with spring high water occurring early and lasting for 1-2 months, with high Carpathian hydrograph for the upper basin (the highest leakage is recorded in winter, spring, and then in autumn, with a mixed supply). Summer can record longer periods of dryness and even drought. Autumn floods have a frequency of 30-45% in the Carpathian sector of the basin and winter floods are above 30%, and can have catastrophic effects.

The middle basin has a west peripheral-Carpathian drainage regime, with a high percentage of winter leakage (35-40%) due to the accentuated instability and action of barometric centres and Mediterranean cyclones. Warm and moist air masses, originating from the Mediterranean, produce sudden melting of snow in the winter not only in the western periphery of Carpathian (Banatului Plain) area but also in the upper basin (Banatului and Godeanu - Ţarcu mountains), which causes winter nival-pluvial and pluvial floods. The frequencies of floods in warm winters reach around 60-70%. The months of May and June are also characterized by a high leakage with numerous floods, and during summer and autumn the small waters are installed. The interval from November to December is also noted by leakage increase, with pluvial floods at a frequency of 50-60%.

Due to numerous arrangements in the Timiş Basin, the natural flow regime is altered by the storing of water in lakes and by the artificial flow transfer between Timiş Basin and Bega Basin and vice versa. Major influences on the flow regime are? the consumers, especially urban settlements and agriculture. A real analysis of the hydrological features must be based on the updating and restoring of natural flow. This operation needs a great effort to update the hydrological data base with the data registered in the last years, to quantify the volume of drained water in the managed regime and to assess the volume which would be taken by consumers. This requires a good management at INHGA, a good collaboration with another institution and also a better knowledge of field reality.

ACKNOWLEDGMENTS

This work is a part of the scientific study of the quality of the Timiş River water, "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of "Lucian Blaga" University, Faculty of Sciences, financed by the European Community. The author is grateful to Ecotur Sibiu NGO for the publishing of this paper. Also, the author thanks the reviewers for suggestions and to all colleagues involved in the research, especially to Mr. Bănăduc D. for the support in riverbed measurement in the field campaign.

REFERENCES

1. Costea M., 2006 – Riscul la inundaţii. Impactul în peisaj, în Hidrologie aplicată, Ştef V. and Costea M., (eds.), Edit. Universităţii "Lucian Blaga" din Sibiu, 205-240. (in Romanian)
2. Linc R., 2002 – Culoarul Timiş-Cerna, Edit. Universităţii din Oradea. (in Romanian)
3. Panţu H., 2009 – Modernizarea sistemului hidrotehnic Timiş – Bega, Edit. Politehnica, Timişoara, 241. (in Romanian)
4. Pop G., 1996 – România. Geografie hidroenergetică, Edit. Presa Universitară Clujeană, Cluj-Napoca, 233. (in Romanian)
5. Ştef V. and Costea M., 2006 – Hidrologie aplicată, Edit. Universităţii "Lucian Blaga" din Sibiu, 297. (in Romanian)
6. Diaconu C., 1971 – Râurile României. Monografie hidrologică, Edit. INMH, Bucureşti, 494. (in Romanian)
7. Badea L., Gâştescu P. and Velcea V., 1983 – Geografia României. Geografie fizică, Edit. Academiei, Bucureşti, 652. (in Romanian)
8. Oancea D. and Velcea V. (coord.), 1987 – Geografia României, III, Carpaţii şi Depresiunea Transilvaniei, Edit. Academiei Române, Bucureşti, 647. (in Romanian)
9. Badea L. and Bugă D. (coord.), 1992 – Geografia României IV, Regiunile pericarpatice, Edit. Academiei Române, Bucureşti, 580. (in Romanian)
10. ***, 1968 – Harta geologică a României. Foile Jimbolia, Timişoara, Deva, Scara 1:200000, Institutul Geologic al României.
11. http://www.rowater.ro/dabanat/default.aspx
12. http://www.rowater.ro/INHGA/default.aspx

TIMIŞ RIVER FLOODING IN BANAT (ROMANIA) IN 2005

Daniel Mihuţ CODEA *

* "Politehnica" University of Timişoara, Enescu Street 1/A, RO-300022, codea_dani@yahoo.com

DOI: 10.2478/trser-2013-0029

KEYWORDS: flood, flooding, risk, causes, effects, damage.

ABSTRACT

Flooding that occurs in the Banat basin is a natural and frequent phenomenon on the water courses in this catchment area, where 1,085 km of the water courses are dammed and there are also numerous hydrotechnical and water management works. Although these works are well made and are intended to protect against floods, a review of these natural phenomena occurring in Banat highlights the fact that over a period of approximately 250 years, major flooding has occurred with a frequency of about once every 30 years, and in some cases these phenomena occur every few years, for example the floods of 2005 which occurred just five years after the floods of 2000. In almost every month in 2005 (February-September), throughout Romania, river water volumes exceeded the capacity that water defences were built to handle. The most important floods in Banat occurred in April. In April 2005 heavy rains were recorded in the Banat region: Oraviţa (226.4 mm), Resiţa (205.3 mm), Lugoj (201.2 mm), Caransebeş (200.6 mm). These rain falls exceeded previously recorded maximum monthly levels. This rainfall combined with snow melt - the thickness of snow layers in the mountains at that time exceeded one meter (Ţarcu - 126 cm, Semenic - 26 cm) – led to historically significant flooding from April to September 2005, affecting extensive areas and resulting in casualties and significant property damage.

ZUSAMMENFASSUNG: Vom Timiş-Fluss im Jahr 2005 im Banat (Rumänien verursachte Überschwemmungen.

Die Überschwemmungen, die im Einzugsgebiet des Timiş-Flusses im Banat stattgefunden haben, stellen ein häufig auftretendes, natürliches Phänomen an den Fließgewässern dieses hydrographischen Raumes dar, in dem 1085 km von Wasserläufen eingedeicht und zahlreiche wasserbauliche sowie wasserwirtschaftliche Maßnahmen durchgeführt wurden.Obwohl diese Arbeiten sachgemäß durchgeführt wurden und den Zielen des Hochwasserschutzes dienen, zeigt die Analyse dieser natürlichen, im Banat stattgefundenen Ereignisse, dass sich die Jährlichkeit der außergewöhnlichen Hochwässer von einem 250 jährlichen Hochwasser auf einen Zeitraum von 30 Jahren reduziert hat. Es gibt Fälle, in denen sich derartige Ereignisse auch im Zeitraum von einigen Jahren wiederholen, so wie es das Hochwasser von 2005 zeigte, das nach nur fünf Jahren auf jenes von 2000 folgte. Fast in jedem Monat des Jahres 2005 (Februar - September) wurden die Wasserstände der Sicherheitsbemessung für Hochwässer im Lande überschritten, wobei die größten Hochwässer im Banat im April gemessen wurden.

Die für das Banat heftigsten Regenfälle des Jahres 2005 wurden im April an folgenden meteorologischen Stationen registriert: Oraviţa (226,4 mm), Reşiţa (205,3 mm), Lugoj (201,2 mm), Caransebeş (200,6 mm). Sie überschritten den bis dahin monatlich gemessenen Höchststand. Die Regenfälle überlagerten sich mit der Schneeschmelze in den Gebirgen, wobei die Mächtigkeit der Schneedecke auch über 1 Meter Höhe lag (Ţarcu -126 cm, Semenic - 26 cm). Die im Zeitraum April bis September 2005 registrierten Überschwemmungen waren dann von besonderer Bedeutung, wenn sie an fast allen Flüssen auftraten. Dabei erreichten einige unter ihnen auch historische Abflüsse, die große Flächen erfassten und zu Opfern sowie einem beträchtlichen materiellen Schaden führten.

REZUMAT: Inundaţii în Banat (România), datorate râului Timiş în 2005.

Inundaţiile care au avut loc în bazinul Banat constituie un fenomen natural frecvent pe cursurile de râu din acest spaţiu hidrografic, unde sunt 1.085 km de curs de râu, care sunt îndiguiți, precum și numeroase lucrări hidrotehnice și de gospodărire a apei. Deși aceste lucrări sunt bine realizate şi au ca scop apărarea împotriva inundațiilor, o analiză a acestor fenomene naturale petrecute în Banat, scot în evidență faptul că pe un interval de aproximativ 250 ani, periodicitatea acestor inundaţii majore este de circa 30 ani, existând şi cazuri când aceste fenomene se produc la intervale de numai câţiva ani, cum este şi exemplul inundaţiilor din 2005 petrecute la doar cinci ani după cele din 2000. Aproape în toate lunile anului 2005 (februarie-septembrie) s-au produs depășiri ale cotelor de apărare pe cursurile de apă din țară, cele mai importante inundaţii înregistrate în Banat au fost în luna aprilie.

Ploile torențiale căzute în 2005, în Banat, în aprilie au fost înregistrate la stațiile meteorologice: Oravița (226,4 mm), Reșița (205,3 mm), Lugoj (201,2 mm), Caransebeş (200,6 mm) au depășit nivelul maxim lunar înregistrat. Aceste precipitații combinate cu topirea stratului de zăpadă existent în munți cu grosimea de peste un metru (Țarcu -126 cm, Semenic - 26 cm), inundațiile înregistrate în perioada aprilie-septembrie 2005 au fost cele mai importante, când au avut loc pe cele mai multe râuri, unele cu debite istorice, afectând arii extinse și au dus la victime și pagube materiale deosebit de importante.

INTRODUCTION

Floods are natural and recurring events in rivers and streams. Floods are usually described in terms of their statistical frequency, such as a “100-year flood” or “100-year floodplain” describes an event or an area subject to a 1% probability of a certain flood occurring in any given year. The frequency of flood depends on the climate, the material that makes up the banks of the waterway, and the channel slope. When substantial rainfall occurs in a particular season each year, or where the annual flood is derived principally from snowmelt, the floodplain may be inundated nearly every year, even along large streams with very small channel slopes. In regions without extended periods of below-freezing temperatures floods usually occur in the season with the highest precipitation (USA Agency, 1991), (Balica, 2007).

In 2005 Banat rivers had the highest recorded water levels of all the existing observations of most hydrometrical stations in the region, prompting additional discharge at dams on the Timiş and Bârzava rivers downstream of Lugoj in Gătaia. The Bega River and the Timiş River, which are united by a hydraulic node transition because of the Topolovăţ flood, had the highest volume recorded during observations in 2005.

During almost all months of 2005 water levels exceeded the capacity of flood mitigation defenses along waterways. During the major flooding period between April to September 2005 there were significant floods on most rivers, some with water rising to historical levels and causing property damage and loss of life. Although in the past 40-50 years there have been significant flooding events - though never as large as a 100-year event - flood-level water flows have not occurred over such an extended period of time, February to September 2005 in this case. Other flood events, such as those in 1970 and 1975, were concentrated in much smaller geographic areas than the 2005 flood event (Nichita et al., 2005).

RESULTS AND DISCUSSIONS

Timiş River geography and characteristics

The Timiş River (Figs. 1 a and 1 b), the main hydrographical artery in the western part of Romania, springs from the Semenic Mountains at an altitude of approximately 1,135 m. The Timiş River also collects runoff waters and snowmelt from the slopes of the Banat Mountains, the Ţarcu Mountains, the Godeanu Mountains and the Poiana Ruscă Mountains, as well as the Piedmont Hills of Lugoj and Pogăniş. These runoff areas create a hydrographical basin of 5,795 km² of surface area (Arba et al., 2013).

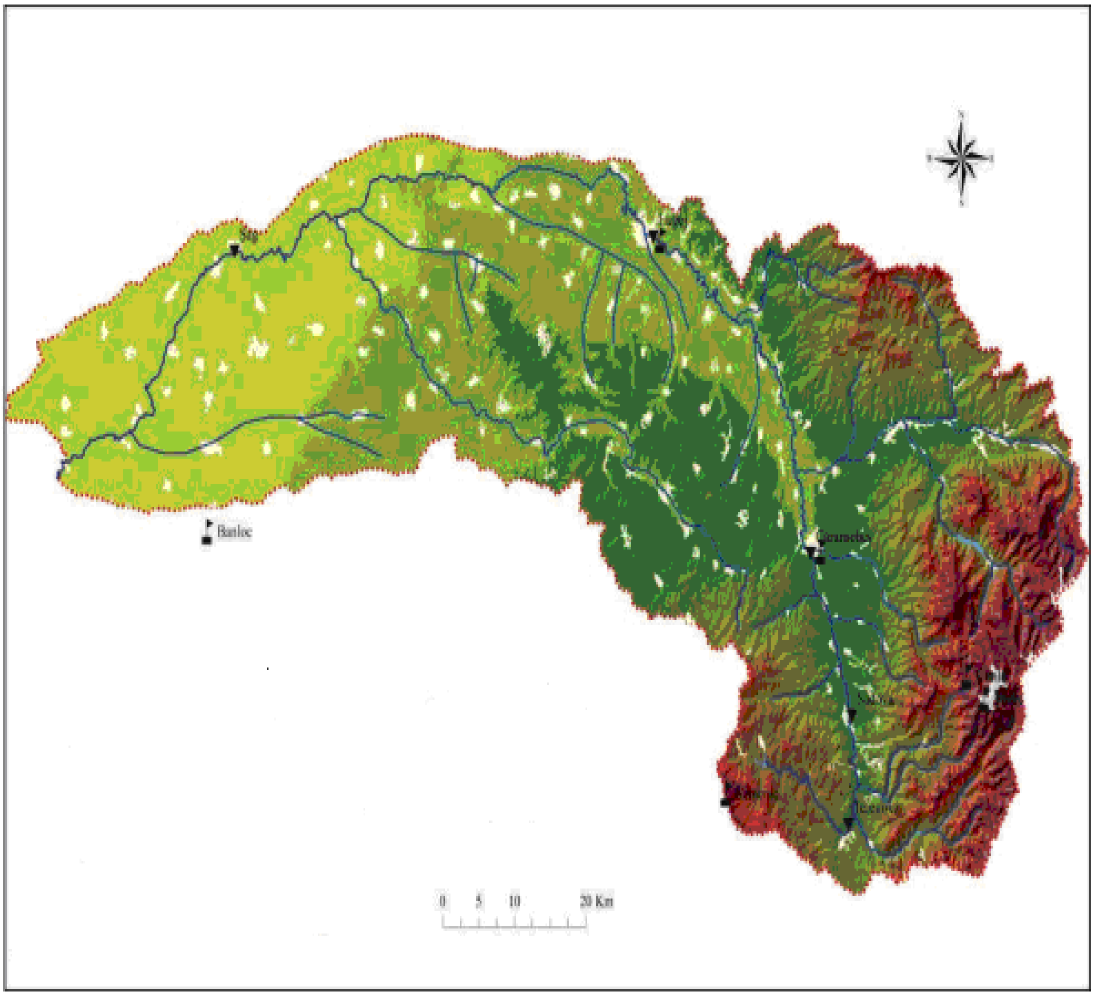


Figure 1a: The map of the hydrographical basin of Timiş River.

Figure 1b: The map of the hydrographical basin of Timiş River.

The Timiş River is the largest waterway in the Banat hydrographic area with a watershed basin area of 10,352 km², 5,795 km² of which is in Romania. With a total length of about 340 km, nearly three quarters (244 km) of the Timiş is in Romania. About 970 km of the Banat basin is divided with 824 km on the Timiş River, and 146 km on the Bega River in the area where the Timiş and Bega interconnect (Fig. 2).

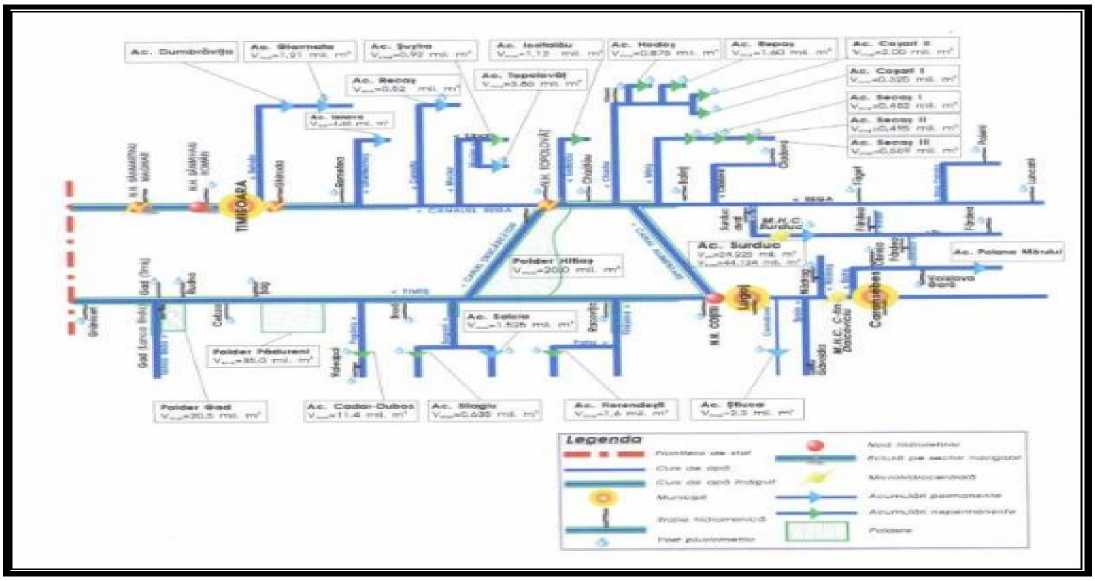


Figure 2: Bega-Timiş Interconnection (Banat Water Directorate, Romania).

The Timiş River is formed by the confluence of three rivers: the Semenic, the Grădiştei, and the Brebu. The Brebu Stream springs originate in a massif mountainous area in the north-eastern part of the Brebu watershed. After passing the man-made Trei Ape Lake, the Timiş River flows northwest to southeast through a narrow valley with slopes greater than 20 m/km. At the Teregova Depression between the Caransebeş and Mehadia Mountains the Timiş turns north. Here the slopes are a more moderate 5 m/km. In this part of the Timiş River the most notable waterways feeding into the Timiş are the Pârâul Rece, the Feneş, the Bolvaşniţa, the Sebeş, the Axin and especially the Bistra. After the Bistra the Timiş River again changes direction northwest to Lugoj. Contributing waterways along this stretch include the Măcicaş, the Vâna Ohaba, the Spaia, the Cernabora and the Nădrag, which is the largest. The lower course of Timiş River meanders through a wide valley with a low slope, crossing the Timiş Plain to leave the country at Grăniceri. The Grăniceri area is often threatened by flooding and consequently has many hydrotechnical works to handle this regular flooding. Finally, the Timiş River flows into the Danube in Serbia near the town Pancevo. (Udo et al., 2011)

HYDROLOGICAL AND METEOROLOGICAL CHARACTERIZATION

The year 2005 was characterized by a slightly lower average temperature across the country, specifically 0.1º C lower than temperatures in the reference period of 1961-1990. It is worth pointing out this near-normal average temperature for 2005 includes noteworthy positive temperature deviations between 0.2-2.4º C during six months of the year (January, May, July-September, December), and lower temperature values of 0.3-2.60º C in the remaining six months of the year (February-April, June, October, November). Throughout the country the average amount of rainfall was 866.5 mm in 2005 compared to a normal average rainfall of 647.0 mm. Precipitation was above average in January-May, July-September, and December but below average in June, October, and November. Overall, the average rainfall in 2005 was 33.9% percent higher than the average rainfall during the reference period (Ministry of Environment and Water Management, 2005).

In April 2005, precipitation values recorded at 12 meteorological stations in the Banat physiographic zone exceeded normal values, in some cases by 200 mm (Fig. 3). Most of these excessive rainfall amounts were recorded in three short intervals during the second half of April. Rainfall in May was concentrated in the southern part of the country with heavy and intense precipitation events exceeding normal amounts by 100 mm at many stations from the Romania river basins (Stănescu et al., 2006).

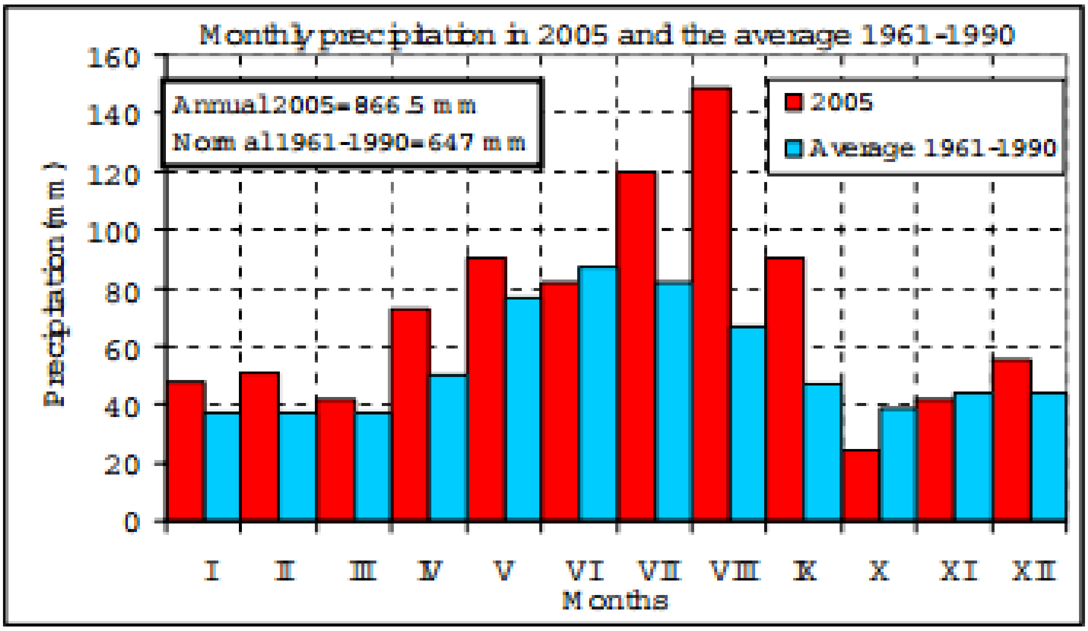


Figure 3: Monthly precipitation in 2005 and the normal amounts (after ANM-Romania).

To define hypothetical flood areas this analysis used hydrological data (levels and flows recorded at the hydrometric stations of Caransebeş and Lugoj) collected prior to 2005, which was a year with one of the fastest rising freshets and largest floods in the past few decades. In this analysis, waterways where streams were modified, altered, dammed, or otherwise regulated, were not taken into account. Only natural, unmodified floodplains of the Timiş River were analysed. From 2000 to 2005 there were no significant hydrological events recorded on the Timiş River, however, in April 2005 the Timiş River had a very large flood event, both in terms of effects on the environment, and in terms of the scale of physical damage, especially in the low plain of Banat. During the analysis period in the early 2000's the most important factor contributing to excessive water resources, and consequently to excessive water flows, was rainfall. The quantity of rainfall was also a determining factor in the impacts of water flows (Arba, 2010).

The flood of Timiş River basin in April 2005

In April 2005 temperatures across Romania were close to normal. Rainfall was above average in Maramureş, Crişana, Banat, Transylvania, Dobrogea, Muntenia and northern and central Moldova, while precipitation was nominally deficient in other areas. The greatest precipitation amounts (more than 200 mm) in April 2005 occurred in Oraviţa (226.4 mm), Resița (205.3 mm), Lugoj (201.2 mm), Caransebeş (200.6 mm), all localities in the Banat region. A handful of weather stations recorded highest-ever precipitation amounts for a 24-hour period: Resița (79.2 mm), Caransebeş (67.6 mm), Bozovici (66.4 mm), Timişoara (63.0 mm); (Ministry of Environment and Water Management, 2005).

The worst flooding of the last 35 years occurred in 2005, primarily due to high quantities of precipitation, which were generated by intense cyclonic air movement across the entire European continent. High air temperatures also helped set the stage for record flood conditions. Last, but not least, extreme water flows were augmented by sudden snow melts. The combination of these causes led to several successive record-level flash floods along the inferior course of the Timiş River. Water spilling over the dam canopy (Fig. 4a) at Crai Nou led to accelerated erosion and the formed two breaches around the dam on the right bank of Timiş River. (Stănescu et al., 2006)

Figure 4a: Effects of 2005 floods.

These historically high water flows led to flooding on river lands, which in turn led to flooding (Fig. 4b) around Crai Nou, and to a lesser extent at Rudna, Cruceni, Foeni, Ionel, Otelec and Sînmartinul Sârbesc. The effects of this record hydrological event were exacerbated by a transversal landfill on Serbian territory between the Timiş River and the Bega River. (Ministry of Environment and Water Management, 2005).

Damages produced by flood events in 2005

In 2005 flooding, spills, and damage to the dams and other water management improvements, small leaks on the slopes and other dangerous weather phenomena affected all Romanian counties and 1,734 localities with a total damage loss estimated at 5,975,201 RON. There were 76 deaths, 93,976 houses and ancillary buildings were damaged, 1,063 social and economic programs and objectives were impaired, and over 656,392 hectares of agricultural land were damaged. A total of 630 defensive hydrotechnical structures, mainly dikes and riverbank stabilization measures, were also badly damaged, necessitating immediate reconstruction work.

In the Banat area the total of damage loss in counties Caraş-Severin was 363,209 RON and in Timiş it was 406,069 RON. (Ministry of Environment and Water Management, 2005)

Figure 4b: Effects of 2005 floods.

CONCLUSIONS

Natural phenomena such as torrential rains that occur during the spring months, combined with snow melt, are very dangerous because of the physical and economic damage it can cause due to flooding, including loss of life. Flood conditions are a product not only of excessive water flows due to heavy rain, but a river's ability to adequately handle water volumes far in excess of normal. In low-lying areas or plains where river slope is relatively low (typically areas where people have built settlements) water-flow velocity tends to drop in relation to the hydrographical network upstream.

In order to mitigate the effects of record water flow events it is necessary to accurately forecast weather with enough time for water management authorities to take structural and non-structural measures in advance of any potentially destructive hydrological events.

ACKNOWLEDGMENTS

This work was partially supported by the strategic grants: POSDRU/88/1.5/S/50783, Project ID50783 (2009) and POSDRU 107/1.5/S/77265, Project ID77265 (2010), co-financed by the European Social Fund - Investing in People, within the Sectoral Operational Programme Human Resources Development 2007-2013.

REFERENCES

1. Arba A., 2013 – Extreme Hydro-Meteorological phenomena on the hydrographical basin of Timiş (1965-2009), *Riscuri şi Catastrofe*, XII, 12, 1, 99-112.
2. Arba A., 2010 – History of floods occurred in Banat, Review of Historical Geography and Toponomastics, V, 9-10, 45-52.
3. Balica S., 2007 – Development and Application of Flood Vulnerability Indices for Various Spatial Scales, MSc Thesis (WSE - HERBD - 07.01), April 2007, 151.
4. Ministry of Environment and Water Management, 2005 – Analysis of the activities developed in 2005 for the management of the emergency situation generated by floods and the strategy for 2006 (published on the internet site), 1-31.
5. Nichita C., Hauer E. and Croitoru A. E., 2006 – Situaţii de vreme severă cauzate de producerea precipitaţiilor abundente: inundaţiile din Banat, aprilie 2005, III, *Riscuri şi Catastrofe*, Edit. Casa Cărţii de Ştiinţă, Cluj Napoca, 105-114. (in Romanian)
6. Oncia S., Copăcean L. and Hebei M., 2012 – Flood risk assessment in Timiș river basin - The Caransebeș-Lugoj sector - Using GIS technique, *Geographia Napocensis*, VI, 2, 173-179.
7. Udo J., Aldescu C., Dumitrache R. and Luca L., 2011 – INHGA, 109-122. (in Romanian)
8. Stănescu V. A. and Drobotă R., 2006 – Great floods in Romania in 2005. Lessons on preparedness and prevention role in flood control, International Workshop on Hydrological Extremes, University of Calabria, Cosenza (Italy), May 3-4, 55-69.

SOME GEOMORPHOLOGIC ASPECTS ALONG THE TIMIŞ RIVER IN THE ROMANIAN SECTOR

Marioara COSTEA *

* "*Lucian Blaga*" University, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, 7-9 Raţiu Street, Sibiu, Romania, RO-550012, marioara_costea@yahoo.com

DOI: 10.2478/trser-2013-0030

KEYWORDS: floodplain, riverbed, transversal sections, fluvial processes.

ABSTRACT

This paper presents a geomorphologic analysis of the Timiş riverbed in Romania. The analysis was based on data from own observations in the field, within the project called "Protection measurements of Timiş River - Step II" Contract 411/90964/30.12.2010/07 by the University "Lucian Blaga" of Sibiu, Faculty of Sciences - Research Center of Applied Ecology, from June to December 2011.

Minor riverbed configuration and morphometry, the size of the material from the riverbed, and the forms of erosion and accumulation have been considered. This paper highlights the riverbed morphology in the different sectors (mountain, depression and plain), identifies the dominant fluvial processes and key features in the evolution of the Timiş riverbed, and also establishes links between morphology, size of fluvial deposits and natural and anthropogenic control factors.

ZUSAMMENFASSUNG: geomorphologische Aspekte entlang des Timiş-Flusses im rumänischen Abschnitt.

Vorliegende Arbeit beinhaltet eine geomorphologische Analyse des Timiş-Flussbettes in Rumänien. Sie beruht auf eigenen Felduntersuchungen, die im Rahmen des Projektes "Schutz-Maßnahmen des Timiş-Flusses - Stufe II", Vertrag 411/90964/30.12.2010/07 an der "Lucian Blaga" Universität Sibiu/Hermannstadt - Forschungszentrum für Angewandt Ökologie, von Juni bis Dezember 2011 durchgeführt wurden.

Untersucht wurde Morphometrie und Konfiguration des Niedrigwasserbettes, die Korngröße des Bettmaterials sowie die durch Erosion und Anlandung entstandenen Bettstrukturen. Vorgestellt wird dabei die Morphologie des Flussbettes in verschiedenen Abschnitten, d.h. im montanen sowie dem Senkenbereich und den Tiefebenen. Hauptprozesse und Besonderheiten in der Entwicklung des Flussbettes wurden identifiziert und auch einige Beziehungen zwischen Morphologie, Größe der Ablagerungen und den natürlichen und anthropogenen Kontrollfaktoren festgelegt.

REZUMAT: Aspecte geomorfologice de-a lungul albiei Timişului, în sectorul românesc.

Lucrarea prezintă o analiză geomorfologică a albiei râului Timiş pe teritoriul României. Analiza s-a realizat pe baza datelor obţinute în urma observaţiilor de teren realizate în 2011, în cadrul proiectului „Măsuri de protecţie a râului Timiş - Etapa II" contract 411/ 90964/30.12.2010/07 realizat de Universitatea „Lucian Blaga" din Sibiu, Facultatea de Ştiinţe, în perioada iunie - decembrie 2011.

Au fost analizate configuraţia şi morfometria albiei minore, dimensiunea materialelor din albie, formele de eroziune şi cele de acumulare. În această lucrare este evidenţiată morfologia albiei pe diferite sectoare (montan, depresionar şi de câmpie), sunt identificate principalele procese fluviatile şi particularităţile în evoluţia albiei şi de asemenea s-au stabilit unele legături între morfologie, dimensiunea depozitelor şi factorii de control naturali sau antropici.

INTRODUCTION

The Timiş River basin is part of the Banat hydrographic system and it drains an area of 7319 square kilometres, of which 5795 square kilometres are in Romania. The Timiş course exceeds the national border of Romania and flows into the Danube at Pančevo, downstream of Belgrade, in Serbia. The total length of the course is about 359 km, from which 241.2 kilometres in Romania (Ujvari, 1972). The fluvial system is extremely complex due to its overlap over distinct relief units: mountains, depressions and hills, plains. The morphogenetic and morphometric features of transited relief units generate distinct geomorphologic characteristics of riverbed and morphodynamic differentiations (Fig. 1).

Between source (Semenic Mountains at 1,135 m altitude below Piatra Goznei Peak) and Armeniş the riverbed has a mountainous character. The course is carved into crystalline schists, presents an accentuated slope (average slope of 20 m/km) and the erosion processes prevail. Downstream Teregova, Timiş River enters into Timiş-Cerna Transcarpathian Corridor (*, 1987), where the fluvial morphology is influenced by tectonics and by the contribution (liquid and solid flow) of Carpathian tributaries. In this sector, small depressionary areas alternate with gorges. In the Caransebeş Depression, developed on the sedimentary deposits of the Neogene basin, the Timiş riverbed has a meandered and divagated character (Linc, 2002).

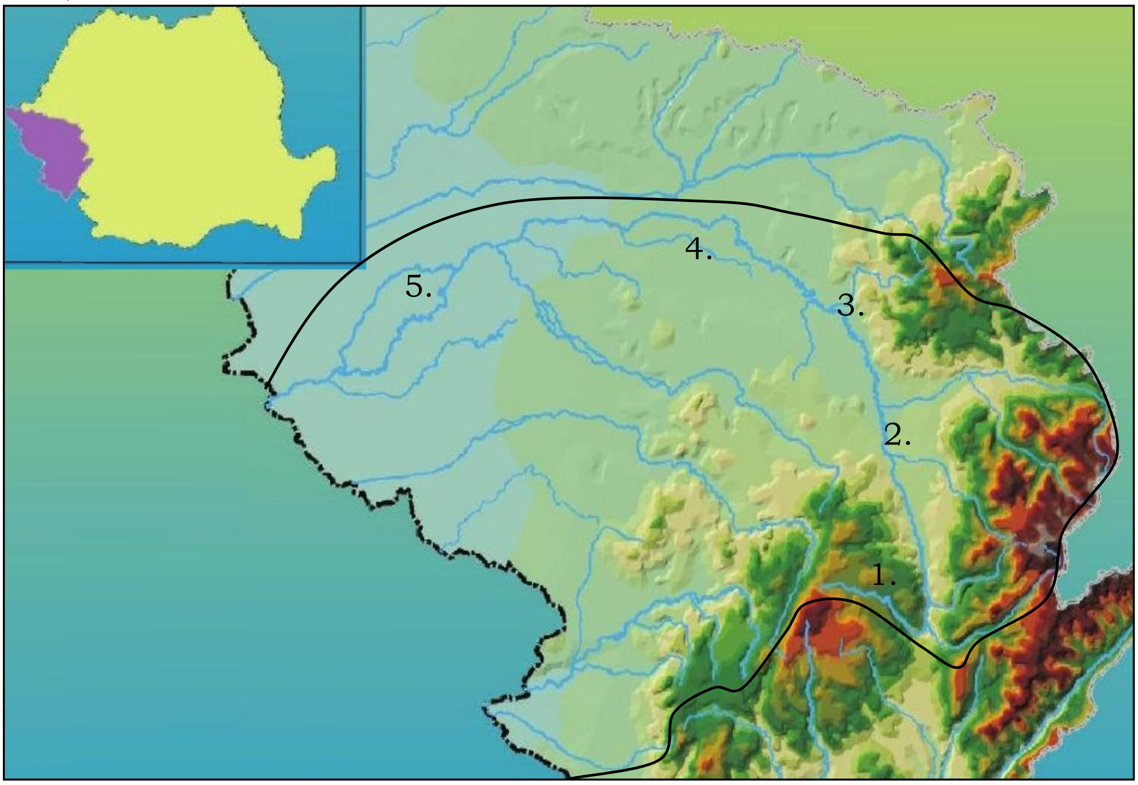


Figure 1: Timiş River basin in the Romanian territory and the relief units along the Timiş riverbed. Mountainous sector: 1. Semenic Mountains; 2. Caransebeş Depression; Hilly sector: 3. Lugoj Hills; Plain sector: 4. Lugoj Plain; 5. Timiş Plain. (http://www.directiaapelorbanat.ro)

The morphometric characteristics of relief (very low slopes 0-7^o, low relief energy 2 to 10-50 m) determine the dominance of accumulation processes in the riverbed. In the piedmont plain of Lugoj, the Timiş Valley widens, the meandering processes and divagating character are increasing due to the decreasing slope (the average slope of the riverbed is about 1.6 m/km). In the Timiş Plain, the natural subsidence (1-2.5 mm/year) and the low slope (1-0.15 m/km) caused a great mobility of the riverbed (Ştef and Costea, 2006) by: disentangling, strong meandering, watercourse divagation, the presence of local depressionary areas with excess moisture. Agradation and riverbed elevation caused river flowing above the plain (**, 1992). This character is maintained still nowadays, even though the river is embanked.

Throughout the entire course length, the dynamics of Timiş riverbed is subject to anthropogenic influence (Panţu, 2009) through direct intervention by crossing accumulation (Trei Ape dam), lateral reservoir, embankment, evacuation or additional off-flow through derivatives systems (Timiş-Bega), and by exploitation of materials (sand and gravel).

METHODOLOGY

The research methodology was based on field observations and on the geological, geomorphologic and hydrological data and procedures. The geomorphologic interpretations were derived from topographic maps (scale 1:100 000) and geologic maps (Harta geologică a României, 1968), direct measurements and cross section representation. Morpho-hydrographic analysis follows some significant issues: regional characteristics of geomorphologic features, data on petrography and superficial deposits, data on landform morphometry, especially on the floodplain (Lewin, 1978) and minor riverbed (Thorne, 1982; Schumm, 1985), fluvial forms and processes distribution (Leopold et al., 1964; Ichim et al., 1989). The field campaign was conducted on the entire length of the Timiş course. Representative sections were selected for observations and measurements (Fig. 2; Tab 1). Also, the analysis was based on minor riverbed transversal profiles (Figs. 3-8) obtained using graphics processing Mathcad (Sîrbu, 2009) of the collected morphometric data.

ANALYSIS AND INTERPRETATION

Section 1 is located on the upper sector of the Timiş River, in the Semenicului Mountains, downstream of the Trei Ape dam, at 802 m altitude. The mountainous relief is represented by Nergana leveling surface (*, 1987), developed on the interfluves which surrounding the depression Gărâna - Brebu Nou, at altitudes of 1100-1050 m. It is a polycyclic complex formed in the late Oligocene, located in extension of the upper complex (Semenic). The connection of this leveling surface with Gărâna - Brebu Nou Depression is done by inclined slopes (45-60^o). Located around ± 200 m below this, there is an erosive depression dug into Holocene deposits. Timiş River has carved here a complex of five terraces (4-7 m, 10-15 m, 20-30 m, 35-50 m, 60-80 m) and two levels of meadow. The horizontality of interfluves, the minor relief energy of medium leveling surface (25-50-80-120 m/km^2) and width of the depression, along with the favorability of climatic conditions have facilitated installation of the permanent settlements Gărâna and Brebu Nou.

Downstream of the depression, the Timiş River deepens in the lower leveling platform - Tomnacica (sculpted at the end of Miocene and early Pliocene). In this sector, there is a typical Carpathian Valley, carved in crystalline rocks of Timiş series, with relief energy of 200-250 m and a slope of 22 to 24 m/km. Downstream of the dam, the Timiş major riverbed is quite wide, with bilateral development, having two levels, the lower one at 0.5 to 1 m and a higher one at 1.5-3 m. The inferior level has a width of 4 - 6 to 10 m. The slopes are in direct contact with the major riverbed and have high declivity (45°-50°-70°).

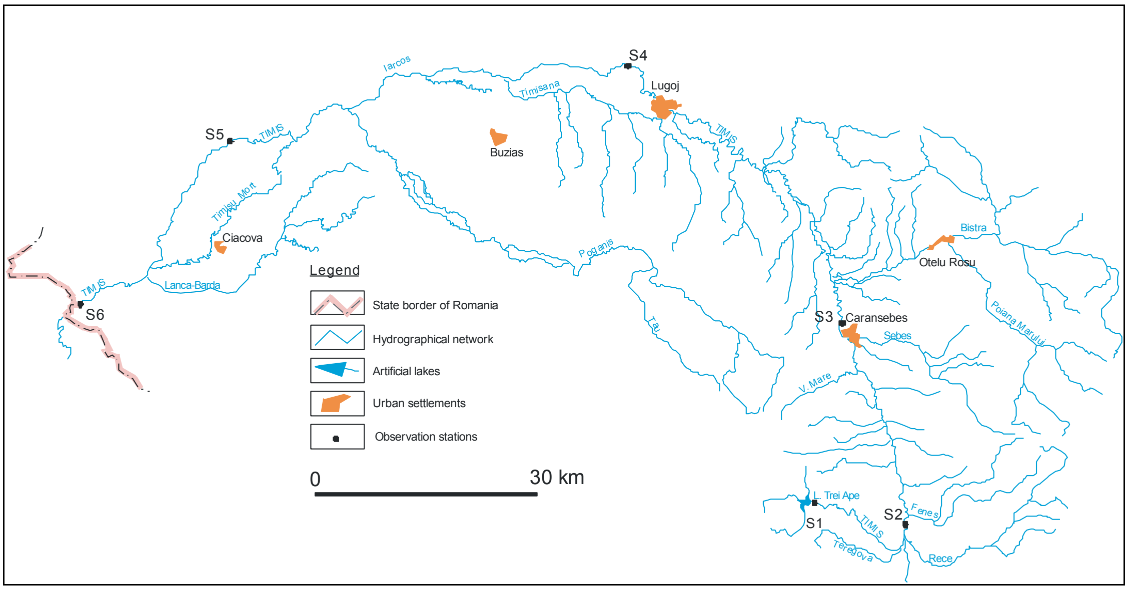


Figure 2: Transversal sections position along the Timiş River.

Table 1: Morphometry of Timiş riverbed; measured data.

No.	Section	Altitude (m)	Channel width B(m)	Maximum depth (m)	Average depth h_{med} (m)
1.	Timiş downstream of Trei Ape dam	802	6.20	0.27	0.152
2.	Timiş upstream Armeniş	354	16.10	0.40	0.202
3.	Timiş downstream of Caransebeş	175	49.30	1.20	0.447
4.	Coştei Channel - Timiş-Bega bypass	116	26.0	2.32	1.291
5.	Timiş at Şag	83	49.5	1.60	0.518
6.	Timiş at Grăniceri	74	22	1.70	0.584

The minor riverbed has a width of 6.2 m in the active section. The riverbed is made of hard rocks, metamorphic rocks belonging to the series of Timiş (gneiss, micaschists, amphibolites) with large size blocks (5 m/2 m). Coarser (1000 mm/600 mm, 300 mm/250 mm, 400 mm/250 mm) and smaller boulders (200 mm/150 mm, 240 mm/160 mm) and gravel agglomerate the riverbed and form large islands and side accumulations. Accumulation of coarse material in the riverbed is caused by sudden reduction in this sector of the transport capacity of the river as a result of the fluid flow blocking behind the upstream dam (Ichim and Rădoane, 1986). Aggradation of the river channel by gravitationally intake from the slopes is also registered. The flow passed through the active section at the time of observation was about 0.108 m^3/s, the salubrious flow being assured through the bottom spillway. The riverbed depth is uneven, being minimum at river sides and maximum near the centre of the riverbed. The river average depth is about 0.152 m (Fig. 3).

Section 2 is located at an altitude of 354 m in Teregova Gorges, 5 km downstream to Teregova, on the right side of the European road E 70. This sector is part of the Timiş - Cerna tectonic corridor. Upstream Teregova Gorges, along Timiş corridor develops a typical piedmont level - the Teregova level (400-550 m) that decreases in altitude from south to north according to the direction of the river flow, which has been shaped in Romanian-Villafranchian sedimentary deposits. The landscape is complex. Teregova and Armeniş Gorges alternate with depressions. These two epigenetic gorges are carved into the Getic Nappe crystalline of the Timiş series and downstream of them the valley returns to the wide configuration of a depressionary corridor. Alternation of depressionary basins with gorges gives not only landscape diversity, but also a differentiated land use. Also, there are different conditions for the human settlements, these being located at the extremities of gorges in the small depressionary basins.

The valley is narrow and very sinuous. The slopes of the valley have accentuated slope (60-70^{o}) and a different energy relief: 200-400 m on the left side and 80-100 m on the right side. The top of the interfluves on this side is part of the piedmont level with altitudes of 550-400 m and is covered by pastures and meadows, with small areas of orchards. On the left slope of the valley the high relief energy makes possible the direct connection of riverbed with lower levelled surface Tomnacica - Cârja (± 800 m). Both slopes and tops of the interfluves are well wooded with deciduous forests, thus limiting the action of gravity and pluvial denudation processes.

The riverbed has a width of 16 m in the active section, a maximum depth of 0.40 m, an average depth of 0.20 m and a flow rate of 1.87 m^2/s at the time of observation (Fig. 4). The bottom pavement (Ichim et al., 1989) is made of boulders (500mm/400 mm), coarser gravels and sands indicating a balance between fluvial processes. The active section has a right asymmetry, the maximum depth being reached at 2.5 m from this riverbank, which is higher, with accumulation of stones. The left bank is lower with accumulation processes of boulders, gravels and sands.

Section 3 is located downstream of Caransebeş, at 175 m altitude, upstream of the railway bridge. From a physico-geographical point of view, this section is located at the northern end of the Caransebeş Depression in a maximum wide sector which makes the transition to the Banat Plain. The Caransebeş Depression is built on sedimentary deposits of gravel, sandstone, limestone and sandy clays. In this geological substratum, the Timiş River has dug a wide valley in which we can identify the lower levels of the floodplain and terraces (4 - 7 m, 10 - 15 m). Floodplain of the Timiş River at Caransebeş has a width of 1.5 - 2 km and is suspended 2 - 3 m from the river channel. The transition to the first fluvial terrace is gradual, almost imperceptible, which gives the depression a lowland character. The riverbanks along Timiş are fixed by spontaneous forest vegetation, reeds and sedges and the floodplain is occupied by meadow and different crops, especially cereals. In the considered active sections, the river channel is asymmetrical, with depths up to 0.5 m over a distance of 35 m from the left bank, after which the depth suddenly increases up to 1.20 m (40 m above the left bank) (Fig. 5). The left bank is accumulated on a length of about 65 m with boulders, gravel and silt and is lower compared to the right bank which is higher (2-3 m) and eroded. In the river channel and at the left bank, coarser and medium size formations (boulders and gravel) predominate in proportion of 90%, embedded in a sandy and muddy mass. The ccompetence of the river is quite high due to the accumulated flow on the upstream route. The reduced slope of the river favours the accumulation and unplaite processes and the formation of islands.

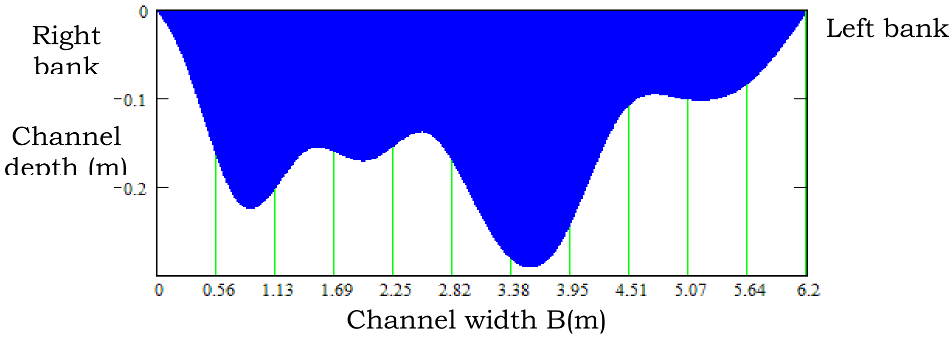


Figure 3: Active section on Timiş River downstream Trei Ape

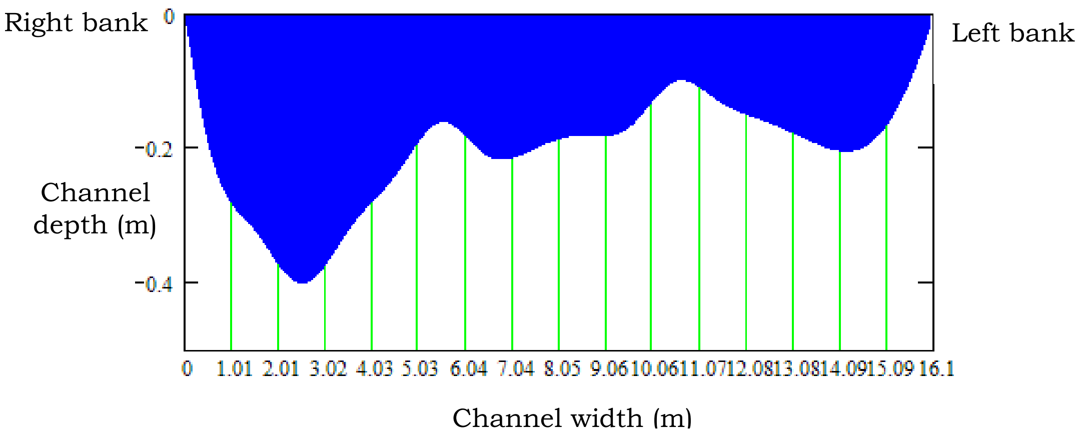


Figure 4: Active section on Timiş in Teregova Gorge.

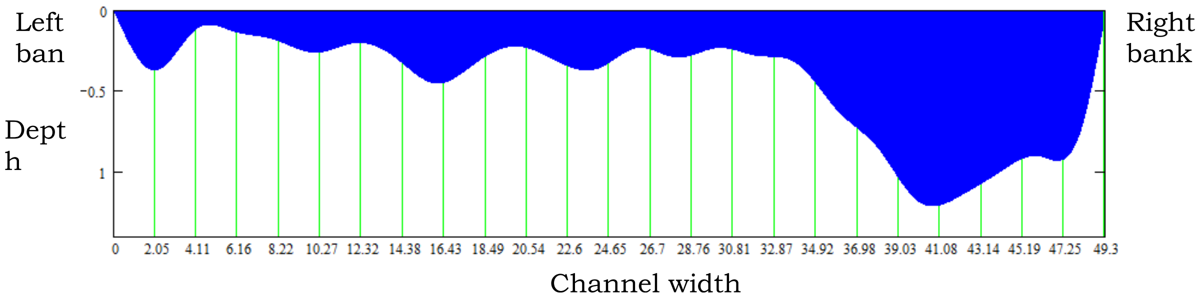


Figure 5: Active section on Timiş downstream Caransebeş.

The forms of accumulation and the banks are stabilized by vegetation: riverside coppice, adventives vegetation, reeds and sedges. At the time of observation the Timiş flow-rate calculated by the section-velocity method was 15.46 m^2/s. Massive accumulations of gravel and boulders are exploited through the ballast pits at Caransebeş, as well as throughout Timiş. Export of material from riverbed changes the relationship between fluvial processes and deepens the minor riverbed to 3 m at least from the floodplain. Construction materials are exploited also from the floodplain, where the excavation depressions are fuelled from the river by groundwater and give rise to permanent ponds with specific vegetation.

Section 4 is situated near the settlement Coştei, in Lugojului Plain, at an altitude of about 116 m, in the hydrotechnical junction node Timiş - Bega. In this sector, the major riverbed of Timiş River is very large; the river has strong meanders, has formed many oxbows, abandoned meanders, disentangling and wetlands, especially upstream of Coşteiu. Following the work of land reclamation, Timiş was embanked and deepened and downstream Coştei the riverbed is dammed throughout its length in the plain. The dams have a height of 3 - 5 m above the riverbed and protect the agricultural land of floodplain and settlements of flooding. In the alluvial plain, fluvial deposits consist of coarse sand and even gravel, on which occur alluvial soils in association with gley soils and eumezobazic wet soils. The granulometric composition is diverse and the horizons of soil profile are chaoticly stratified (cross structure).

Between the high banks of the Timiş River, protisoils are found - alluvisols developed on sand banks and on higher accumulations with coarser texture. The banks and islands are fixed or partially fixed by hygrophilous vegetation. Repeated fluvial processes, especially alluviation, lead to expansion and to formation of new alluvial layers between dikes. In the analysed section, the Timiş River channel has a width of about 110 m and is strongly modified as a result of human intervention. Through the bypass of Coştei (Panţu, 2009), a part of the flow is exported towards Bega. The Timiş River flow is deviated through minor riverbed changes towards the Coştei channel and through the existence of a transversal island and dam which are blocking the flow into Timiş. The flow rate directed toward Bega, calculated by the method of section – velocity, was 7.6 m^2/s at the time of observation. (Fig. 6).

In this context, during the observation period, the Timiş riverbed was visibly affected by a drastic decrease of water level, by flow blocking and by interruption of connectivity with the river channel downstream of the dam. Behind the spillway dam, the waters are stagnant in quasi-lacustrine systems. The water level has decreased both because of flow removal through the Coştei channel and due to a severe drought recorded in the second half of 2011. The effects of this deviation and disruption of connectivity are emphasized downstream of the dam by the material exploitation from the riverbed. Excavations have led to the formation of isolated ponds and puddles that do not communicate with each other because of sand banks and artificial islands which block the leak. Under these conditions the riverbed geomorphology balance, but also the ecological, are deeply disturbed.

Section 5 is located in the Timiş Plain, at an altitude of 83 m to the south of Şag, upstream of the road bridge. Due to the lower altitude (90-80 m) than Lugojului Plain and due to the subsidence and divagation character of this plain, the Timiş course has meandered and has numerous bed mobility problems caused by active fluvial processes. The divagation character was slowed due to damming throughout the Timiş Plain, but the very small bed slope (from 0.15 to 0.45 m/km) still favours, between dikes, the meandering processes, strong and active processes of accumulation and the existence and continuous formation of sandy beaches. Stationary hydrologic processes occurred both between and beyond the dams lead to the formation of wetland areas, maintained by the direct contact with the river or groundwater which is near the surface.

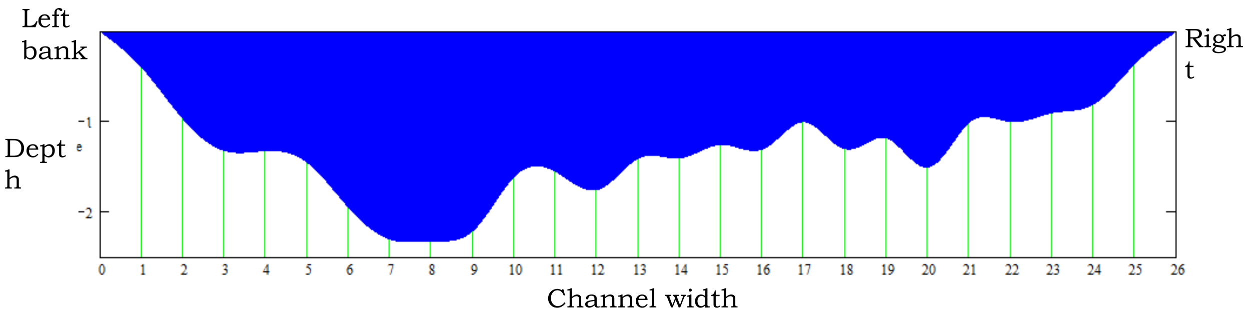


Figure 6: Active section on Coştei Channel - junction to Bega.

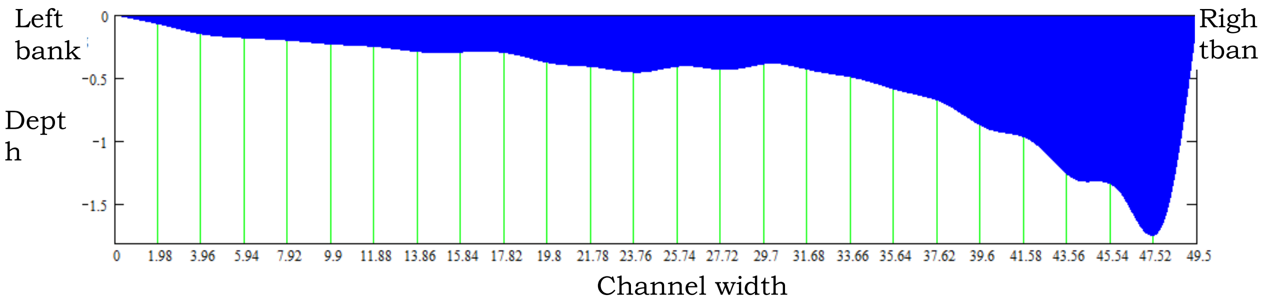


Figure 7: Active section on Timiş River to Şag.

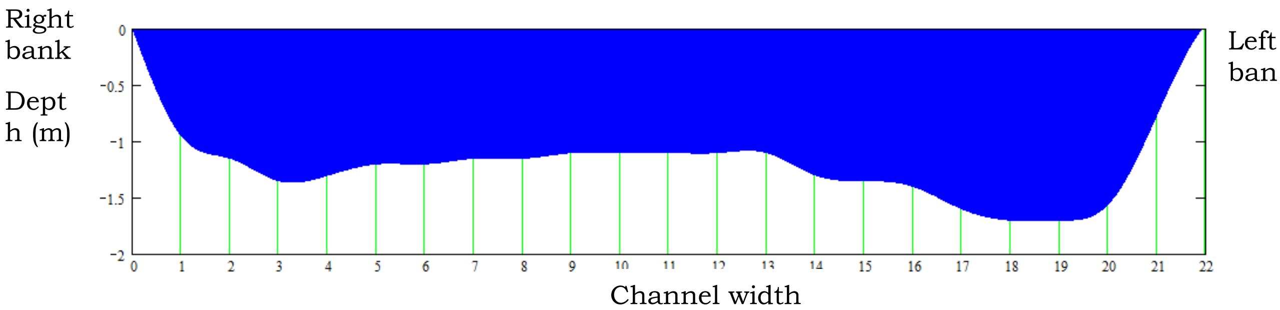


Figure 8: Active section on Timiş River to Grăniceri.

Direct observations were made in a meander loop (Fig. 7). The river is totally embanked. The right bank is high and eroded, and the left side is lower and accumulated. The sands are dominant (90%) (micaceous sand, fine and silty sand) and silt (10%) that were formed psamosoil and undeveloped soils (Ianoş et al., 1997). The terracing and embankment of the dam is done on three levels. Sands are fixed by willow riverside coppice forming a green corridor, interrupted here and there by grassy areas. Where the depositional processes are still active sands are not fixed. This sector of Timişului riverbed has also a leisure and recreation function for local people interested in fishing, walking or sunbathing.

Outside the dammed enclosures, on the newer alluvial deposits cambisoils are formed. Soil formation processes are increasing as a result of minor riverbed damming and reduction of the flooding risk in these areas (Ianoş et al., 1997). The land is used for agriculture, grain and forage being cultivated.

Section 6 is located at 74 m altitude, about 1 km upstream from the Romanian-Serbian border. Here the floodplain has the same characteristics as in the previous sector, belonging to the same unit of relief - the Timiş Plain: lack of terraces, flatness of the surfaces, meandering of riverbed. Altitudes are between 74 and 78 m. Sedimentary geological substrata are composed of Quaternary deposits (sands, gravels), all covered by recent alluvial deposits.

The riverbed is embanked, and between dykes the soils (protisols) and alluvial deposits (recent fine silt) are subjected to the action of groundwater (near the surface 1 - 2 m) and level fluctuations of Timiş River. The dykes system was rehabilitated after the floods from autumn 2006. These dams were built at a higher safety class to prevent flooding in this region and to reduce transboundary hydrological risks (Panţu, 2009). The dyke height from the water level at the time of observation was about 14 m. The dikes are terraced and the riverside coppice which accompanied the Timiş course in this sector has been cleared to avoid the leakage blocking. The minor riverbed was also relatively levelled and the banks were consolidated to limit the erosion.

Due to the course meandering between dykes, an asymmetrical internal meadow has been formed. Upstream of the bridge, the riverbed is wider, with disentangling and active accumulation of islands and beaches. The riverbed is uniform downstream the bridge (Fig. 8), almost rectilinear, as a result of human intervention, and the internal meadow develops better on the right side (over 200 m wide). The dimension of fluvial forms and the continuous developing of them between the dykes indicate the entering of the riverbed into a new geomorphologic equilibrium phase after embankment.

CONCLUSIONS

The active fluvial processes and the flow contribute to the changing of the riverbed morphology. Erosion and accumulation are processes that succeed over time and in space along the river Timiş. Cross sections indicate a relative bed symmetry in the mountain and a strong asymmetry in the depression and plains. Changes in the riverbed by extension, narrowing, deepening or suspension are the result of flow regime and alternation of processes of erosion, transport and accumulation, all these being phases of the riverbed dynamics. The geological features, the morphometry of the riverbed and the flow remain the most important control factors, a correct management of the fluvial system being necessary. The monitoring of geomorphologic and hydrologic processes along the Timiş River is required even more, especially due to the already verified possibility of erosion of banks with destructive character and negative impact on the human habitat and economy (ex. 2006 floods).

The equilibrium adjustment and maintenance can be solved in an anthropic way, by a series of measures for the prevention and attenuation of the effects of erosion or accumulation processes and anthropogenic degradation. A comprehensive approach to all the factors involved in the riverbed dynamic and morpho-hydrographic imbalances induced by flow, gravel exploitation, calls for further interdisciplinary studies and their integration in the sustainable regional development desiderate.

ACKNOWLEDGMENTS

The author is grateful to "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of "Lucian Blaga" University of Sibiu, Faculty of Sciences, financed by the European Community and to NGO Ecotur Sibiu for publishing of this paper. Also, the author thanks to the reviewers for suggestions and to all colleagues involved in the research, especially to Mr. Bănăduc D. and students Răchită R., Mărginean M. and Stoilă V. for the support in riverbed measurement in the field campaign.

REFERENCES

1. Ianoş G., Puşcă I. and Goian M., 1997 – Solurile Banatului. Condiţii naturale şi fertilitate, Edit. Mirton, Timişoara, 392. (in Romanian)
2. Ichim I. and Rădoane M., 1986 – Efectele barajelor în dinamica reliefului, Edit. Academiei Române, Bucureşti, 157. (in Romanian)
3. Ichim I., Rădoane M., Bătucă D. and Duma D., 1989 – Morfologia şi dinamica albiilor de râuri, Edit. Tehnică Bucureşti, 404. (in Romanian)
4. Leopold L. B., Wolman M. G. and Miller J. P., 1964 – Fluvial Processes in Geomorphology, Freeman W. H., San Francisco, 522.
5. Lewin J., 1978 – Floodplain geomorphology. Progress in Physical Geography, 2, 3. Edit. Arnold, 408-437.
6. Linc R., 2002 – Culoarul Timiş - Cerna, Edit. Universităţii din Oradea.
7. Panţu H., 2009 – Modernizarea sistemului hidrotehnic Timiş-Bega, Edit. Politehnica, Timişoara, 241. (in Romanian)
8. Schumm A. S., 1985 – Patterns of alluvial rivers, *Annual Review of Earth and Planetary Sciences*, 13, 5-27.
9. Sîrbu I., 2009 − Bazele modelării proceselor şi sistemelor ecologice, Edit. Universităţii „Lucian Blaga” din Sibiu, 175. (in Romanian)
11. Ștef V. and Costea M., 2006 – Hidrologie aplicată, Edit. Universității „Lucian Blaga” din Sibiu, 297. (in Romanian)
12. Thorne C. R., 1982 − Processes and mechanisms of river bank erosion. Gravel-bed rivers, Hey R. D., Bathurst J. C. and Thorne C. R., (eds), John Wiley and Sons, Inc., Chichester, U. K., 227-271.
13. Ujvari I., 1972 – Geografia apelor României, Edit. Științifică, București, 577. (in Romanian)
14. *, 1987 – Geografia României. Carpații și Depresiunea Transilvaniei, Edit. Academiei Române, București. (in Romanian)
15. **, 1992 – Geografia României. Regiunile pericarpatice, Edit. Academiei, București. (in Romanian)
16. ***, 1968 – Harta geologică a României. Foile Jimbolia, Timişoara, Deva, Scara 1:200000, Institutul Geologic al României. (in Romanian)
17. http://www.directiaapelorbanat.ro/ (in Romanian)

MONITORING AND EVALUATION OF TIMIŞ RIVER (BANAT, ROMANIA) WATER QUALITY BASED ON PHYSICOCHEMICAL AND MICROBIOLOGICAL ANALYSIS

Letiţia OPREAN *, *Ecaterina LENGYEL* ** and *Ramona IANCU* ***

* "*Lucian Blaga*" University, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, 7-9 Raţiu Street, Sibiu, Romania, RO-550012, oprean_letitia@yahoo.com

** "*Lucian Blaga*" University, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, 7-9 Raţiu Street, Sibiu, Romania, RO-550012, kalengyel@yahoo.de

*** "*Lucian Blaga*" University, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, 7-9 Raţiu Street, Sibiu, Romania, RO-550012, iancu_r@yahoo.com

DOI: 10.2478/trser-2013-0031

KEYWORDS: physico-chemical analysis, heavy metals, bacteriological indicators.

ABSTRACT

Flowing water, like rivers, represent an important drinking water source for Romania, their quality being influenced by the quantity of materials in suspension and in colloidal form, and their physicochemical and microbiological characteristics. The Timiş River is generally characterized by the presence of some impurities in natural state, their specific composition being dependant on the nature of the surrounding soils, the soils in the reception basin, waste water spills from different users, and the dissolving capacities of the gases in the atmosphere.

The Timiş River has in general a lower level of mineralization, the sum of mineral salts dissolved being below 280 mg/l and formed of bicarbonate, chloride, nitrate, phosphates, sodium sulphate, potassium, calcium and magnesium coming from the erosion of rocks, soils and precipitations. The concentration of hydrogen ions (pH) is situated around neutral, ranging from 7.3 to 8.8; among the dissolved gases is oxygen, with values ranging between 4.52 and 7.46 mg/l. The main characteristic of the water flow is represented by the variable charge (sometimes appreciable) of materials in suspension and colloidal materials (clay, sand, silica) but also by organic substances, the charge being directly proportional to the meteorological and climate conditions. This charge grows during rainfalls, reaching the maximum during large floods and the minimum during freezing periods (CCOMn max. 30.2 mg O_2). Heavy metals like mercury and arsenic are found in the Timiş waters, but in quantities that do not conclusively affect the water quality, their values being below the maximum allowable amounts.

Bacteriological contamination is also observed. Microorganisms, viruses and protozoa are derived from wastewater spills with human or animal waste, and microorganisms specific to the ecosystem. The total coliforms reach $5x10^3$/100 ml water, the fecal coliforms $2.2x10^2$/100 ml water, which results in several sectors of the river being classed as lower quality.

ZUSAMMENFASSUNG: Monitoring und Bewertung der Wasserqualität des Timiş-Flusses anhand von physikalisch-chemischen und mikrobiologischen Analysen.

Die Fließgewässer stellen eine wichtige Trinkwasserresource für Rumänien dar, wobei ihre Qualität von der Menge der Schwebstoffe und der kolloidalen Stoffe sowie deren physikalisch-chemische und mikrobiellen Charakteristika beeinflusst wird. Der Timiş-Fluss kennzeichnet sich allgemein im natürlichen Zustand durch das Vorhandensein von Verunreinigungen, die spezifische Zusammensetzung ist jedoch abhängig von der Art der Böden durch die das Wasser fließt, von den Böden im Einzugsgebiet, aber auch von den Abwässern die von verschiedenen Verbrauchern eingeleitet werden sowie der Lölichkeitskapazität.

Der Timiș-Fluss kennzeichnt sich allgemein durch eine niedrige Mineralisierung, wobei die Summe der gelösten Mineralsalze unter 280 mg/l liegt und aus Bicarbonaten, Chloriden, Nitraten, Phosphaten, Natirumsulfaten, Kalium, Kalzium und Magnesium besteht, die sich durch die Erosion der Gesteine, des Bodens und durch die Regenfälle gebildet haben. Die Konzentration der Wasserstoffionen (pH) liegt um den neutralen Wert, zwischen 7,3 und 8,8; von den gelösten Gasen ist der gelöste Sauerstoff mit Werten von 4,52 und 7,46 mg/l zu nennen. Das Hauptkennzeichen des Flusses ist die wechselnde Belastung (manchmal beachtliche) durch Schwebstoffe und kolloidale Stoffe (Ton, Sand, Silizium), aber auch durch organische Stoffe, die direkt proportional abhängig sind von den meteorlogischen und klimatischen Bedingungen. Diese steigen während Regenzeiten, erreichen ein Maximum während der großen Hochwässer und sinken auf ein Minimum während Frostzeiten (CCOMn max. 30,2 mgO_2). Schwermetalle wie Quecksilber und Arsen sind im Timiș-Fluss vorzufinden, jedoch in Mengen, die Wasserqualität kaum beeinflussen, da die Werte unterhalb der zugelassenen Höchstmengen liegen.

Es wurden auch bakteriologische Verunreinigungen festgestellt. Die dem Ökosystem eigenen Mikroorganismen, Viren, Protozoen stammen aus der Einleitung von Abwässern, die mit menschlichen oder tierischen Ausscheidungen verunreinigt sind. Die Gesamt Coliformen erreichen bis zu 5 x 103/100 ml Wasser, die fäkalen bis zu 2.2 x102/100 ml, was abschnittwese zur Einstufung des Flusswassers in eine niedrigere Qualitätsklasse führt.

REZUMAT: Monitoringul şi evaluarea calităţii apei râului Timiş pe baza analizei fizico-chimice şi microbiologice.

Apele curgătoare, precum râurile, reprezintă o sursă importantă de apă potabilă pentru România, calitatea acestora fiind influenţată de cantitatea de materii în suspensie şi coloidale, caracteristicile fizico-chimice şi microbiologice ale acestora. Râul Timiş este caracterizat în general, de prezenţa unor impurităţi existente în stare naturală, compoziţia specifică fiind însă dependentă de natura solurilor traversate de cursul de apă, a solurilor din bazinul de recepţie, dar și de apele uzate deversate de diferiţi utilizatori şi a capacităţii de dizolvare a gazelor din atmosferă.

Cursul râului Timiş prezintă, în general, o mineralizare mai scăzută, suma sărurilor minerale dizolvate fiind sub 280 mg/l şi formată din bicarbonaţi, cloruri, azotaţi, fosfaţi, sulfaţi de sodiu, potasiu, calciu şi magneziu, provenite din eroziunea rocilor, solului şi datorită precipitaţiilor. Concentraţia ionilor de hidrogen (pH-ul) se situează în jurul valorii neutre, fiind cuprinsă între 7,3 şi 8,8 oxigenul dizolvat prezintă valori între 4,52 şi 7,46 mg/l. Caracteristica principală a cursului de apă o prezintă încărcarea variabilă (uneori apreciabilă) cu materii în suspensie şi coloidale (argile, nisip, silice), dar şi substanţe organice, încărcare legată direct proporţional de condiţiile meteorologice şi climaterice. Acestea cresc în perioada ploilor, ajungând la un maxim în perioada viiturilor mari de apă şi la un minim în perioadele de îngheţ (CCOMn max. 30,2 mg O_2). Metale grele precum mercurul sau arsenul se regăsesc în apele râului Timiș, dar în cantități ce nu afectează în mod concludent calitatea acestor ape, valorile fiind sub limitele maxime admise.

De asemenea, se remarcă poluarea de natură bacteriologică. Microorganismele, virusurile, protozoarele provin din deversări ale apelor uzate contaminate cu dejecţii umane sau animale, microorganisme propri ecosistemului. Coliformii totali ajung până la 5 x 10^3/100 ml apă, cei fecali până la 2,2 x 10^2/100 ml apă, ceea ce pe anumite sectoare încadrează apele râului într-o clasă inferioară de calitate.

INTRODUCTION

One of humanity's biggest present problems is pollution. It is obvious that the natural environment is slowly deteriorating and ecosystems are no longer able to adapt to the pressure of anthropic factors, the self regulation of the ecosphere being no longer possible (Kirschner et al., 2009; Oprean et al., 2007; Balzer et al., 2010). Water pollution represents an alteration of its physical, chemical, biological, bacteriological and radioactive qualities above an established admissible limit that is directly or indirectly produced by human activity. Polluted waters become unsuitable for normal usage as potable water, in industry, recreation or agriculture (Oprean et al., 2009; Darie et al., 2007).

Biological pollution mainly represents a bacteriological contamination. It raises serious public hygiene problems, which disseminate fast. Polluted water accentuates the pathogen affections like: typhoid fever, dysentery, enteric viruses (Hirotani et al., 2010; Korajkic et al., 2010; Basemer et al., 2005).

The usage of water streams as dilution medium of the urban effluent may have severe consequences on the public hygiene. It has been demonstrated that water polluted by different organic matters allow numerous pathogen germ species to multiply in incommensurable proportions compared to a clean water medium (Oancea et al., 2007; Blanch et al., 2004).

Canal systems, municipal and industrial insufficiently treated wastewater, human or animal directly spilled dejections into surface waters can produce bacteria, virus and parasite contaminations which lead to water transmissible diseases also called hydric diseases (Korajkic et al., 2010).

MATERIAL AND METHODS

Water samples have been collected from 11 key points, (T1-T11), the following parameters being kept track of in the physicochemical analysis of the water in the Timiş River: pH, electric conductivity, filterable dry residuum at 105°C, CCOMn, CCOCr, CBO5, ammonia azoth, nitrates, nitrites, orthophosphate, sulfurs, sulfates, matter in suspension, heavy metals.

- The pH determined according to SR ISO 10523/1997 acid or basic disrupts the biological treatment and auto treatment processes;

- The chemical and biochemical oxidability, respectively CCOCr (SR ISO 6060/1996) and CBO_5 (SR ISO 5815/1991), are global indicators of the organic substances; the CBO_5/CCOCr proportion, if it is below 0.4, indicates the presence of non-biodegradable substances in the water;

- Nitrogen, in a ammonia form, represents the main indicator that highlights the organic azoth pollution degree of wastewater, being determined according to (SR ISO 7150-1/2001), nitrate according to SR ISO 7890-3/2000 and nitrite according to SR ISO 6777/1996;

- Sulphides (SR 7510/1997) can influence the biologic purification processes when their quantities exceed certain limits; they can appear in the effluents coming, in general, from textile producing companies, tanneries, etc.;

- Heavy metals (As, Cd, Hg) are toxic for the microorganisms participating to the biological purification of water.-The above mentioned metals have been determined by using the SR EN ISO 15586/2004 "Water quality - Determination of trace elements using atomic absorption spectrometry with graphite furnace" method. Graphite Furnace Atomic Absorption Spectrophotometer a ZEENIT 650 - Analytik Jena Germany equipped with a graphite atomizer, a Zeeman-effect background correction, and an integrated auto sampler were used.

Graphite furnace atomization is a technique of improving the sensitivity and limit-of-detection for atomic absorption measurements. A small amount of sample or standard solution is placed inside a hollow graphite tube. This is resistively-heated in a temperature program to remove sample, burn off impurities, atomize the analyte to form a plume of free metal vapors, and finally clean the tube. Graphite tubes with coating and platforms made of pyrolytic graphite were used throughout the work. Argon of 99.998% purity was used as the purge gas. All reagents were of analytical–reagent grade, unless stated otherwise. For both techniques, ultrapure concentrated HNO_3 solution (Merck) was used. Standard solutions were prepared daily from the stocks, in PFA tubes, with deionized water (0.055 µS cm^{-1}conductivity). High purity ICP Multi Element Standard Solution XXI CertiPUR obtained from Merck (Darmstadt, Germany) was used for calibration during all quantitative analysis. For quantitative determinations, a calibration curve was obtained for each element. All plastic labware used for the sampling and sample treatment were new or cleaned by soaking 24 h first in 10 % HNO_3 then in ultra-pure water.

In view of a better correlation of the obtained results, the physicochemical indicators have been grouped depending on their chemical role as such: SOT – implies total oxidable substances (homogenous sample) or dissolved (decanted sample for 30 min.), expressed in CCO-Cr or CCO-Mn and CBO_5.

- S – salts – chloride have been included here, fix residuum, sulfates; represent the sum of azoth containing compounds which confer water quality groups classification qualities. The bacteriological evaluation of water and especially of coliforms bacteria can be done both by using the multiple tubes method as well as the filtering membrane method. This method presents the advantage of quick filtering of the water samples (100 m L) and of the dilutes (10^{-1}, 10^{-2}), with a porosity membrane 0.45µm. The dilutions 10^{-1} are realized as follows: a 10 mL water sample is pipette in 90 mL of normal saline solution and the mix is homogenized. After homogenization, 10 mL of dilution 10^{-1} is harvested and introduced in another 90 ml of normal saline solution to obtain a dilution of 10^{-2}.

The determination of the probable number of coliform bacteria (total coliforms)(CT)

Three Petri plates are prepared with dehydrated VRBA medium. The culture medium is being hydrated according to the producer's indications. Two dilutions will be harvested (10^{-1}, 10^{-2}) and afterwards filtrated with membranes of 0.45µm porosity. The membranes will be taken with sterile pincers and introduced into the Petri plates with rehydrated VRBA medium. The 3 Petri plates will be incubated at 37°C for 24 h. The counting will be carried out bearing in mind the dilution.

Three Petri plates are prepared with dehydrated VRBA medium. The culture medium is being hydrated according to the producer's instructions. Two dilutions will be harvested (10^{-1}, 10^{-2}) and afterwards filtrated with membranes of 0.45µm porosity. The membranes will be taken with sterile pincers and introduced into the Petri plates with rehydrated VRBA medium. The three Petri plates will be incubated at 37°C for 24 h. The counting will be carried out bearing in mind the dilution.

The determination of the probable number of thermo tolerant bacteria (fecal coliforms)(CF)

Petri plates are prepared with dehydrated MFC medium. The culture medium is being hydrated according to the producer's indications. Two dilutions will be harvested (10^{-1}, 10^{-2}) and afterwards filtrated with membranes of 0.45µm porosity. The membranes will be taken with sterile pincers and introduced into the Petri plates with rehydrated MFC medium. The three Petri plates will be incubated at 44°C for 24 h. The counting will be carried out bearing in mind the dilution.

RESULTS AND DISCUSSIONS

The pH varies during the run from 7.31 neutral, to basic reaching the harvest point 10 with a value of 8.81 (Fig. 1). A basification of the water can be concluded, under the influence of the exterior effluents, coming from industry or human settlements. The legislation permits a maximum pH value of 8.5. For the collection points 10 and 11 a correction intervention will be undertaken along with an investigation of the causes of this growth in pH.

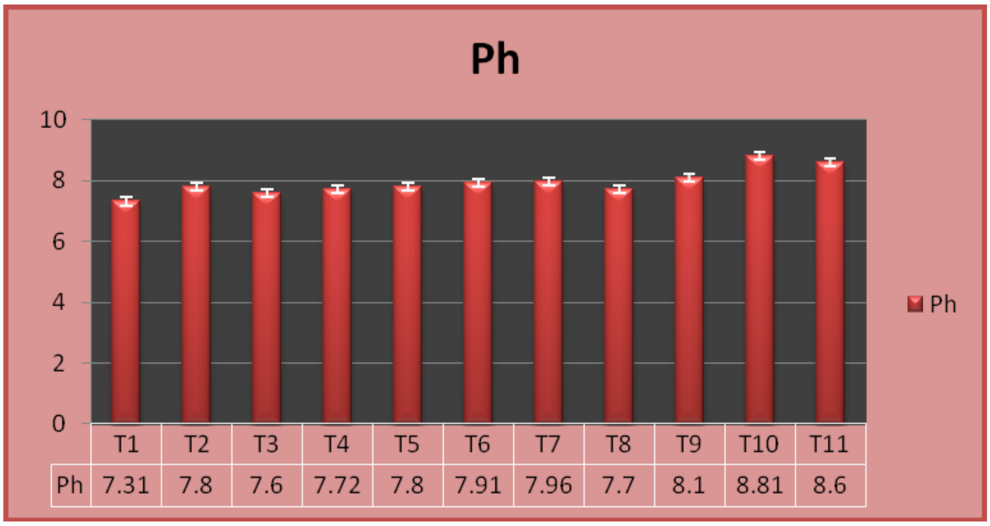


Figure 1: pH evolution in the 11 collection points along the Timiş River.

Following the oxygen regime, it can be concluded that it presents a series of particularities depending on the collection point. The most pronounced organic charge is identified in collection point T4, according to figure 2, and the lowest in T1, where the determination value ranges from 30.72 mg/L to 50.08 mg/L.

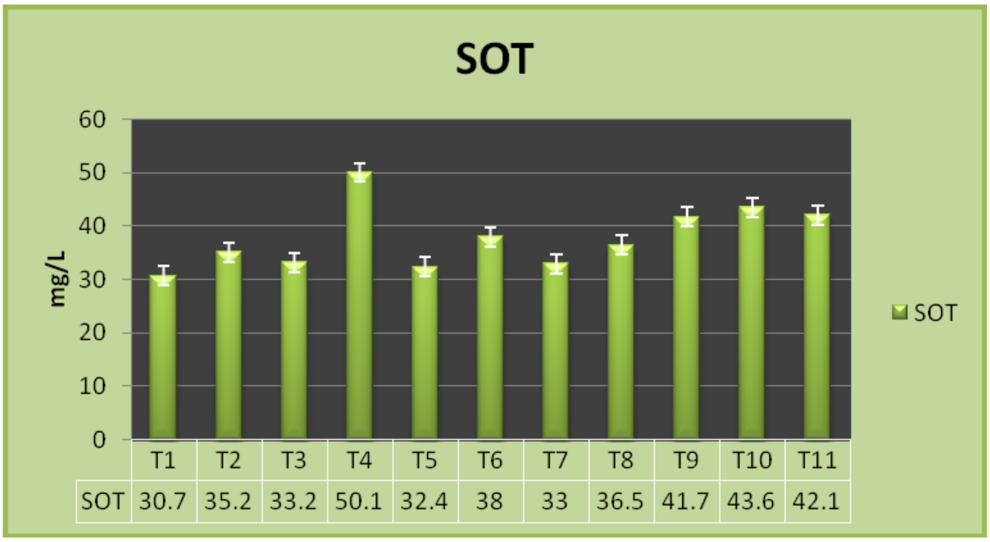


Figure 2. The evolution of total and dissolved oxidizable substances in the 11 collection points, along the Timiş River.

The quantity of organic substances that can be degraded by the bacteria (biodegradable) that is present in the waters of the Timiş River, represented by CBO5, reaches maximum values of 1.43 mg/L, values which are within the maximum obligatory frame for the first quality class. The total quantity of organic substances present in the river water, which can be chemically oxidized (by the potassium dichromate and/or potassium permanganate) reach values of 13.6 respectively 30.2 mg/L, which places segment 4 of the river in quality class III.

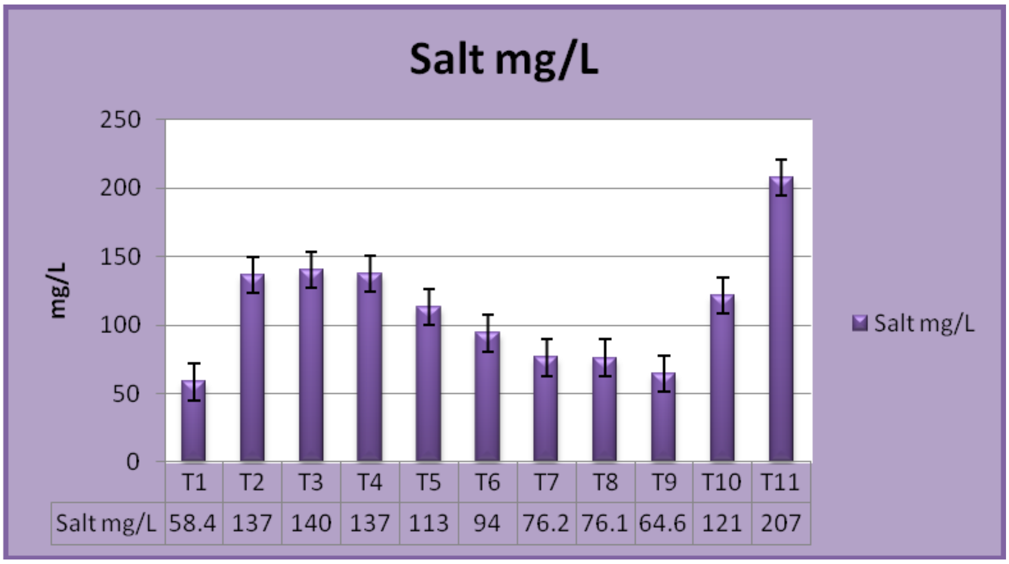


Figure 3: Salt evolution (chloride, fixe residuum fix, sulphates) in the Timiş River, along the 11 collection points.

The salt quantity measured in the 11 collection points during the monitoring period indicates that water reaches T1 with a charge of 58.441 mg/L salts, then grows to 140.19 mg/L at T3 and drops from T3 to T9 up to 64.64 mg/L, while in T10 and T11 it grows again up to 207.44 mg/L. According to figure 3 and to the salt indicator, the water subjected to the monitoring process fall into the first quality group, their accumulation not exceeding 210 mg/L, the actual standards allowing double this value.

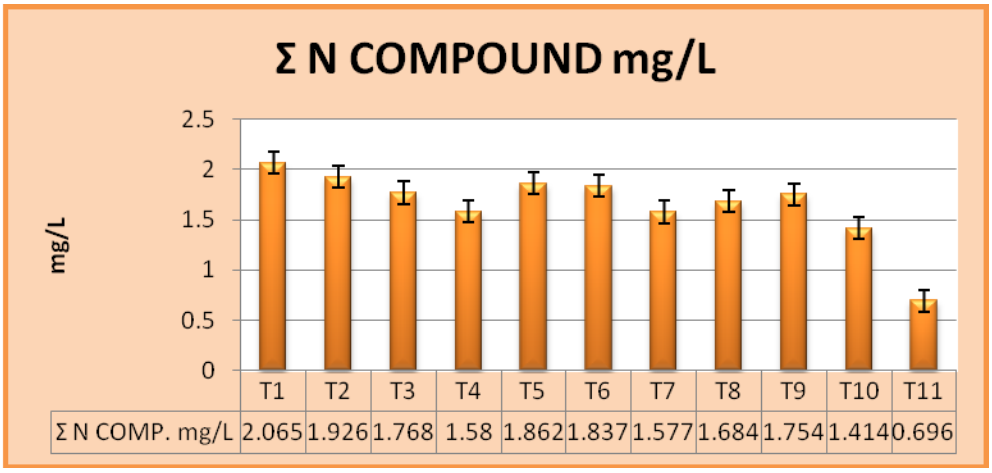


Figure 4: The evolution of the azoth compounds, along the 11 collection points.

Regarding the azoth based compounds, figure 4 shows a uniform evolution, meaning that maximum values are found in T1, T2 and minimum values in T11. The uneven evolution of these compounds is firstly due to the chemical structure of the rock along the river as well as to the human and animal dejections, industrial residuum and agrochemical waste contamination. The oscillation of these values leads to the 1-2 quality category framing for the Timiş River. The NO_3 is actually the compound which determines this framing because it frequently exceeds the values of 1, admitted by the normative.

Heavy metals, As, Cd and Hg, have been identified in reasonable quantities, their amount not exceeding the maximum admitted values in the Timiş River. The tracked metals have only been found in three3 collection points, according to figure 5.

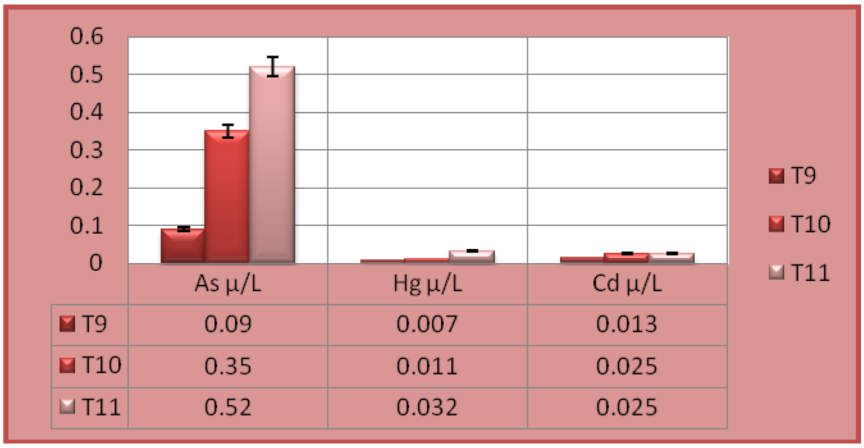


Figure 5: The evolution of Arsenic, Lead and Cadmium in the Timiş River.

The determination of the probable coliform bacteria number (total coliforms)

By observing figure 6, it can be concluded that total coliforms has been identified in Timiş River in quantum of $7x10^3$ coliform /100cm³, in collection point T2, and the lowest is T11, where this value does not exceed 79 units. The most crowded areas are T2 and T6, followed by T3, T5, T4 where they are situated around $2.2\text{-}2.8x10^3$units. From this point of view, the waters are classified in quality class II.

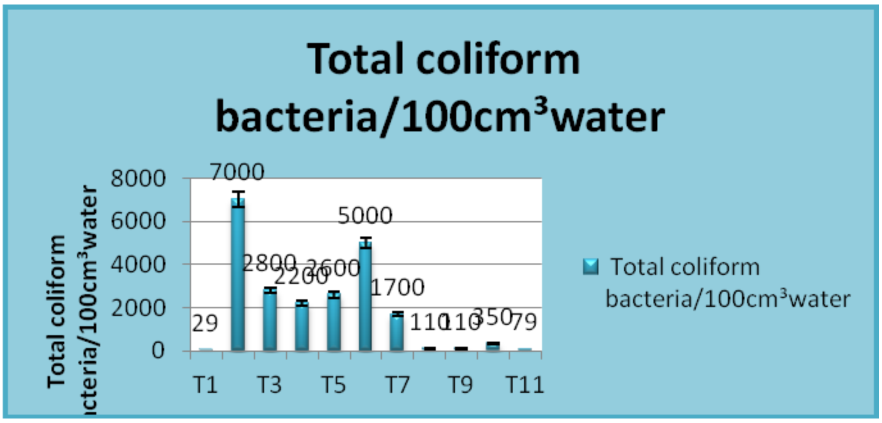


Figure 6: The evolution of the total number of coliform bacteria that has developed at 37ºC, along the 11 harvest points on the Timiş River.

As shown in figure 7, the fecal coliforms, the contamination factors made of human and animal dejections, are present in large numbers in harvest points T2 and T4, where their values exceed 200 de units / 100cm^3 water. The recommendation for these points is the stopping of the fecal pollution by means of uncontrolled spills in the Timiş River. The fecal coliforms number is reduced throughout the following harvest points, explained by the regulation and control over the spills but also possible dilutions from tributary rivers. The values of the fecal coliforms detected throughout points T1, T6, T7, T8, T9, T10 and T11 are situated under 100, the legal limit established for I quality class waters since 1996.

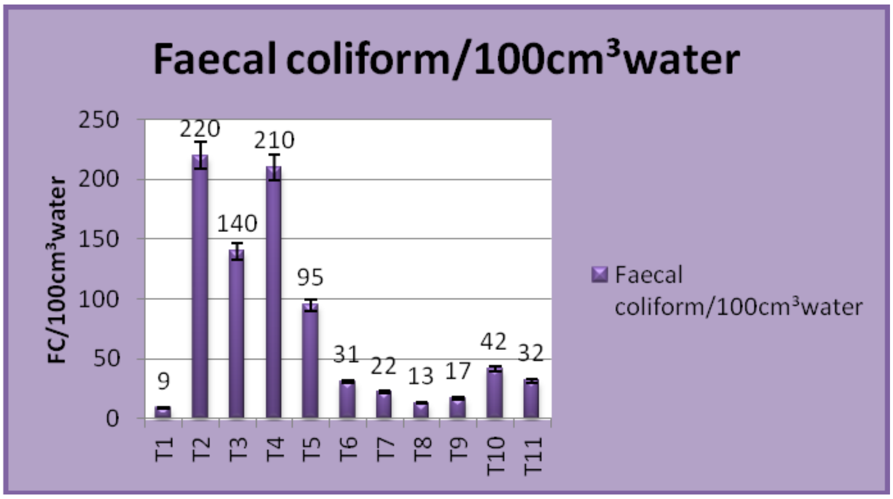


Figure 7: The evolution of the total fecal coliforms number that has developed at 44ºC along the 11 harvest points on the Timiş River.

CONCLUSIONS

The water sample swab in the 11 harvest points led to obtaining precise results but revealed neuralgic zones in the Timiş River.

From a physicochemical point of view, the waters can be classified in I-II quality class, not being affected by the heavy metal contaminations.

A more efficient monitoring over the organic substances spills which lead to oxygen level and active fauna drops is recommended.

From a microbiologic point of view, the waters are classified as being I-II quality class, but a more rigorous control from the qualified factors over these zones is recommended in view of stopping the touristic pollution in the area, especially in holiday houses and improperly decorated areas.

To conclude with, the appreciation of water quality and implicitly the usage possibilities in different purposes is a complex activity. The simple existence of some precise results based on a great variety of organoleptic, physical, chemical, biological and bacteriological analysis proves to be insufficient for a correct interpretation, for establishing the causes, predicting the evolution tendencies and establishing the other necessary elements for a proper management.

ACKNOWLEDGMENTS

This work is part of the "Study of the quality of Timiş water and registry of polluters' source to border" (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of "Lucian Blaga" University, Faculty of Sciences, financed by the European Community.

REFERENCES

1. Balzer M., Witt N, Flemming H. C. and Wingender J., 2010 – Fecal indicator bacteria in biofilms, *Water Science and Technology*, 61, 05, 1105-11.
2. Basemer K., Markus M. M., Jesus M. A., Gerhard J. H. and Peter P., 2005 – Complexity of Bacterial communities in a River-floodplain System (Danube, Austria), *Applied and Environmental Microbiology*, 609-620.
3. Blanch A, Luis B. M. and Xavier B., 2004 – Tracking the origin of faecal pollution in surface water: an ongoing project within the European Union research programme. Journal programme. *Journal of Water Health*, 249, 249-260.
4. Darie N., Oprean L., Ognean M., Ognean C. and Lengyel E., 2007 – Monitoring enzyme activity in Cibin River water and sludge IND ECOIND, International symposium, 221-225.
5. Hirotani H. and Yoshino M., 2010 – Microbial indicators in biofilms developed in the riverbed, Water Science and Technology., 62, 5, 1149-53.
6. Kirschner A. K. T., Gerhard G. K., Branko V., Robert L. M., Regina S., Andreas H. F., 2009 – Microbiological water quality along the Danube River: Integrating data from two whole-river surveys and a transnational monitoring network, 3673-3684.
7. Korajkic A., Brownell M. J. and Harwood V. J., 2010 – Investigation of human sewage pollution and pathogen analysis at Florida Gulf coast beaches, *Journal of Applied Microbiology*, 110, 1, 174-83.
8. Oancea S., Oprean L., Gaspar E. and Lengyel E., 2007 – Study on some toxic parameters level of waters and sediments sampled from the river Cibin upstream and downstream of the waste waters spill, IND ECOIND, International symposium, 323-328.
9. Oprean L., Gaspar E., Mironescu M., Oprean C., Oancea S. and Lengyel E., 2007 – The degree of pollution regarding the Cibin River, IND ECOIND, International symposium, 335-341.
10. Oprean L., Poplăcean M., Oancea S., Oprean C. and Lengyel E., 2009 – Monitoring the microbiological and physico-chemical pollution degree of the river Visa, *Studia Universitatis*, Arad, 203-207.

RELATIONS BETWEEN RIVER CHEMISTRY AND ITS PHYTOPLANKTON. CASE STUDY - TIMIŞ RIVER (BANAT, ROMANIA)

Hanelore MUNTEAN *

* Banat River Basin Administration - Timişoara National Administration Apele Române, Mihai Viteazul Boulevard 32, Timişoara, Timişoara Country Romania, RO-300023, hane_elena@yahoo.com

DOI: 10.2478/trser-2013-0032

KEYWORDS: phytoplankton, water chemistry, correlation, integrated approach, Timiş River.

ABSTRACT

The river plankton - potamoplankton - consists predominantly of autochthonous as well as allochthonous elements and it is poorly represented in rivers due to the water flow. The allochthonous elements that reach streams from stagnant waters suffer changes or, if they cannot adapt to the environment, quickly die. Usually, in a current stronger than 1 m/s they do not survive. Potamoplankton variety increases from spring to effusion, plankton being almost completely absent in the region of the spring.

In medium and small basins, places with stagnant water are formed and plankton growth is supported, but in areas where there are no crossings and water speed is too high, plankton is destroyed due to mechanical action.

In rivers, phytoplankton mainly consists of diatoms, chlorophytes, euglenophytes and cyanobacteria, etc.

The aquatic environment is wide, having various physico-chemical characteristics which determine different ecological conditions, so that the distribution of aquatic animals and plants differs.

Aquatic ecosystems are structural and functional units consisting of biotopes and biocenosis that support self-integrated activities, the result being biological production and destruction.

Timiş River was monitored in 2012 in the months of May and September in the Lugoj, Hitiaș, Şag and Grăniceri sections. Also pH was monitored for oxygen and the nutrient flow of these sectors and interpretations and correlations of the phytoplankton quality indicators were made.

RÉSUMÉ: Les relations entre la chimie de la rivière et son phytoplancton. Etude de cas - la rivière Timiş (Banat, Roumanie).

Le potamoplancton, plancton des rivières, est formé d'éléments autochtones prédominants, ainsi que d'éléments allochtones. Il est faiblement représenté dans les rivières à cause de l'écoulement d'eau. Les éléments allochtones, arrivés dans les rivières à partir des eaux stagnantes, subissent des modifications ou meurent rapidement car ils ne s'adaptent pas aux nouvelles conditions environnementales. En règle général, au delà d'une vitesse de 1m/s, le potamoplancton ne survit pas. Le nombre d'espèces de potamoplancton augmente de la source vers le débouché; le plancton étant quasiment inexistant au niveau de la source.

Dans les bassins moyens et inférieures, des eaux stagnantes apparaissent et permettent le développement du plancton. Au niveau des zones où la vitesse de l'eau est trop grande, le plancton est détruit par action mécanique.

Dans les rivières, le phytoplancton est formé principalement de diatomées, suivis de chlorophycées, d'euglenophytes, de cyanobactéries etc.

Le milieu aquatique est particulièrement riche, avec des caractéristiques physico-chimiques variées déterminant des conditions écologiques tout aussi variées, menant ainsi à une répartition différenciée des organismes aquatiques d'origine animale et végétale.

Les écosystèmes aquatiques représentent des unités structurelles et fonctionnelles formées du biotope et de la biocénose ayant une activité intégrée, le résultat étant la production et la dégradation biologique.

La rivière Timiş a été suivit en 2012 durant les mois de mai et septembre dans les sections de Lugoj, Hitiaş, Şag et Grăniceri. Le pH, le flux d'oxygène et de nutriments y ont été relevés puis interprétés et corrélés avec les données du phytoplancton en tant qu'indicateur de qualité.

REZUMAT: Legături între chimia râului şi fitoplanctonul acestuia. Studiu de caz – râul Timiş.

Planctonul din râuri, numit şi potamoplancton, este format atât din elemente autohtone, cât şi alohtone şi este slab reprezentat datorită curgerii apei. Elementele alohtone, ajunse în apele curgătoare din apele stătătoare, suferă modificări sau, dacă nu se pot adapta la noile condiţii, mor repede. De obicei, la o viteză de curgere mai mare de 1 m/s fitoplanctonul nu supravieţuieşte. Varietatea potamoplanctonului creşte de la izvoare spre vărsare, la izvoare planctonul fiind aproape inexistent.

În bazinele mijlocii şi inferioare se formează locuri cu apă stătătoare, unde dezvoltarea planctonului este avantajată, însă, în zonele unde există praguri şi viteza apei este prea mare, planctonul se distruge prin acţiune mecanică.

În râuri, fitoplanctonul este format în principal de diatomee şi în număr mult mai mic din cloroficee, euglenofite, cianobaterii etc.

Mediul acvatic este deosebit de vast, cu variate caracteristici fizico-chimice ce determină diferite condiţii ecologice, astfel repartizarea organismelor acvatice, fie vegetale fie animale, este diferenţiată.

Ecosistemele acvatice reprezintă unităţi structurale şi funcţionale, alcătuite din biotop şi biocenoză, care desfăşoară o activitate integrată, rezultatul fiind producţia-distrugerea biologică.

Râul Timiş a fost monitorizat în anul 2012, în lunile mai şi septembrie în secţiunile Lugoj, Hitiaş, Şag şi Grăniceri. S-a monitorizat pH-ul şi regimul oxigenului şi cel al nutrienţilor în aceste secţiuni şi s-au realizat intepretări şi corelaţii cu indicatorul de calitate fitoplancton.

INTRODUCTION

In 1991, in order to avoid the long term qualitative and quantitative water degradation, the problem of implementing a new program related to the sustainable use of water resources up to year 2000 came about.

On November 10th, 1995, the "Environment in the European Union" report elaborated by the European Environmental Agency, the up-to-date situation of water resources. The conclusion came to be the necessity to take action towards the qualitative and quantitative water protection in the community.

For maintaining and improving the aquatic environment, qualitative and quantitative control of waters, the directive has to develop principles and structures for the sustainable use of water resources over a long period of time.

The directive has to contribute to a decrease in pollutant emission in waters towards a better control of the cross-border water problems and aquatic ecosystem protection.

An integrated approach including not only qualitative and quantitative elements, but the hydrological floating conditions of waters contribute to a better environment protection.

This paper describes the study of Timiş River from upstream from Lugoj city until upstream of Grăniceri. Timiş River, first degree tributary of the Danube, springs from the eastern part of the Semenic Mountains, below Piatra Goznei Peak (1145 m), from 1280 m height, having a lenght of 244 km (in Romania), gathers the waters of 150 rivers, measuring a lenght of the hydrological system of 2434 km and a density of 0.33 km/km^2. The river basin area is of 7310 km^2. In its mountain sector, Timiş receives two small tributaries: Brebu and Semenic, and after 25 km from its spring it enters Timiş-Cerna couloir where it receives tributaries both from Semenic and Ţarcu Mountains (the tributaries from the right side are bigger): Teregova, Râul Rece (Hidegul), Feneş, Sadoviţa, Goleţ, Bolvaşniţa. At Caransebeş it confluences with Sebeş River, after which Timiş River receives its greatest tributary, Bistra.

Afterwards, Timiş's alluvial cone starts under the shape of a fan until the border with Serbia. In the arial of this cone, a gradual deviation of Timiş River to the right can be noticed, especially due to its tributaries a little bit bigger to the left. Timiş river's deviation to the right is highlighted by its abandoned course, Timişul Mort, which used to be the main course. The route followed by Timiş River, has a tortuosity coefficient of 2.50 and an average slope of 5‰, a flinty geology with a river bed made of boulders, gravel, sand and silt (Nagy et al., 2004).

MATERIALS AND METHODS

Chemical samples were collected from four sectors of Timiș River twice in the year 2012. Samples were collected according to the standards in force under the WFD for each chemical indicator of water quality.

From a biological point of view, phytoplankton samples were collected, according to Draft N 109/ 2008/04/15 Draft proposal for "Water Quality-Guidance on quantitative and qualitative sampling of phytoplanktonfrom inland water" and processed according to SR EN 15 204 – Ghid pentru analiza de rutină a abundenței şi compoziției fitoplanctonului prin utilizarea microscopiei inverse (metoda Uthermol), determining the taxonomical cathegories present; density and biomass.

RESULTS AND DISCUSSIONS

It is known that the physico-chemical characteristics of water plays an important role in understanding the processes that take place in the aquatic environment and that influence the development and functionality of aquatic biocenosis.

More chemical parameters are taken into consideration in order to establish water quality classes. A very important parameter is pH, which has a very important role in the processes that take place in the aquatic environment. pH varies by day and night, during the night due to organism breeding and the release of CO_2 into water, and in the day-time its value increases due to photosyntesis. In surface running waters, pH value is between 3.4 – 6.95 for acid environments, 6.95 – 7.3 for neutral environments and > 7.3 for the basic ones. Aquatic organisms prefer the neutral pH to a little bit alkaline (Varaduca, 1997).

Along Timiş River, in the studied sectors, pH has the following values (Fig. 1).

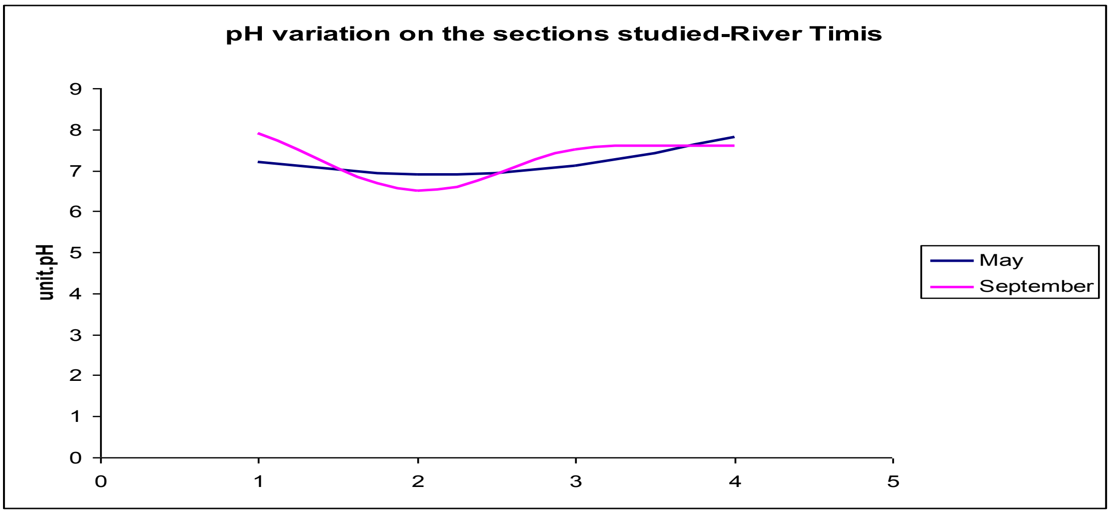


Figure 1: pH fluctuations in the monitored sectors, respectively monitored months.

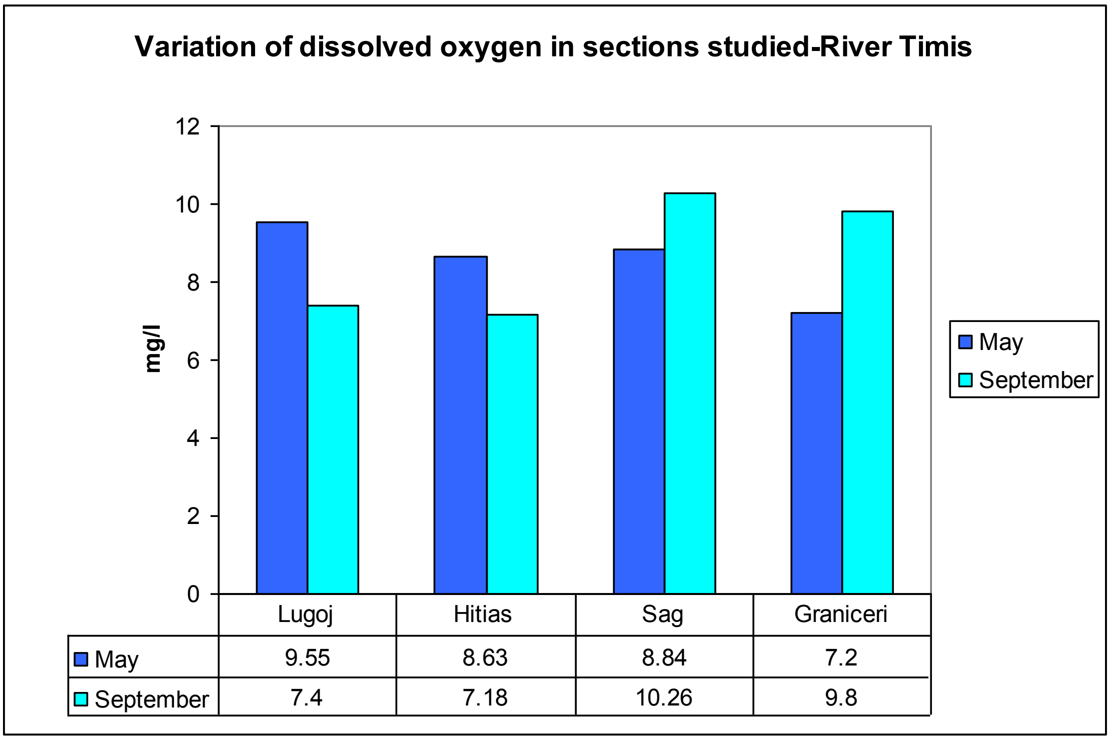


Figure 2: The fluctuation of dissolved oxygen in the monitored sectors.

The pH varies among sections and from one monitored period to another, the smallest pH being in September in Hitiaş, with a value of 6.4, which is similar to the water in an acid environment, and the highest value is in Lugoj sector (pH = 7.9), the environment being basic.

Oxygen regime contains the concentration of saturated oxygen and the group of substances that biodegrade through biochemical reactions that consume oxygen.

Dissolved oxygen is the most important parameter for aquatic ecosystems, which is the existence and survival of aquatic organisms being limited by its quantity.

The quantity of dissolved oxygen also shows the oxidation level of the residues and its effects upon water ecosystems, the self-cleaning capacity of these ecosystems. Disolved oxygen from waters comes from the gas exchange between water and atmosphere (exogenous) and photosynthesis of aquatic organisms (endogenous) (Varaduca, 1997).

The quantity of dissolved oxygen consumed by aquatic organisms or in different processes is replaced by another quantity from the atmosphere or from photosynthesis (Mălăcea, 1969).

Timiș River is characterized by a relatively good oxigenation (Fig. 2).

Independently of the season or the monitored sector, the quantity of dissolved oxygen is high, which shows that this river sector has a high self-purification capacity and a good biological productivity.

Biogenic substances contain chemical elements with a restrictive character that contribute to the development of the aquatic organisms.

Nitrite, nitrate and ammonia are formed in waters as a consequence of the decomposition and mineralization of the protein products that enter surface water together with waste waters. Indirectly, different forms of nitrogen can reach surface and underground waters due to diffuse pollution from agriculture and stock raising.

A high quantity of ammonia together with a high quantity of nutrients in the water indicate pollution from a certain past time, while ammonia without nitrites being present indicate a recent pollution.

Waters that cross fields rich with humus contain high quantities of phosphates, which can also come from diffuse pollution (Varaduca, 1997).

In the studied area, these parameters characterize water quality (Fig. 3). The monitored sections are characterized during all seasons by an almost equal phytoplankton density. Only in September in Grăniceri sector the density drops to half compared to the month of May.

The predominant species in Lugoj sector in the month of May are: *Cocconeis pediculus, Cymbella cistula, Cymbella ventricosa, Diatoma vulgaris, Diatoma ehrenbergii, Nitzschia acicularis,* and in September: *Cocconeis pediculus, Cymbella tumida, Navicula capitatoradiata, Diatoma vulgaris, Cyclotella meneghiniana, Dydimosphenia geminata* species (Fig. 5) has been identified for the first time in Prut River, then in Bistriţa River and in Bicaz dam basin. Recent data shows that *Didymosphenia geminata* appeares suddenly in the year 2000 and can be abundently found in a few rivers from Transylvania, like: Someşul Rece, Someşul Cald, Someşul Mic, Crişul Repede, Valea Drăganului, Arieş River, Mureş River and Olt River. Today situation in Romania, characterized by the lack of monitoring programs for the algae in many aquatic ecosystems make the evaluation of the impact caused by this species to the already existing communities impossible (Momeu, 2009).

The results of many authors of Europe, Asia, New Zeeland, North America concerning the invasive behaviour of *D. geminata* shows that the massive development of this species affects the habitat of benthic macroinvertebrate and fish species. A decrease is also shown in number and abundance of some invertebrate groups like Chironomidae and Oligochaeta that feed on algae, but can not consume *Didimosphenia geminata.* The high development of this species leads to "water blooming" and affects the dissolved oxygen not only during the vegetation period, but also in the decomposition of the organic matter period, due to mucilaginous peduncles. *Didymosphenia geminata* causes problems to humans aswell, like eye irritations (Momeu, 2009).

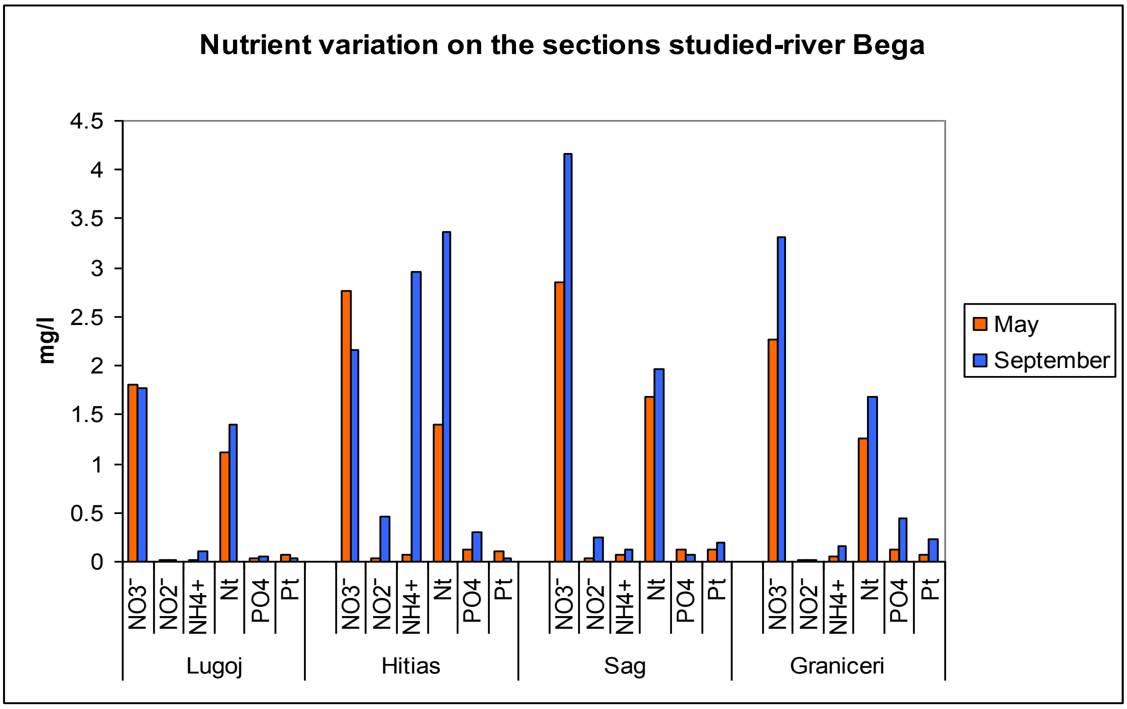


Figure 3: Nutrient variation in the studied sections.

In the given chemical conditions, phytoplankton varies in the studied sections as it follows in figure number 4.

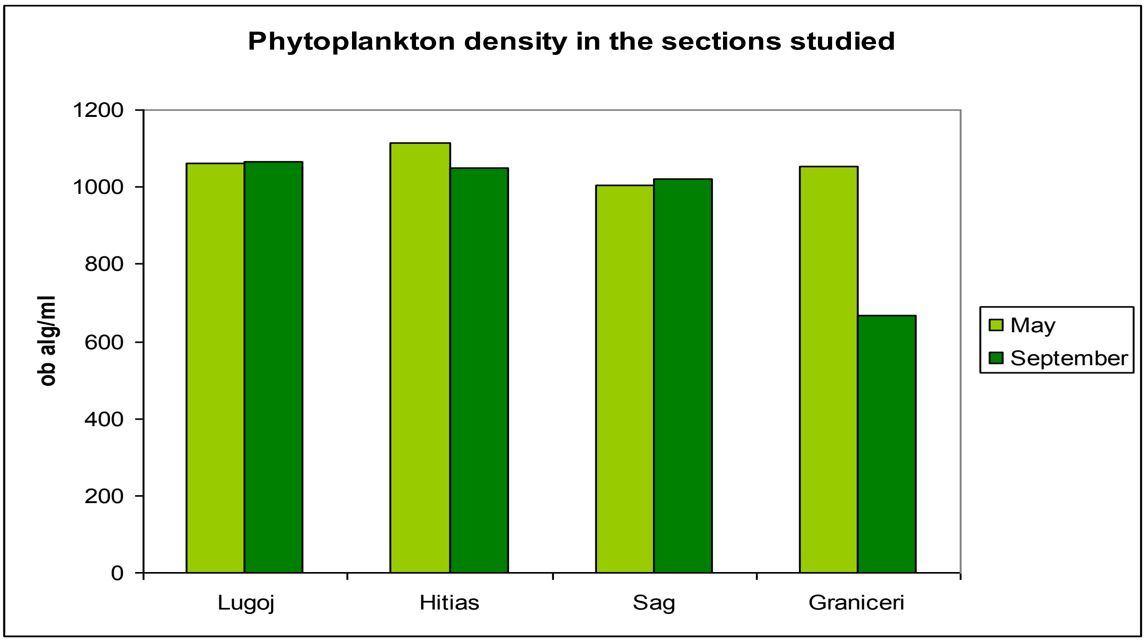


Figure 4: Phytoplancton density in studied sections.

Didymosphenia geminata has been identified in Timiş as well, in Lugoj, Hitiaş, Şag and Grăniceri areas. From Lugoj, it stopped migrating towards the upper Timiş River sector.

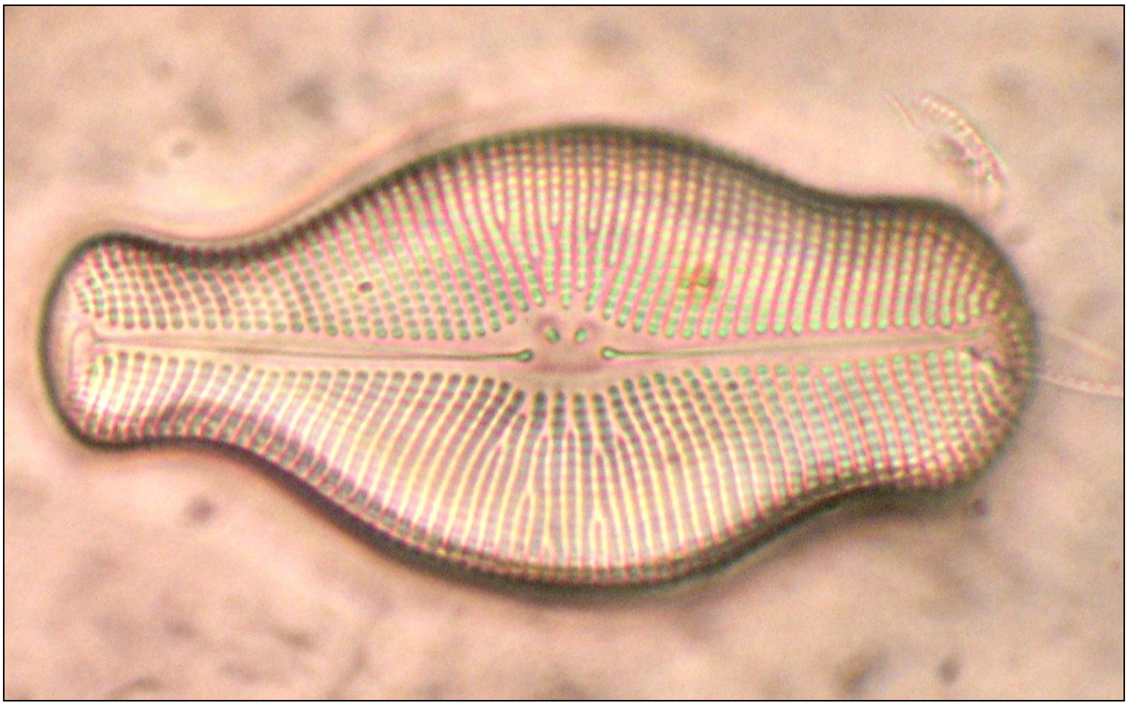


Figure 5: *Didimosphenia geminata*.

In Hitiaş sector, the dominant species are: *Cocconeis pediculus, Diatoma mesodon, Diatoma vulgaris, Fragilaria crotonensis, Synedra acus, Ulnaria ulna*, in May and September predominate: *Caloneis silicula, Cymbella cuspidata, Diatoma vulgaris, Navicula bacillum.*

In Şag section, in the month of May predominate: *Ccocconeis placentula, Cyclotella meneghiniana, Diatoma vulgaris* and *Nitzschia levidensis*, and in September: *Cocconeis pediculus, Cymbella tumida, Fragilaria crotonensis, Ulnaria ulna*.

Grăniceri sector is characterized in the month of May by the following species: *Asterionella formosa, Fragilaria crotonensis, Melosira varians, Navicula cryptocephala*, and in September the dominant ones are: *Cocconeis pediculus, Diatoma vulgaris, Navicula capitata, Stephanodiscus hantzschii* and *Ulnaria ulna*.

The algae species vary from one season to another and from one species to another. The phytoplankton biomass varies too, as follows (Fig. 6):

In September, in Şag section we have the biggest phytoplancton biomass and the highest quantities of nitrate, nitrite and total phosphorus, which reveals the nutrients influence onto the aquatic flora growth.

The highest quantity of ammonia was found in September in Hitiaş sector, but neither the density, biomass, or the number of phytoplanktonic algae were influenced by it. The highest quantity of total nitrogen/azote was found in Hitiaş section in September, but it doesn't influence the density nor the phytoplankton biomass.

Didimosphenia geminata was not present in Şag section in May, in Hitiaş and Grăniceri sections in September. In these months, the phosphates have high quantities, which reveals the fact that this species does not grow when high quantities of phosphate are present, especially because in the Lugoj section this species was found in both monitored months, where the phosphate quantity is the lowest out of all the studied sections.

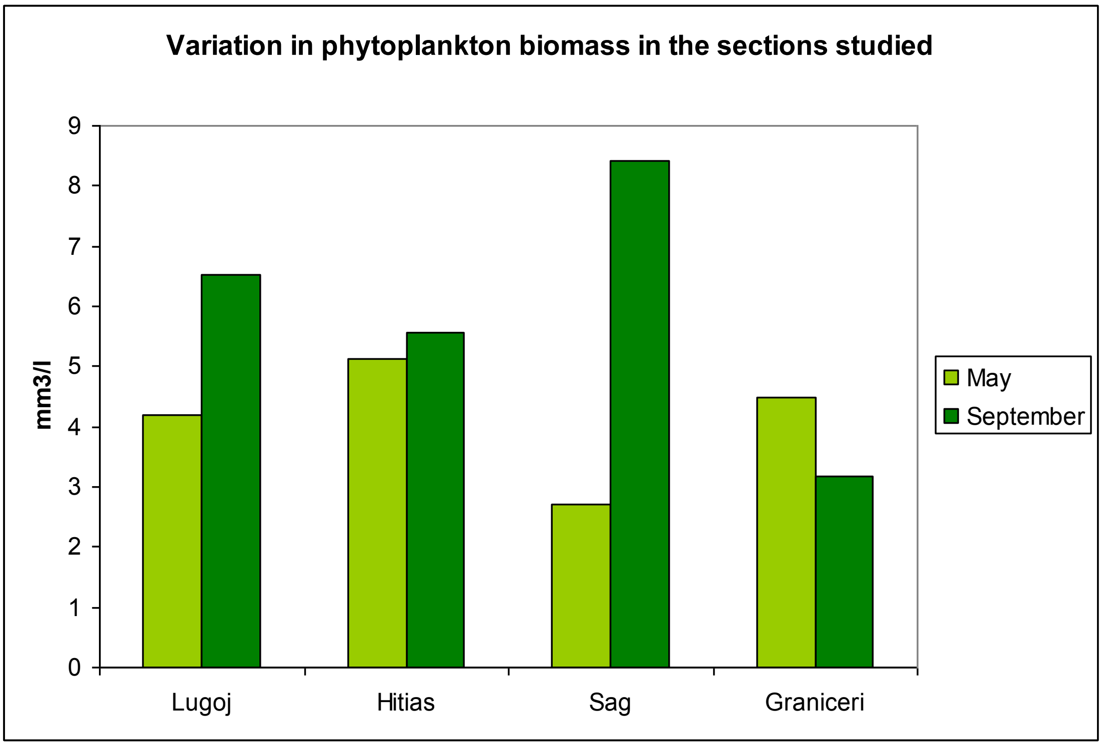


Figure 6: Phytoplanktonic biomass fluctuation in the studied sections.

The main phytoplankton species vary from one river section to the other and from one season to another.

Nutrients influence phytoplankton biomass growth.

Ammonia does not inhibit nor influence the phytoplankton evolution.

Didimosphenia geminata doesn't grow in waters with high content of phosphates.

REFERENCES

1. Mălăcea I., 1969 – Biologia apelor impurificate, Editura Academiei Române, Bucureşti, 130-131. (in Romanian)
2. Momeu L., 2009 – Problems concerning the invasive species from continental aquatic ecosystems Case study: Didymosphenia geminata (Lyngb.) M. Schmidt in Rakosy L. and Momeu L. (eds.), Neobiota din România, Presa Universitară Clujeană, 11-30.
3. Nagy C. and Şerban P., 2004 – Raportul 2004, Planul de Management al Spaţiului Hidrografic Banat, Administraţia Bazinală de Apă Banat, Timişoara, 4-55. (in Romanian)
4. Varaduca A., 1997 – Hidrochimie şi poluarea chimică a apelor, Edit. *H*G*A*, Bucureşti, 34-65. (in Romanian)
5. ***** Legea 107/1996, 1996 – Monitorul Oficial, Bucureşti.

THE PHYTOPLANKTON BIOTA VARIATION ON THE TIMIȘ RIVER ACCORDING TO THE CHEMISTRY AND HYDROLOGY OF THE WATER COURSE

Hanelore MUNTEAN *, *Iuliana DOBAI* *, *Cătălin MILOTIN* * and *Cristina GROZA* *

* Banat River Basin Administration, Mihai Viteazul St. 32, Timişoara, Timiş County, RO-300223, hane_elena@yahoo.com, iulianna.dobai@yahoo.com, catalin_rowater@yahoo.com, grozacris@yahoo.com

DOI: 10.2478/trser-2013-0033.

KEYWORDS: phytobentos, phytoplankton, variation, integrated approach.

ABSTRACT

The Timiș River is the biggest tributary of the Banat catchment area. It springs at an elevation of 1145 m, under Piatra Goznei peak. Due to the fact that it crosses several relief forms, its hydrology, chemistry and biological characteristics are modified in consequence.

The chemical and biological analysis of the water course and their correlation with hydrological data displayed evidence of the interdependence of these factors. The phytoplankton composition and richness are directly influenced by river's chemistry and hydrology. In the mountain area, the flow and the speed of the watercourse are inducing a specific flora and fauna for the area. In the lower areas, the river hydrology triggers a change in the biological characteristics as the water chemistry changes. The mountain species are adapted to rocky substrata in order to resist high water velocity and pressure. In the lower areas they are replaced by lowland species adapted to larger yet slower flows.

The Timiș River is a watercourse that did not undergo major qualitative changes in terms of water quality.

RÉSUMÉ: La variation du phytoplancton dans la rivière de Timiș induite par l'hydrologie et la chimie de l'eau.

Le Timiș est le plus grand effluent du bassin hydrographique du Banat. Ses sources se trouvent à une altitude de 1145m sous la cime de Piatra Goznei. L'hydrologie, la chimie et la biologie de la rivière changent le long de son tracé car la rivière traverse plusieurs types de relief.

Les résultats obtenus par l'analyse chimique de l'eau et de l'analyse du phytoplancton ont été corélés avec les données hydrologiques, mettant en evidence les relations d'interdépendence entre ces paramètres. La composition et l'abondance du phytoplancton sont directement influencées par la chimie de l'eau et pas l'hydrologie de la rivière. Dans la région de montagne, le débit et la vitesse de l'eau séléctionnent une flore et une faune spécifique. Dans les secteurs de plaine, l'hydrologie de la rivière change, tout comme la chimie de l'eau, ce qui engendre également un changement des caractéristiques de la flore planctonique. Les espèces de montagne sont adaptées à un substrat rocheux leur permettant de résister aux pressions dues à la vitesse de l'eau. Elles sont remplacées dans les secteurs infèrieures par des espèces de la zone de plaine, étant donné que le débit est plus grand et la vitesse de l'eau plus faible.

La rivière de Timiș est un cours d'eau qui n'a pas subit des changements majeurs de la qualité de l'eau.

REZUMAT: Variaţia biotei fitoplanctonice din râul Timiş în funcţie de chimia şi hidrologia cursului de apă.

Râul Timiș este cel mai mare drenant din spațiul hidrografic Banat. Izvorăşte de la o altitudine de 1145 m, de sub vârful Piatra Goznei. Datorită faptului că traversează mai multe forme de relief suferă modificări ale hidrologiei, chimiei și biologiei.

Prin analiza chimică și biologică, pe segmentul de fitoplancton, a cursului de apă și prin corelarea cu datele hidrologice s-au evidențiat relațiile de interdependență dintre ele. Compoziția și abundența fitoplanctonului sunt direct influențate de chimia apei și de hidrologia râului. În zona de munte, debitul și viteza apei imprimă o floră şi o faună specifică acestei zone. Spre zona de câmpie hidrologia râului se modifică, chimia apei de asemenea, ceea ce determină și o schimbare a caracteristicilor florei planctonice. Speciile de munte sunt adaptate la substrat pietros pentru a rezista la presiunile datorate vitezei apei. Acestea sunt înlocuite în sectoarele inferioare cu speciile din zona de câmpie, unde debitul este mai mare și viteza apei mai mică.

Râul Timiş este un curs de apă care nu a suferit modificări calitative majore ale calității apei.

INTRODUCTION

Human activity often engenders the water pollution. The water is necessary in order to sustain life, but it also has the role to collect and transport different kinds of residues.

The water pollution determines its qualitative depreciation downstream and has negative effects on human health and aquatic ecosystems, thus further implying the reduction of the effective use as well as a larger competition for "proper" water. The protection of terrestrial and aquatic ecosystems plays an important role in the development of different processes in nature. The full awareness of the status, activity and even more of the evolution of a water course cannot be achieved without data on all composing parameters: biological, chemical and hydrological.

The integrated approach in the river analysis is very important considering the interdependence relations between biological, chemical and hydrological factors acting together or separately in the processes taking place in water.

MATERIAL AND METHODS

The samples for the chemical analysis were taken according to the standards in force, according to the provisions of DCA 2000/60/EC.

The chemical data were obtained from the tests performed on water samples by the Banat Catchment Area Water Resource Administration - the Water Quality Laboratory of Timișoara. The standards used for the analysis of the monitored chemical parameters are:

•oxygen variation monitoring:

- SR EN 25813/2000 - Water quality. Dissolved oxygen dosage. Iodometry method.
- SR EN 1899-1/2003 - Water quality. Biochemical oxygen use determination after "n" days. Dilution and allylthiourea adding method.
- SR EN 1899-2/2002 - Water quality. Biochemical oxygen use determination after "n" days. Diluted samples method.

•nutrients monitoring:

- SR EN ISO 6878/2005- Water quality. Phosphorus determination. Spectrophotometric method using ammonia molibdate.
- SR ISO 10048/2001 - Water quality. Nitrogen content determination. Catalytic mineralisation after reduction with Devarda alloy.

- SR ISO 7890-1/1998 - Water quality. Nitrates content determination. Spectrometric method with 2.6 dimethyl-phenol.
- SR ISO 7150-1-2001 - Water quality. Ammonia content determination Part 1 – Manual spectrometric method
- SR EN 26777/C91/2006 - Water quality. Nitrite content determination – Molecular absorption spectrometric method.

•For macrozoobenthos samples

The macrozoobenthos investigation from the river substrata requires various sampling methods (according to standards in force) in order to establish the dominant biotope. The macrozoobenthos samples contain aquatic animals most of which are visible by the naked eye. These are sampled according to the characteristics of the riverbed with different instruments: scraper and hoop net. Afterwards the sample is washed and the sampled individuals are identified at species level using the dedicated literature using a stereomicroscope and classic microscope.

•Phytoplankton samples were taken and treated according to DRAFT N 109/2008/04/15-Draft proposal for "Water Quality - Guidance on quantitative and qualitative sampling of phytoplankton from inland waters".
- Standard SR EN 15204 – Guidelines for routine analysis of phytoplankton composition and abundance using the reverse microscopy (Uthermol method).

•The phytobentos was sampled according to SR EN 13945:2006 Water quality. Guidelines for the routine treatment and pre-treatment of the benthonic diatoms of rivers and according to the SR EN 14407 Standard for river benthic diatom sample identification, numbering and their interpretation.

RESULTS AND DISCUSSIONS

The sustainable management of the water sources must be made is an integrated manner at qualitative and quantitative levels for the entire catchment area. The integrated approach regarding qualitative and quantitative as well as of the hydrological conditions contribute for a better environmental protection. The surface waters and protected areas monitoring is performed as follows:

- surface water monitoring consists of the monitoring of the volume and flow level as well as ecological state, chemical state and ecological potential;
- for water analysis and monitoring, technical specifications and standards methods according to the procedure in force are used (Carabeț, 2009).

The Timiș River is the biggest draining effluent of the Banat catchment area. It collects the waters of the most important relief units of Banat, which register at the Serbian frontier an average altitude of 390 m of the catchment area. The main stream of the Timiş River follows the Caransebeş-Mehadia couloir and it is the main collector of a large number of rivers of the Ţarcu-Godeanu Mountains; as well as of the Semenic and Poiana Rusca Mountain ranges (Nagy, 2004).

For the present study, the river sections surveyed in 2012 on the Timiș River are: upstream Teregova, upstream Sadova Veche, upstream Potoc, upstream Lugoj, upstream Hitiaș and upstream Șag, village of Grăniceri.

The Timiş River suffers qualitative and quantitative modifications of the water resources, one of the causes being that it crosses various types of geological forms, while the second cause is the increase of water use from upstream sectors towards the downstream sectors.

The water flow and speed have an essential role for the aquatic activity and evolution. The water chemical composition as well as the aquatic environment diversity depend on these hydrological parameters.

The Timiş River hydrological characteristics in 2012 are presented below.

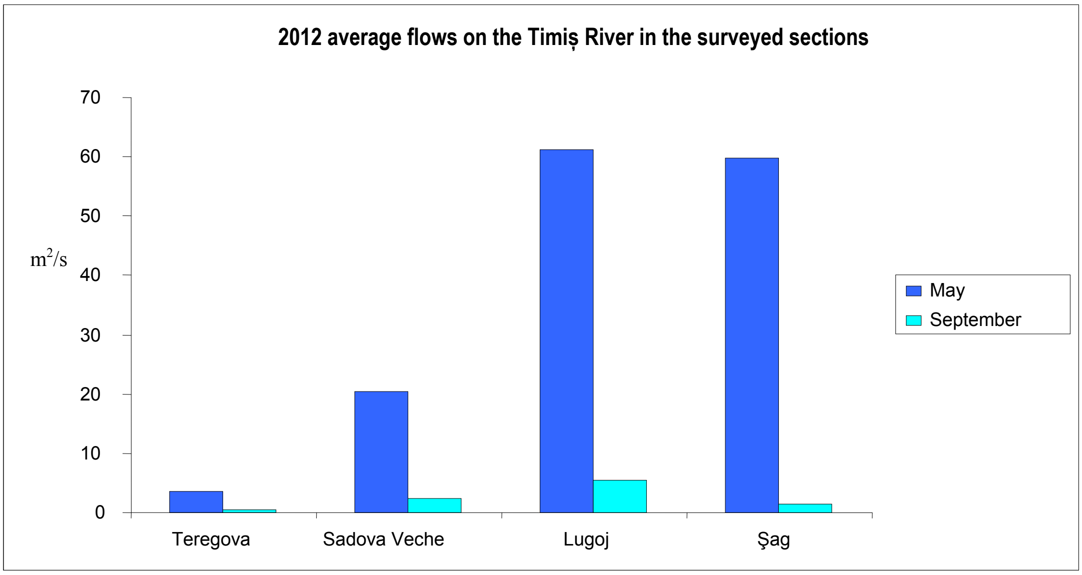


Figure 1: The Timiş River water flow in the surveyed sections.

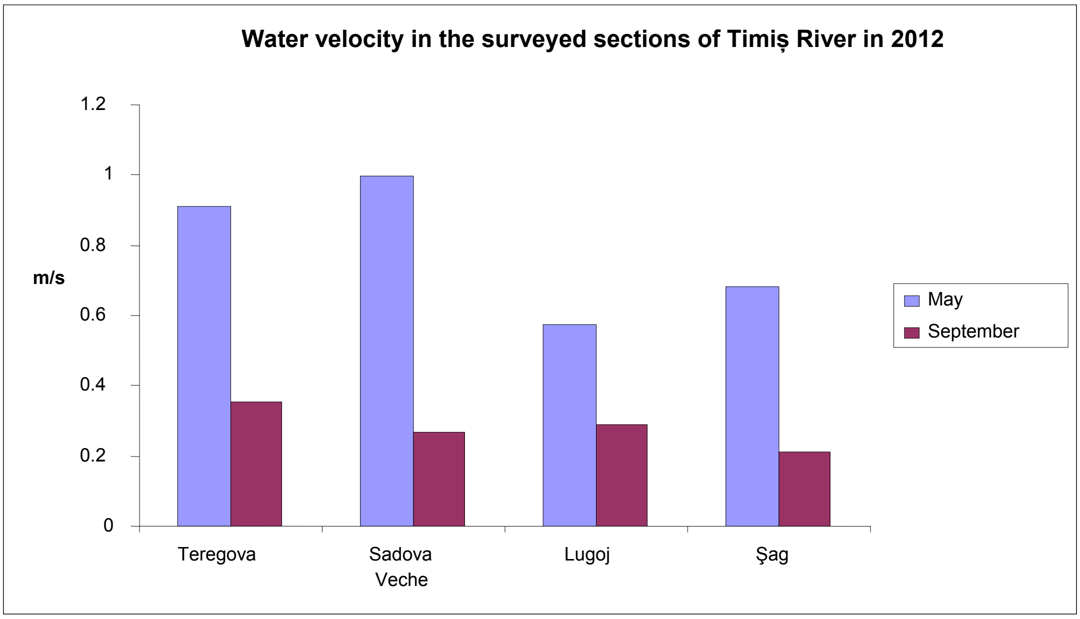


Figure 2: Water speed in the surveyed sections of Timiş River in 2012.

The Timiș River water flow increases from upstream towards downstream (Fig. 1). The largest values are recorded for the month of May, significantly decreasing in September. On the contrary, the speed decreases downstream. As for the flows, the largest water speeds are registered in the month of May and they decrease significantly in September (Fig. 2).

The snow melt and the spring precipitations are at the origin of the increase of these parameters, while the high temperatures and the summer drought led to their significant decrease in September.

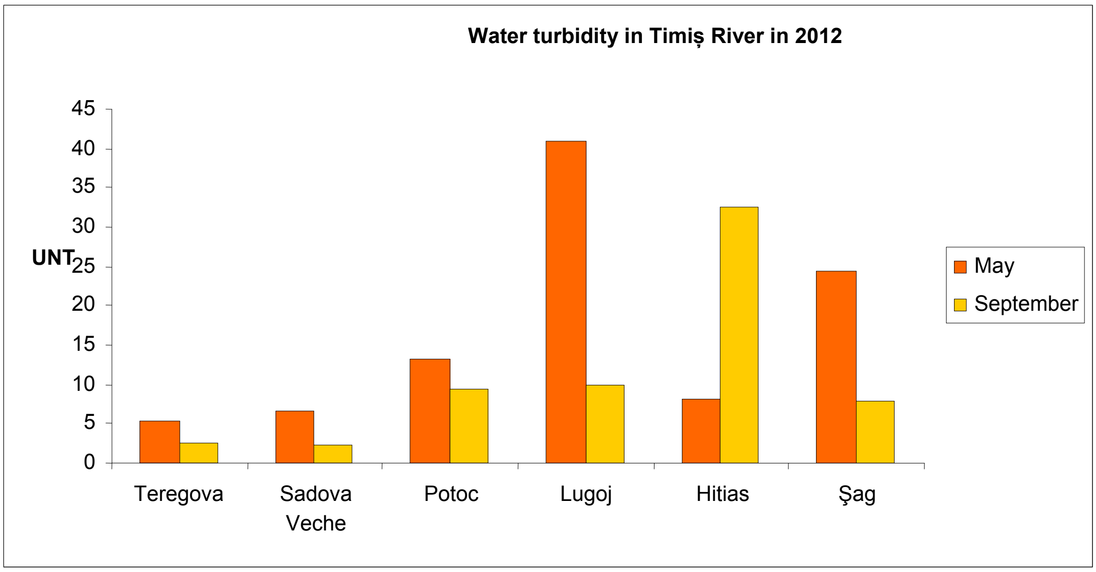


Figure 3: The variation of water turbidity in the Timiş River in the surveyed sections (2012).

A very important parameter directly influencing the aquatic organism's development is turbidity. The water turbidity results in the solid particles fragmentation and floating as well as in the development of planktonic organisms and microorganisms. Turbidity blocks the light penetration in the water layer, thus inhibiting photosynthesis and inducing a negative effect on fish and macrozoobenthos, with the additional effect of the silt depositing on the bottom (Buta and Pişota, 1975; Popa, 1997).

High turbidity can even stop photosynthesis in a short period of time and results in a decrease of the dissolved oxygen concentration. The suspended matter may carry toxic substances or too large quantities of organic substances and by sedimentation can suffocate benthonic organisms.

During the month of May the turbidity is high in all surveyed sections due to the high water speed carrying organic matter in the entire water layer. Once the water speed drops in September, the turbidity is also very low compared to May data (Fig. 3).

The Timiș River in May is chemically characterized as follows.

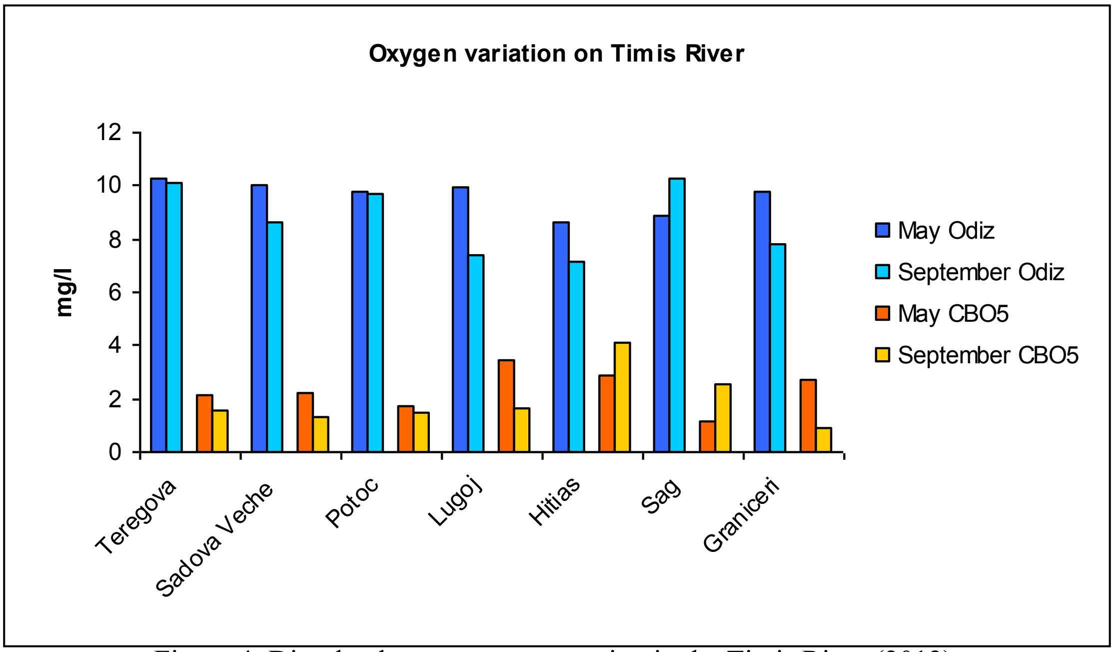


Figure 4: Dissolved oxygen concentration in the Timiş River (2012).

The dissolved oxygen concentration consists, for the surveyed sections of the Timiş River, with a good and very good quality class, and is corroborated with the classification based on the biochemical oxygen consumption. The highest value for the later corresponds to the Lugoj section in May and to Hitiaş section in September.

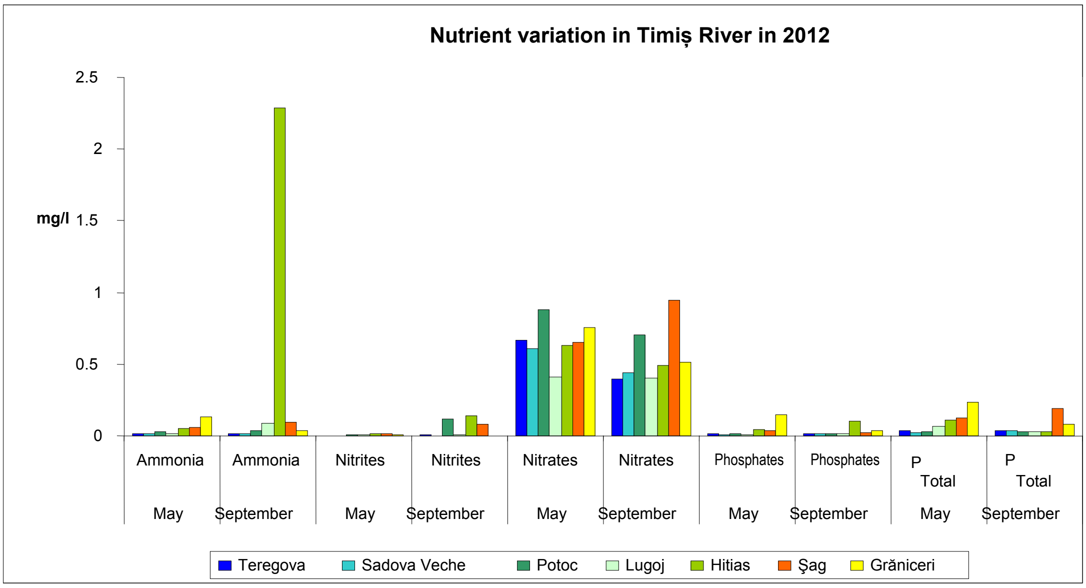


Figure 5: The nutrient variation in Timiş River (P Total – total Phosphorus).

The ammonia has registered the smallest values during the month of May, the water speed and the large flow led to its self-cleaning; but in September the ammonia concentration increases in all sections, especially in the Potoc section. The nitrites are present in very small quantities for the month of May and increase significantly in September.

The largest values of the nitrates concentration are found in the samples of the Potoc section in May and the Șag section in September. The variations of phosphate and total phosphorus concentrations are small. Larger quantities are found in the Șag and Grăniceri sections in both surveyed periods.

The biological parameters, along the Timiș River, vary greatly due to the changes in the hydromorphology and the chemistry of the watercourse.

At the river's springs, in the Teregova section, the macrozoobenthos species registering the highest density in both seasons are: *Ancylus fluviatillis, Gammarus roeseli* and *Heptagenia sulphurea*, but the presence of the oligo-saprobial species *Epeorus sylvicola, Perla marginata* and *Sericostoma personatum* is the parameter showing that the water is very clean in this section.

The phytobentos, in this section, for the month of May, is composed mainly of diatoms, dominated by the oligo-β-mezosaprobial species: *Achnanthes minutissima, Cymbella ventricosa, Diatoma elongatum, Stephanodiscus astrea, Tabellaria fenestrata* and oligo-saprobial species *Ceratoneis arcus*. Their density was of 425 individuals/sample. In September *Tabellaria fenestrata* is no longer found in this section, the rest of the species persisting, and their density in one sample being of 417 individuals/sample.

In the Sadova Veche section persists the Potoc fauna, the water quality is stationary. The phytobentos was surveyed in this section too, its density registering 412 individuals/sample, the dominant species are oligo-saprobial, β-mezosaprobial, as well as α-saprobial: *Cocconeis pediculus, Cocconeis placentula, Cymbella ventricosa, Diatoma elongatum, Melosira granulata, Meridion circulare, Navicula cryptocephala, Rhoicosphenia curvata.*

The section upstream of Potoc is characterized by the present *Ancylus fluviatillis*, *Gammarus roeselli, Hydropsyche pellucidula, Heptogenia sulphurea, Seratella ignita, Glossiphonia complanata.* In this section the oligo-saprobe species are missing, being replaced by α-saprobial species, and the water quality is depreciated.

Due to the riverbed widening and the decrease of the water speed, we monitor the phytoplankton in this section:

- in May, for a density of 1622 algal objects/ml the dominant species are: *Cymbella ventricosa, Diatome elongatum, Diatoma vulgaris, Gomphonema olivaceum*;
- in September the phytoplankton density reaches 1689 algal objects/ml, and the dominant species are: *Achnanthes minutissima, Diatoma vulgaris, Fragilaria capucina, Gomphonema constrictum* and *Navicula rhynchocephala*. *Didymosphenia geminata*, was identified here, after the first identification in the Prut River, then the Bistrița River and in the Bicaz River reservoir. Recent data shows that *Didymosphenia geminata* appears suddenly in the year 2000 and it is profuse in many rivers of Transylvania, such as: Someşul Rece, Someşul Cald, Someşul Mic, Crişul Repede, Valea Drăganului, Arieş River, Mureş River and Olt River. The present situation in Romania, characterized by the lack of monitoring programs for the algal communities of many aquatic ecosystems, is making the evaluation of this species impact on the already established communities nearly impossible.

The results of several authors of Europe, Asia, New Zeeland and North America regarding the invasive behaviour of *D. geminata* show that its massive presence affects the habitat of the benthonic macro invertebrates and fish. A decrease of the abundance and richness of some invertebrate groups was noticed, such as the case of Chyronomids or Oligochaetae that feed on algae, but cannot consume *Didimosphenia geminate* (Momeu, 2009).

This species reproduction at large scale leads to "algal blooms" and impacts the dissolved oxygen concentration not only during the vegetation period but also during the fall and winter when organic matter is decomposed, due to the occurrence of the mucilaginous peduncles. *Didymosphenia geminata* affects humans as well, inducing eye irritations.

The following surveyed section on the Timiș River is the one **upstream of Lugoj** where the dominant species are: *Ecdyonurus venosus, Ephmerella ignita, Micronecta* sp., and *Hydopsyche angustipennis.* The clean water indicating species present in this section are: *Haplotaxis gordioides, Habroleptoides confusa* and *Ecdyonurus venosus.* The water quality in the Lugoj section is good for the month of May. In September the dominant species are *Tanypodinaelae, Calopterix virgo* and *Baetis rhodani.*

The phytoplankton density in the Lugoj section is of 1060 algal objects/ml in May. The following species dominate*: Cymbella cistula, Cymbella ventricosa, Diatoma vulgaris* and *Cocconeis pediculus. Didymosphenia geminata* is also present in this section. In September, phytoplankton density is of 1066 algal objects/ml. During this period, the specific richness increases significantly, the following species being dominant: *Diatoma vulgaris, Cyclotella meneghiniana, Cymbella tumida, Navicula capitatoradiata, Navicula minuta, Ulnaria ulna, Nitzschia palea* and *Cymbella ventricosa.* Other species present during this period are*: Anomoeoneis sphaerophora, Ulnaria oxyrhynchus, Navicula pygmaea, Cyclotella stelligera, Cymbella cymbiformis, Didymosphenia geminata* and *Navicula cuspidata* var. *heribaudii.*

The middle course of the river is characterized by the significant riverbed widening, and the water speed decreases step by step. Thus the Hitiaș section of this river sector is characterized by the presence of the following species *Piscicola geometra*, *Lithogliphus naticoides*, *Procloeon bifidum, Potamanhus luteus*, *Caenis macrura*, *Hydroptila* sp., *Helycomiza ustulata*, *Micronecta* sp., *Tipula lunulata*, *Simulium* sp., *Hydropsyche angustipennis* meaning that the water has good quality.

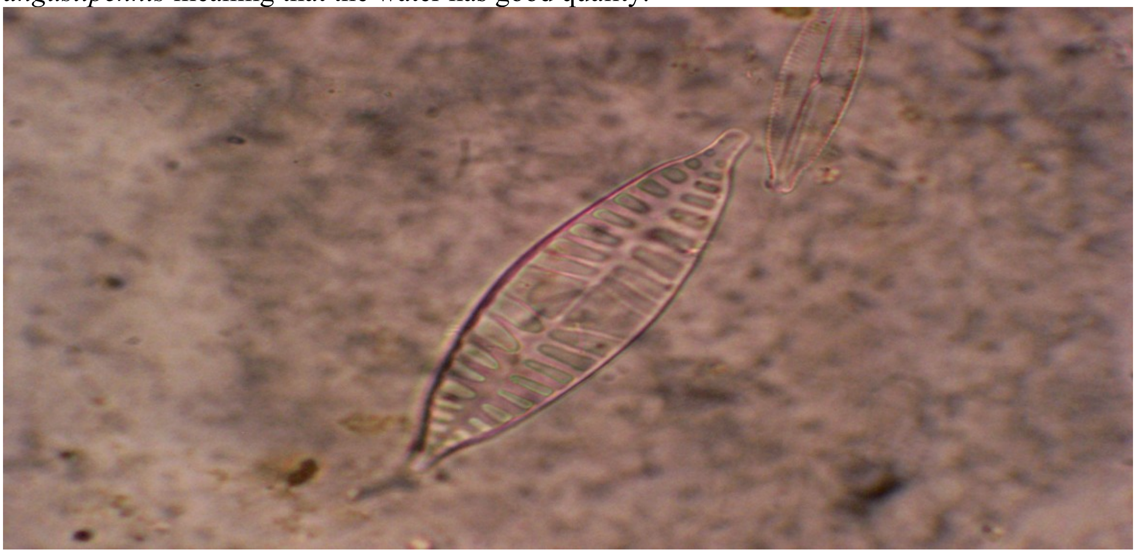


Figure 6: *Navicula cuspidata* var. Heribaudii.

The Hitiaş section went through major riverbed modifications due to excavation works in the area. In these conditions the macrozoobenthos and phytoplankton species richness suffered various changes and their diversity is low. The phytoplankton samples analyzed in this section during the month of May contained species such as: *Ulnaria ulna, Navicula radiosa, Diatoma mesodon, Diatoma vulgaris, Cocconeis pediculus, Synedra acus, Cyclotella meneghiniana, Fragilaria crotonensis, Gomphonema constrictum, Hantzschia amphyoxis* and *Didymosphenia geminata.*

In September the species number increases significantly. There are species that were not accounted for in May but that are present in September: *Navicula pygmaea, Caloneis silicula, Navicula bacillum, Pinnularia microstauron, Gyrosigma scalproides, Neidium affine, Cyclotella radiosa, Cymbella cuspidata, Nitzschia sigma, Pinnularia major, Stauroneis smithii* and *Rhoicosphenia abbreviata.*

The Grăniceri section is situated at the Serbian border in a lowland region. The waterbed is wide, the water course is smooth. The macrozoobenthos is formed of the following species*: Unio pictorum, Haplotaxix gordioides, Gammarus fossarum, Procloeon bifidum, Ecdyonurus dispar, Calopterix virgo, Lestes viridis, Ischnura elegans, Limnephilus lunatus, Limnephilus affinis, Dytiscus marginalis, Simulium* sp. and *Tanypus* sp. The largest density have the species *Haplotaxix gordioides, Simulium* sp. and *Tanypus* sp.

The phytoplankton composition has a larger number of green algae compared to the other surveyed sections where these algae were almost inexistent: *Scenedesmus opoliensis, Ankistrodesmus falcatus, Scenedesmus quadricauda. Asterionella formosa* is also present, even though it is a species occurring mostly in stagnant waters, lakes etc. In September the number and the density of the species are very low. Alfa saprobial species appear*: Navicula rhynchocephala, Stephanodiscus hantzschii, Cyclotella meneghiniana*. The green algae are missing.

CONCLUSIONS

The hydrology of the watercourse of the Timiş River is normal, the slope decreases from the springs to the plain area determining a variation of the chemistry and of the biota. There are no major pressures of water use on this course that might alter the water quality significantly.

The chemical characteristics in the upper course gives indication for a very good water quality. Step by step, the parameter values are modified due to the anthropogenic impact, but the water is still of good quality according to the standards.

Once the water speed and flow drop, some of the parameters have increased concentrations; for instance the ammonia in the Hitiaş section.

The biological parameters are influenced by the water flow, water speed, and chemistry. In May, during high water speed and flow, the biological parameters are modified; the diversity is lower as well as the individual density.

The macrozoobenthos diversity is constant from one campaign to the other. The discrepancies appear when mountain and plain regions are compared. In the mountain area *Ancylus fluviatillis, Perla marginata* and *Sericostoma personatum* are species which adapted to a large water speed and they are not present in the plain. In the Hitiaş, Şag and Grăniceri section, due to the riverbed widening and to the presence of sand and silt, *Unio pictorum* species occurs.

The mountain area surveyed phytobentos registers, an approximate constant density of the individuals, both in the Teregova section and the Sadova Veche section. The species richness is similar.

In the Potoc, Lugoj, Hitiaş, Şag and Grăniceri sections, the phytoplankton was surveyed and analyzed, and the species *Didymosphenia geminate* (Momeu, 2009) was identified. It is an invasive species with potential to affect the macrozoobenthos, produce algal blooms, and affect humans. This species did not migrated upstream; the water speed is too big in the mountain area.

In September, the water speed and flow are very low, thus the number of the phytoplankton species increases and green algae appear.

In the Hitiaş section, the large amount of ammonia from this month does not affect the macrozoobenthos or the phytoplankton.

In the Lugoj section for the month of September the following species are identified: *Navicula cuspidata* var. *Heribaudii* (Fig. 6) and *Anomoeoneis sphaerophora.* The environmental conditions for the occurrence of these species are: relatively low water flow and speed, relatively high amounts of ammonia, very small amounts of phosphates and total phosphorus, nearly inexistent nitrites and quite large amounts of nitrates.

REFERENCES

1. Buta I. and Pisota I., 1975 – Hidrologie, Edit. Didactică și pedagogică București, 11-54. (in Romanian)
2. Carabeţ A., 2009 – Monitoringul apelor, Facultatea Hidrotehnică, Timişoara, 695-699. (in Romanian)
3. Mălăcea I., 1969 – Biologia apelor impurificate, Edit. Academiei Române, Bucureşti, 11-65. (in Romanian)
4. Momeu L., 2009 – Problems concerning the invasive species from continental aquatic ecosystems Case study: Didymosphenia geminata (Lyngb.), Schmidt, in Rakosy L. and Momeu L. (eds.) Neobiota din România, Presa Universitară Clujeană, 11-30.
5. Nagy C. and Şerban P., 2004 – Planul de Management al Spaţiului Hidrografic Banat, Administraţia Bazinală de Apă Banat, Timişoara, 1-75. (in Romanian)
6. Popa R., 1997 – Elemente de hidrodinamica râurilor, Edit. Didactică şi pedagogică, R. A, Bucureşti, 16-38. (in Romanian)

THE HYDROPHILOUS FLORA AND VEGETATION OF THE TIMIŞ DRAINAGE BASIN (BANAT, ROMANIA)

Constantin DRĂGULESCU *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, ctindrg@yahoo.com

DOI: 10.2478/trser-2013-0034

KEYWORDS: Romania, Banat, Timiş Valley, hydrophilous, hygrophilous cormoflora, vegetation, chorology.

ABSTRACT

The paper lists 285 plant species, and 63 aquatic and paludal phytocoenoses, noted across the Timiş drainage basin during the past two centuries (the sign "!" indicates that the author saw such plants or phytocoenoses in the mentioned place).

For each individual species, I noted the scientific denomination, the author, the corresponding family, the bioform, the floristic element, ecological indices for humidity (H), temperature (T), and soil reaction (R), coenotic preference and chorology in the Timiş drainage basin.

ZUSAMMENFASSUNG: Die hydrophile und hygrophile Flora und Vegetation im Einzugsgebiet des Timiş Flusses.

Es werden 285 Pflanzenarten sowie 63 Wasser- und Sumpfpflanzengesellschaften aufgezählt, die im Einzugsgebiet des Timiş-Flusses im Verlauf von zwei Jahrhunderten festgestellt wurden (das hinzugefügte Ausrufezeichen weist darauf hin, dass der Autor die jeweilige Pflanze bzw. Pflanzengesellschaft selbst an dem angegebenen Fundort vorgefunden hat).

Für jede Art ist ihr wissenschaftlicher Namen, Verfasser, Zugehörigkeit zur jeweiligen Pflanzenfamilie, Lebensform und Florenelement angegeben; hinzu kommen die ökologischen Zeigerwerte für Feuchtigkeit (U), Temperatur (T) und Bodenreaktion (R), zönotische Präferenzen sowie die Chorologie der Arten im Einzugsgebiet des Timiş-Flusses.

REZUMAT: Flora şi vegetaţia hidrofilă a bazinului de drenaj Timiş.

În lucrare, sunt enumerate 285 specii de plante şi 63 asociaţii vegetale acvatice şi palustre, semnalate în bazinul Văii Timişului pe parcursul a două secole (semnul ! evidenţiază faptul că autorul a văzut plantele sau fitocenozele asociaţiilor în locul citat).

La fiecare specie vegetală s-a notat denumirea ştiinţifică, autorul, familia la care aparţine, bioforma, elementul floristic, indicii ecologici pentru umiditate (U), temperatură (T), şi reacţia solului (R), de asemenea preferinţele cenotice şi corologia în bazinul Timişului.

INTRODUCTION

The first information regarding the flora of Banat province (including aquatic and paludal plants) comes from the 19th-century botanists Rochel (1823), Heuffel (1858) and Borbás (1884). More than half a century later, several botanical works are published by Buia (1942), Soran (1954, 1956) and particularly Boşcaiu (1942, 1944, 1965, 1966, 1971, 1971a), in which the authors list over two hundred species of hydrophilic, hygrophilous, and mezo-hygrophile plant species, as well as thirty conenoses in such ecological categories. Stere (1971, 1971a) notes species and conenoses in the Timiş-Bega rivers area; Vicol (1974) in the Lugoj Piedmont; Arvat (1977) in and among the rivers Timiş, Pogoniş and Bârzava; Pop (1977) in the lower Timiş River plain. Recently, Neacşu et al. (2008, 2009) have added data regarding aquatic and paludal species with information from Liebling. Finally, the undersigned researched the flora and vegetation of the Timiş from Trei Ape up to Giulvăz (in 2001, 2008 and 2011).

MATERIAL AND METHODS

The paper was developed based on field observation made by the author and information taken from the bibliography to be found at the end of the paper. While in the field, I noted plant species and phytocoenoses (in most cases, including the execution of phytocoenologic samplings). For each individual species, I noted the scientific denomination, the author, the corresponding family, the bioform, the floristic element, ecological indices for humidity (H), temperature (T), and soil reaction (R), coenotic preference and chorology in the Timiş drainage basin.

RESULTS AND DISCUSSIONS

The paper lists 285 plant species and 63 aquatic and paludal phytocoenoses observed across the Timiş drainage basin (the sign "!" indicates that the author saw such plants or phytocoenoses in the place mentioned). For each individual species, I noted the scientific denomination, the author, the corresponding family, the bioform, the floristic element, ecological indices for humidity (H), temperature (T), and soil reaction (R), coenotic preference and chorology in the Timiş drainage basin.

Flora

Equisetaceae

Equisetum fluviatile L. (E. limosum L.): Hh, Cp; U5T3R0, Magnocaricion elatae, Phragmitetea: Bistra Mărului Valley (Boşcaiu, 1971)

Equisetum hyemale L.: G, Cp; U3.5T2.5R4, Alno-Padion:, Armeniş on Alb River and Lung River, Borlova, Hidegu Stream, Poiana Mărului, Rusca, (Boşcaiu, 1971)

Equisetum palustre L.: G, Cp; U5T2R0, Molinietalia: Belinţ, Caransebeş (!), Glimboca, Lugoj (!), Măgura (Boşcaiu, 1971), Marga (!), Obreja, Hidegu Stream, Rusca (Boşcaiu, 1971), Trei Ape (!), Turnu Ruieni, Bistra Valley, Zerveşti (Boşcaiu, 1971)

Equisetum sylvaticum L.: G, Cp; U3.5T2R0, Alno-Padion, Alnion glutinosae-incanae: Borlova, V. Bistra Mărului (Boşcaiu, 1971), Trei Ape (!)

Equisetum telmateia Ehrh. (E. maximum Lam.): G, Cp; U3.5T2R0, Alno-Padion, Eriophorion latifolii, Filipendulo-Petasition: Armeniş on Alb River, Borlova, Sebeşului Spring, Hidegu Stream, Rusca, Teregova, Bistra Mărului Valley, (Boşcaiu, 1971), Armeniş (!), Trei Ape (!); f. ***comosum*** (Milde) Aschers.: Armeniş (Flora I)

Ophioglossaceae
Ophioglossum vulgatum L.: G, Cp; U4T3R0, Molinion coeruleae: Bazoş, Zerveşti (Flora I)

Athyriaceae
Matteuccia struthiopteris (L.) Todaro (Struthiopteris filicastrum All.): H, Cp; U4T2R0, Alno-Padion: Trei Ape (!)

Thelypteridaceae
Thelypteris palustris Schott (Dryopteris thelypteris (L.) A. Gray): Hh-G, Cp; U4T0R3, Alnion glutinosae, Alno-Padion, Magnocaricion elatae: Obreja (Boşcaiu, 1971)

Marsileaceae
Marsilea quadrifolia L.: Hh, Eua (M); U6T3R0, Nanocyperion: Liebling, Moşniţa (Soran, 1954), Urseni (Stere, 1971a)

Salviniaceae
Salvinia natans (L.) All.: Hh, Eua; U6T3R3, Hydrocharition: Albina, Bazoş, Chizătău, Cruceni, Giulvăz, Ivanda (Stere, 1971a), Liebling in fen Tofaia (Soran V., 1956), Lugoj in the lake from Str. Bocşei, at the brick yard Bartoş and in lakes from Complexul III (Boşcaiu, 1966), Pădureni on Timişul Mort (Soran, 1956), Şag, Uliuc, Urseni (Stere, 1971a), Unip on Timiş (Flora I)

Nymphaeaceae
Nuphar lutea (L.) Sm.: Hh, Eua-M; U6T0R3.5, Nymphaeion: between Lugoj and Tapia on Ştiuca Stream (Boşcaiu, 1966), Ciacova, Lugoj, Timiş tributaries (Flora III)
Nymphaea alba L.: Hh, E; U6T0R4, Nymphaeion: Lugoj (Flora III)

Ceratophyllaceae
Ceratophyllum demersum L. subsp. ***demersum***: Hh, Cosm; U6T3R0, Potamion: Lugoj (Flora III)
Ceratophyllum submersum L.: Hh, E; U6T3.5R0, Hydrocharition, Potamion: Caransebeş (!), Chizătău, Cruceni, Diniaş, Foeni, Giroc (Stere, 1971a), Lugoj (!) in the lake from Str. Bocşei, at the brick yard Bartoş (Boşcaiu, 1966), between Lugoj and Tapia on Ştiuca Stream (Boşcaiu, 1966), Moşniţa Veche, Rudna (Stere, 1971a), Pădureni on Timişul Mort and in puddles (Soran, 1956)

Ranunculaceae
Caltha palustris L.: H, Cp; U4.5T0R0, Calthion palustris, Cardamini-Montion, Molinietalia: Lugoj (Boşcaiu, 1966), Mt. Mic (Boşcaiu, 1971), Trei Ape (!); var. ***alpina*** (Schur) Graebn.: Semenic Mts. (Flora II), Armeniş on Alb River and Lung River, Borlova, Sebeşului Spring, Marga, Măgura, Hidegu Stream, Poiana Mărului, Poiana Nedeii, Rusca, Turnu Ruieni, Bistra Mărului Valley (Boşcaiu, 1971); var. ***alpestris*** (Schott, Nym. et Korschy) Beck: Bistra Mărului Spring, Mic Mt. (Boşcaiu, 1971, 1971a), Căleanu Peak (Boşcaiu, 1971), Ţarcu Peak (Boşcaiu, 1971, 1971a), Sebeşului Valley (Boşcaiu, 1971a)
Myosurus minimus L.: Th, Cosm; U4T4R3, Agropyro-Rumicion, Nanocyperion flavescentis: Ciacova (Flora II)

Ranunculus aquatilis L.: Hh, Cosm; U6T4R0, Potamion, Nymphaeion: Dragşna, Foeni (Stere, 1971a), Liebling (Neacşu et al., 2008)
Ranunculus flammula L.: H, Eua; U4.5T3R0, Agrostion stoloniferae, Caricion canescenti-nigrae, Magnocaricion elatae: Caransebeş-Gara Ţiglărie (Boşcaiu, 1965), Bistra Valley beside Măgura (Boşcaiu, 1971)
Ranunculus lateriflorus DC.: Th, Eua(C); U5T3R5, Nanocyperion, Beckmannion: Diniaş, Giulvăz (Stere, 1971a)
Ranunculus lingua L.: Hh, Eua; U6T3R4, Phragmition australis: Lugoj at the brick yard Bartoş (Boşcaiu, 1966)
Ranunculus ophioglossifolius Vill.: H, Atl-M; U5T3,5R0, Calthion: Peciu Nou (Flora XIII)
Ranunculus repens L.: H, Eua; U4T0R0, Agropyro-Rumicion, Alno-Padion, Bidentetalia tripartiti, Calystegion, Molinio-Arrhenatheretea, Phragmitetea, Plantaginetea majoris, Salicetea purpureae: Armeniş (!) on Alb River and Lung River (Boşcaiu, 1971), Bazoş, Belinţ (!), Bolvaşniţa (Boşcaiu, 1971, !), Borlova, Caransebeş, Chizătău, Coşteiu, Criciova, Gărâna, Giulvăz (!), Glimboca (Boşcaiu, 1971, !), Ilova, Sebeşului Spring (Boşcaiu, 1971), Liebling (Neacşu et al., 2008), Lugoj (Boşcaiu, 1966, !), Lugojel (!), Marga, Măgura (Boşcaiu, 1971,!), Ţarcu Peak, Obreja (Boşcaiu, 1971), Oţelul Roşu (Boşcaiu, 1971, !), Peciu Nou (!), Hidegu Stream, Poiana Mărului, Rusca, Sadova Nouă, Sadova Veche (Boşcaiu, 1971), Sacu, Şag, Trei Ape (!), Bistra Mărului Valley, Sebeşului Valley (Boşcaiu, 1971, 1971a), Vălişoara, Vârciorova, Zăvoi, Zlagna (Boşcaiu, 1971), between Zerveşti and Turnu Rueni (Boşcaiu, 1965, 1971); f. ***haynaldi*** (Menyh) Borza.: Giroc (Buia, 1942)
Ranunculus sardous Cr.: Th-TH, Eua; U3T3R4, Agropyro-Rumicion, Agrostion stoloniferae, Nanocyperion: Jebel, Liebling (Soran, 1956)
Ranunculus trichophyllus Chaix. (Batrachium trichophyllum (Chaix) Bosch, B. divaricatum (Schrank) Wimmer): Hh, E; U6T3R0, Potamion: Caransebeş (Flora II), Liebling in Balta Mare and Balta Mică (Soran, 1956)
Thalictrum flavum: H, Eua; U4,5T0R4,5, Molinietalia, Filipendulo-Petasition, Alno-Padion: Caransebeş-Gara Ţiglărie (Boşcaiu, 1965), Liebling (Neacşu et al., 2008), between Zerveşti and Turnu Rueni (Boşcaiu, 1965)
Thalictrum lucidum L.: H, Ec; U4.5T3R5, Alnetea glutinosae, Alno-Padion, Filipendulo-Petasition, Molinietalia, Salicetea purpureae: Hidegu Stream, Poiana Mărului (Boşcaiu, 1971)
Thalictrum simplex L. subsp. ***galioides*** (Nestl.) Borza: H, Eua; U4T3R0, Molinion: Caransebeş-Gara Ţiglărie (Boşcaiu, 1965), Teregova (Boşcaiu, 1971), between Zerveşti and Turnu Rueni (Boşcaiu, 1965, 1971)

Betulaceae

Alnus glutinosa (L.) Gaerter: Mph-mPh, Eua; U5T3R3, Alnion glutinosae, Alno-Padion: upstream of Armeniş (!) on Alb River and Lung River, Borlova (Boşcaiu, 1971), Buchin, Bucoşniţa, Gărâna (!), Măgura, Obreja, Hidegu Stream (Boşcaiu, 1971), Petroşniţa (!), Poiana Mărului, Rusca, Sadova Veche (Boşcaiu, 1971, !), Teregova, Trei Ape (!), Turnu Ruieni, Bistra Valley, Bistra Mărului Valley, Bolvaşniţa Valley, Sebeşului Valley, Var, Vălişoara, Vârciorova, Zerveşti (Boşcaiu, 1971)
***Alnus incana* (L.)** Moench: Mph-mPh, E; U4T2R4, Alno-Padion, Salicion albae: Armeniş (!) on Alb and Lung River, Borlova, Bucova, Ilova, Sebeşului Spring, Hidegu Stream, Poiana Mărului, Poiana Nedeii, Rusca, Sadova Nouă, Turnu Ruieni, Bistra Valley, Bistra Mărului Valley, Var, Vălişoara, Vârciorova, Zerveşti, Zlagna (Boşcaiu, 1971)

Alnus x pubescens Tausch. (glutinosa x incana): Armeniş, Poiana Mărului, Bistra Valley at Măgura, Bistra Mărului Valley (Boşcaiu, 1971)

Portulacaceae

Montia minor C. C. Gmelin (M. verna Necker, M. fontana L.): Th, Cp; U4.5T3.5R2.5, Alnetalia glutinosae, Cardamini-Montion, Nanocyperion flavescentis: Belinţ (Stere, 1971), Caransebeş, Lugoj (Bujorean, 1959), Sacu (Stere, 1971, Flora XIII); subsp. ***chondrosperma*** Cham.: Sacu (Herb. Grăd. Bot. Iaşi)

Caryophyllaceae

Lychnis flos-cuculi L.: H, Eua; U4T2.5R0, Magnocaricion elatae, Molinietalia, Molinio-Arrhenatheretea: Armeniş (!) on Alb River, Borlova (Boşcaiu, 1971), Caransebeş (!), Caransebeş-Gara Ţiglărie (Boşcaiu, 1965), Glimboca, Sebeşului Spring (Boşcaiu, 1971), Mic Mt. (Boşcaiu, 1971a), Obreja, Hidegu Stream, Poiana Mărului, Bistra Valley, Bistra Mărului Valley (Boşcaiu, 1971), between Zerveşti and Turnu Rueni (Boşcaiu, 1965)

Myosoton aquaticum (L.) Moench (Stellaria aquatica (L.) Scop.): H, Eua; U4T3R0, Alno-Padion, Bidention tripartiti, Salicion albae, Senecion fluviatilis: Armeniş (!) on Alb River, Borlova (Boşcaiu, 1971), Caransebeş (!), Hidegu Stream, Măgura, Poiana Mărului, Rusca (Boşcaiu, 1971), Trei Ape (!), Turnu Ruieni, Bistra Valley, Bistra Mărului Valley, Zerveşti (Boşcaiu, 1971)

Stellaria uliginosa Murray (S. alsine Grimm.): H, Cp; U4.5T2.5R2.5, Cardamini-Montion: Armeniş (!), Trei Ape (!)

Polygonaceae

Polygonum amphibium L.: Hh, Cosm; U6T3R0, Agropyro-Rumicion, Agrostion stoloniferae, Alnetea glutinosae, Phragmitetea, Polygono-Chenopodion polyspermi, Salicetea purpureae: Chizătău (!), Liebling (Neacşu et al., 2008); f. ***aquaticum*** Leyss: Boldur, Lugoj at the brick yard Bartoş (Boşcaiu, 1966)

Polygonum bistorta L.: G, Eua; U4T2.5R3, Calthion palustris, Molinietalia, Triseto-Polygonion: Semenic Mt. (Flora I), Mic Mt. (Boşcaiu, 1971, 1971a)

Polygonum cuspidatum Sieb. et Zucc. (Reynoutria japonica Houtt.): G, Adv; U3.5T3R4, Alno-Padion, Calystegion, Salicion albae: Armeniş (!), Bucoşniţa (!), Obreja (Boşcaiu, 1971), Petroşniţa (!), Sadova Veche (!), Bistra Valley between Glimboca and Măgura (Boşcaiu, 1971)

Polygonum hydropiper L.: Th, Cp; U4.5T3R4, Alnetea glutinosae, Bidention tripartiti, Salicion albae: Armeniş (Boşcaiu, 1971, !), Borlova (Boşcaiu, 1971), Boldur (Boşcaiu, 1966), Buchin, Bucoşniţa, Caransebeş, Giulvăz (!), Glimboca (Boşcaiu, 1971, !), Liebling (Neacşu et al., 2008), Lugoj (Boşcaiu, 1966, !), Măgura, Obreja (Boşcaiu, 1971), Oţelul Roşu, Peciu Nou (!), Hidegu Stream, Rusca, Sadova Veche, Turnu Ruieni, Bistra Mărului Valley, Var, Vălişoara, Vârciorova, Zerveşti (Boşcaiu, 1971)

Polygonum lapathifolium L. ssp. ***lapathifolium***: Th, Cosm; U4T0R3, Bidention tripartiti, Polygono-Chenopodion polyspermi, Sisymbrion officinalis: Armeniş (!), Borlova (Boşcaiu, 1971), Caransebeş, Glimboca (!), Lugoj (Boşcaiu, 1966, !), Lugojel (!), Măgura, Obreja, Rusca, Sadova Veche, Turnu Ruieni, Bistra Valley, Var, Zerveşti (Boşcaiu, 1971)

Polygonum minus Hudson: Th, Eua; U4,5T3R4, Bidention: Obreja, Bistra Valley beside Măgura, Bistra Mărului Valley (Boşcaiu, 1971)

Polygonum mite Schrank: Th, E; U5T3R4, Bidentetalia tripartiti: Liebling (Neacşu et al., 2008), Lugoj (Boşcaiu, 1966, !), Obreja, Bistra Valley beside Măgura, Bistra Mărului Valley (Boşcaiu, 1971)

Polygonum persicaria L.: Th, Eua; U4.5T3R0, Phragmitetea, Polygono-Chenopodietalia, Salicetalia purpureae: Armeniş (!), Jebel, Liebling (Soran, 1956), Teregova (!)
Rumex conglomeratus Murray: H, Cp; U4T3R4, Agropyro-Rumicion, Bidention tripartiti: Armeniş (Boşcaiu, 1971,!), Bucoşniţa, Caransebeş (!), Lugoj (Flora I,!), Obreja, Rusca, Turnu Ruieni, Bistra Valley, Bistra Mărului Valley, Zerveşti (Boşcaiu, 1971),
Rumex crispus L.: H, Eua; U4T3R0, Agropyro-Rumicion, Arrhenatherion elatioris: Armeniş, Borlova (Boşcaiu, 1971, !), Bucoşniţa, Caransebeş (!), Glimboca, Măgura (Boşcaiu, 1971, !), Jebel (Soran, 1956), Liebling (Neacşu et al., 2008, Soran, 1956), Hidegu Stream, Poiana Mărului, Rusca (Boşcaiu, 1971), Trei Ape (!), Turnu Ruieni, Bistra Mărului Valley, Zerveşti (Boşcaiu, 1971)
Rumex hydrolapathum Hudson: Hh, E; U6T4R4, Phragmition australis: V. Ştiuca beside Tapia (Boşcaiu, 1966)
Rumex palustris Sm (R. limosus Thiull.): Th-TH, Eua; U5T3R4, Bidention: Liebling (Neacşu et al., 2008)
Rumex sanguineus L.: H, E; U4T3R4, Alno-Padion, Fagetalia silvaticae: Armeniş (!) on Alb and Lung River, Borlova, Sebeşului Sping, Măgura, Poiana Mărului, Rusca, Bistra Mărului Valley (Boşcaiu, 1971)
Rumex x gayeri Rech f. (crispus x kerneri): Lugoj (Flora I)

Saxifragaceae
Chrysosplenium alternifolium L.: H, Cp; U4T2R4, Alno-Padion, Fagetalia silvaticae: Mt. Semenic (Flora IV), Armeniş, Borlova, Bucova, Izvorul Sebeşului, Marga, Măgura, Oţelul Roşu, Pâr. Hidegu, Poiana Mărului, Rusca, V. Bistra, Vf. Călianu, Vf. Piga, Zăvoi (Boşcaiu N., 1971), Groapa Bistrei, Mt. Mic, Mt.. Ţarcu, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971, 1971a)
Saxifraga aizoides L.: Ch, Eua; U4,5T0R4,5, Cratoneurion commutati: Dunga Gropii Bistra under Vf. Ţarcu (Boşcaiu N., 1971a)
Saxifraga stellaris L. subsp. ***robusta*** (Engler) Gremli: Ch, Eua (arct-alp); U5T1.5R3, Cardamini-Montion: Groapa Bistrei, Mt. Mic (Boşcaiu N., 1971, 1971a), Mt. Ţarcu (Flora IV, Boşcaiu N., 1971, 1971a), V. Bistra Mărului (Boşcaiu N., 1971, 1971a), Vf. Călianu, Vf. Piga (Boşcaiu N., 1971)

Parnassiaceae
Parnassia palustris L.: H, Cp; U4.5T2R4.5, Caricetalia davallianae, Molinion coeruleae, Tofieldietalia: Groapa Bistrei (Boşcaiu N., 1971, 1971a), Mt. Mic, Mt. Ţarcu (Boşcaiu N., 1971, 1971a), Vf. Căleanu, (Boşcaiu N., 1971)

Rosaceae
Filipendula ulmaria (L.) Maxim.: H, Eua; U4.5T2R0, Alno-Padion, Filipendulo-Petasition, Molinietalia; Caransebeş, Gărâna (!), Măgura, Obreja, Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Trei Ape (!), V. Bistra, V. Bistra Mărului, Zerveşti (Boşcaiu N., 1971)
Geum rivale L.: H, Cp; U4.5T0R4.5, Adenostylion alliariae, Calthion palustris, Filipendulo-Petasition: Mt. Mic (Boşcaiu N., 1971a), Mt. Ţarcu (Flora IV, Boşcaiu N., 1971), Mt. Semenic (Flora IV)
Potentilla anserina L.: H, Cosm; U4T3R4, Bidentetalia tripartiti, Molinietalia, Nanocyperetalia, Plantaginetalia majoris: Belinţ (!), Borlova (Boşcaiu N., 1971), Chizătău, Coşteiu, Giulvăz (!), Liebling (Neacşu A. et al., 2008), Lugoj, Lugojel, Peciu Nou, Sacu, Şag (!), V Bistra, Vârciorova, (Boşcaiu N., 1971)

Potentilla supina L.: TH-H, Eua-sM; U4T3R0, Bidention tripartiti, Nanocyperion flavescentis: V. Bistra (Boşcaiu N., 1971)
Sanguisorba officinalis L.: H, Cp; U3T3R0, Molinietalia: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965; Flora IV), Moşniţa (Flora IV), V. Bistra, (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)

Fabaceae
Lotus pedunculatus Cav. (Lotus uliginosus Schkuhr): H, Atl-sM; U4T3R3, Molinietalia: Lugoj (Boşcaiu N., 1966)
Trifolium hybridum L. ssp. ***hybridum***: H, Atl-E; U3.5T3R4, Agropyro-Rumicion, Agrostion stoloniferae, Calthion palustris: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş (!), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Lugoj (Boşcaiu N., 1966), Marga, Obreja, Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), V. Bistra (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971); subsp. ***elegans*** (Savi) Acherson et Graebner: Sadova Veche (Boşcaiu N., 1971 ap. V. Borbas, 1873)

Haloragaceae
Myriophyllum spicatum L.: Hh, Cp; U6T0R4.5, Potamion, Nymphaeion: Liebling in Balta Mare and Balta Mică (Soran V., 1956), Lugoj (!) in the lake from Str. Bocşei and in lakes from Complexul III (Boşcaiu N., 1966), between Şag and Urseni in Timiş (Soran V., 1956), Urseni (Stere G., 1971a)
Myriophyllum verticillatum L.:Hh, Cp; U6T3,5R3,5, Potamion, Nymphaeion: Rudna (Stere G., 1971a)

Lythraceae
Lythrum hyssopifolia L.: Th, Cosm; U4T3R0, Nanocyperion flavescentis: Armeniş (Boşcaiu N., 1971), Jebel (Soran V., 1956), Liebling (Soran V., 1954, 1956), Lugoj in the lake from Str. Bocşei (Boşcaiu N., 1966), Obreja (Boşcaiu N., 1971)
Lythrum portula (L.) D.A. Webb. (Peplis portula L.): Th, Atl-M; U4T3R0, Nanocyperion flavescentis: Bucoşniţa (!), Glimboca (Boşcaiu N., 1971), Jebel, Liebling (Soran V., 1954, 1956), Lugoj (Boşcaiu N., 1966, !), Pâr. Hidegu, Obreja (Boşcaiu N., 1971), Trei Ape (!),
Lythrum salicaria L.: H, Cp; U4T3R0, Alnetea glutinosae, Filipendulo-Petasition, Molinietalia, Phragmitetea, Salicetea purpureae: Armeniş (Boşcaiu N., 1971,!), Belinţ (!), Borlova (Boşcaiu N., 1971), Bucoşniţa, Caransebeş, Gărâna, Giulvăz (!), Glimboca, Ilova, Izvorul Sebeşului (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Marga, Măgura, Obreja, Oţelul Roşu, Pâr. Hidegu (Boşcaiu N., 1971), Pădureni on Timişul Mort (Soran V., 1956), Poiana Mărului, Rusca (Boşcaiu N., 1971), Sadova Veche (Boşcaiu N., 1971,!), Tapia (Boşcaiu N., 1966), Teregova (!), Turnu Ruieni, V. Bistra, Var, Zerveşti (Boşcaiu N., 1971)
Lythrum virgatum L.: H, Eua-C; U4,5T3,5R4, Agrostion stoloniferae: Jebel, Liebling (Soran V., 1956)

Onagraceae
Chamerion (Chamaenerion) dodonei (Vill.) Holub (Chamaenerion palustre auct., Epilobium dodonaei Vill.): H, Ec; U4.5T0R2, Thlaspietea rotundifolii: Măguri, Sacu in V. Timişului (Flora V)

Epilobium alsinifolium Vill.: H, E (arct-alp); U5T1.5R0, Montio-Cardaminetea: Groapa Bistrei (Boşcaiu N., 1971), Mt. Ţarcu (Flora V, Boşcaiu N., 1971), Poiana Mărului (Boşcaiu N., 1971)
Epilobium anagalidifolium Lam. (E. alpinum auct. non L.): H, Cp (arct-alp); U4T1.5R0, Androsacetalia alpinae, Cardamini-Montion: Groapa Bistrei, Mt. Ţarcu (Flora V, Boşcaiu N., 1971), Izvorul Hidegu (Boşcaiu N., 1971)
Epilobium ciliatum Rafin (E. adenocaulon Hausskn, E. hirsutum var. adenocaulon Hausskn.).: H, Adv; U4T3R3, Filipendulo-Petasition, Molinietalia, Phragmitetea
Epilobium hirsutum L.: H, Eua; U4T3R3, Filipendulo-Petasition, Phragmitetea: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Bucoşniţa, Caransebeş (!), Glimboca (Boşcaiu N., 1971), Lugoj (Boşcaiu N., 1966,!), Pădureni on Timişul Mort (Soran V., 1956), Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Sadova Veche (!), Teregova (!), Trei Ape (!),V. Bistra (Boşcaiu N., 1971); var. ***villosum*** (Roch.) Hausskn.: Borlova (Boşcaiu N., 1971)
Epilobium nutans F.W. Schmidt: H, E (alp); U5T2R2, Cardamini-Montion, Sphagnion fusci: Groapa Bistrei (Flora V), Mt. Mic (Boşcaiu N., 1971, 1971a), Mt. Ţarcu (Flora V, Boşcaiu N., 1971, 1971a)
Epilobium obscurum Schreber: H, E; U5T0R2, Cardamini-Montion, Epilobietea angustifolii, Glycerio-Sparganion: Caransebeş (!)
Epilobium palustre **L.: H, Cp; U5T0R2, Calthion palustris, Magnocaricion elatae, Scheuchzerio-Caricetalia nigrae: Obreja, Sadova Nouă, V. Bistra, Zerveşti (Boşcaiu N., 1971); var.** *fontanum* **Hausskn.: Groapa Bistrei în M-ţii Ţarcu, M-ţii Semenic (Flora V)**
Epilobium parviflorum Schreber: H, Eua; U5T3R4.5, Glycerio-Sparganion, Phragmitetea: Armeniş (Boşcaiu N., 1971,!), Bucoşniţa (!), Gărâna (!), Lugoj (Boşcaiu N., 1966), Măgura (Boşcaiu N., 1971), Pădureni on Timişul Mort (Soran V., 1956), Poiana Mărului, Turnu Ruieni, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971), Urseni (Soran V., 1956),
Epilobium roseum Schreber: H, Eua; U4.5T3R4.5, Glycerio-Sparganion: Măgura, Mt. Ţarcu, Poiana Mărului, Turnu Ruieni (Boşcaiu N., 1971)
Epilobium tetragonum L. (E. adnatum Griseb.): H, Eua (sM); U4.5T3R0, Agrostion stoloniferae, Bidentetalia tripartiti, Magnocaricion elatae: Bazoş (Flora V)
Epilobium x boissieri Hausskn. (anagalidifolium x alsinifolium): Mt. Ţarcu la Izvorul Hidegu (Flora V, Boşcaiu N., 1971)
Ludwigia palustris (L.) Elliot: Th-Hh, Atl-M; U4,5T3,5R3,5, Magnocaricion; Lugoj (Boşcaiu N., 1966 ap. J. Heuffel, 1858; Flora V)

Trapaceae
Trapa natans L. subsp. ***natans***: Hh, Eua-sM; U6T4R4, Nymphaeion: Liebling (Neacşu A. et al., 2008), Lugoj in lakes from Complexul I şi II (Boşcaiu N., 1966)

Euphorbiaceae
Euphorbia lucida Waldst. et Kit.: H, E-C; U5T3R4, Filipendulo-Petasition, Molinion coeruleae: Lugoj (Flora II)
Euphorbia villosa Walds. Et Kit.: H, p-M; U3,5T3,5R0, Molinion, Alnetea: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965), Zlagna (Boşcaiu N., 1965)

Rhamnaceae
Frangula alnus Miller: mPh, Eua; U4T3R3, Alno-Padion, Alnetea: Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965), Zlagna (Boşcaiu N., 1965)
Vitaceae
Vitis silvestris Gmel.: mPh-L, P-M; U3.5T4.5R4.5, Alno-Padion, Querco-Fagetea, Salicion albae: Caransebeş (Flora VI)

Apiaceae
Angelica archangelica L.: TH-H, Eua (bor); U4.5T2.5R0, Adenostyletalia, Filipendulo-Petasition: Armeniş (!) on Râul Alb and Râul Lung (Boşcaiu N., 1971), Borlova under Mt. Mic (Flora VI, Boşcaiu N., 1971), Gărâna (!), Izvorul Sebeşului, Pâr. Hidegu, Poiana Mărului, Rusca, V. Bistra Mărului (Boşcaiu N., 1971), Trei Ape (!)
Angelica sylvestris L. ssp. ***sylvestris***: TH-H, Eua; U4T3R3, Alno-Padion, Molinietalia: Armeniş (Boşcaiu N., 1971,!), Bucoşniţa (!), Măgura, Obreja, Pâr. Hidegu, Poiana Mărului (Boşcaiu N., 1971), Petroşniţa (!), Sadova Veche (Boşcaiu N., 1966), Trei Ape (!), V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971); f. ***stenoptera*** (Boiss.) Thell.: Borlova under Mt. Mic (Flora VI)
Angelica x mixta Nyar. (archangelica x sylvestris): Armeniş (!), Gărâna (!)
Apium nodiflorum (L.) Lag.: H, Atl-M; U5T4.5R0, Agropyro-Rumicion, Bidention tripartiti, Nanocyperion flavescentis: between Lugoj and Satu Mic (Flora VI ap. J. Heuffel, 1858)
Berula erecta (Hudson) Coville (Sium erectum Hudson): H-Hh, Cp; U6T3,5R0, Alno-Padion, Glycerio-Sparganion, Magnocaricion elatae: Caransebeş, Giulvăz, Peciu Nou (!), Pădureni on Timişul Mort (Soran V., 1956), Urseni (Soran V., 1956)
Heracleum palmatum Baumg.: H, Carp; U4T2,5R0, Adenosrylion: Mt. Mic, Mt. Ţarcu (Boşcaiu N., 1971)
Laserpitium prutenicum L.: TH, Ec-M; U4T3,5R4, Molinion: Turnu Ruieni, var. (Boşcaiu N., 1971)
Oenanthe aquatica (L.) Poiret: Hh, Eua; U6T3R0, Phragmitetalia: Liebling (Neacşu A. et al., 2008), Pădureni on Timişul Mort (Soran V., 1956), Rudna, Uliuc (Stere G., 1971a), Urseni (Soran V., 1956, Stere G., 1971a)
Oenanthe banatica Heuffel: H, P-Pn-B; U4T3.5R0, Alno-Padion: Lugoj (Flora VI)
Oenanthe peucedanifolia Pollich (O. stenoloba Schur): H, D-B; U4T0R4.5, Molinietalia: Băuţar (Flora VI, Boşcaiu N., 1971)
Oenanthe silaifolia Bieb.: H, M; U5T3.5R0, Agrostion stoloniferae: Armeniş, Glimboca, Obreja, Turnu Ruieni, V. Bistra, Zerveşti (Boşcaiu N., 1971); var. *media* (Griseb.) Beck: Lugoj (Flora VI)
Selinum carvifolia (L.) L.: H, Eua; U3,5T3R3, Molinion: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)
Sium latifolium L.: Hh, Eua; U6T0R4, Phragmitetalia, Phragmition australis: Bazoş (Flra VI)

Hypericaceae
Hypericum tetrapterum Fries. (H. quadrangulum L.): H, E; U4T3R4, Filipendulo-Petasition, Glycerio-Sparganion, Magnocaricion elatae: Borlova (Boşcaiu N., 1971), Caransebeş (!), Izvorul Sebeşului, Marga, Măgura, Pâr. Hidegu, Poiana Mărului, Rusca, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971)

Elatinaceae

Elatine alsinastrum L.: Th-TH (Hh), Eua; U5T4R3, Nanocyperion flavescentis, Potamion: Jebel (Flora III, Soran V., 1956), Liebling (Soran V., 1956)

Elatine hexandra (Lapierre) DC.: Th-TH (Hh), Ec; U5T3R2, Nanocyperion flavescentis: Lugoj (Flora III)

Elatine macropoda Guss. (E. hungarica Moesz): Hh, Eua(M): U5T4R2, Nanocyperion flavescentis: Uliuc, Urseni (Stere G., 1971)

Tamaricaceae

Myricaria germanica (L.) Desv.: nPh, Eua; U0T0R4.5, Salicion eleagni: Pâr. Hidegu (Boşcaiu N., 1971)

Brassicaceae

Cardamine amara **L. ssp.** *amara*: **H, Eua; U5T0R0, Alno-Padion, Cardamini-Montion: Armeniş (!), Borlova (Boşcaiu N., 1971), Gărâna (!), Groapa Bistrei, Marga, Măgura, Mt. Mic (Boşcaiu N., 1971), Mţii Semenic (Flora III), Pâr. Hidegu, Poiana Mărului (Boşcaiu N., 1971), Trei Ape (!), V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971, 1971a); ssp.** *opicii* **(J. et C. Presl.) Celak.: H, Ec: Groapa Bistrei (Flora III, Boşcaiu N., 1971a), Mt. Mic (Boşcaiu N., 1971, 1971a), Izvorul Bistrei Mărului, Vf. Căleanu, Vf. Ţarcu (Boşcaiu N., 1971)**

Cardamine flexuosa **With.: Th-TH, Eua; U4T2R2, Cardamini-Montion: Armeniş (!) on Râul Alb and Râul Lung, Borlova, Măgura, Pâr. Hidegu, Poiana Mărului, Sadova Nouă, V. Sebeşului (Boşcaiu N., 1971)**

Cardamine pratensis **L. ssp.** *pratensis*: **H, Cp; U5T3R0, Molinio-Arrhenatheretea: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Obreja, Pâr. Hidegu, V. Bistra (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971); ssp.** *matthioli* **(Moretti) Nyman (ssp. hayneana (Welw.) D.E. Schultz): H, E: Poiana Mărului (Boşcaiu N., 1971); ssp.** *rivularis* **(Schur) Nyman: H, Carp-B: Vf. Căleanu (Boşcaiu N., 1971), Vf. Ţarcu (Boşcaiu N., 1971, 1971a)**

Rorippa amphibia (L.) Besser: Hh, Eua; U6T3R4, Alnetea glutinosae, Phragmitetea, Salicetea purpureae: Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!)

Rorippa austriaca (Crantz) Besser: H, P; U4T3.5R4, Agropyro-Rumicion, Bidentetea tripartiti, Plantaginetea majoris, Senecion fluviatilis: Giulvăz (!), Jebel (Soran V., 1956), Liebling (Neacşu A. et al., 2008) in Balta Mare and Balta Mică (Soran V., 1956)

Rorippa sylvestris (L.) Besser ssp. ***sylvestris***: H, Eua; U4T3R4, Agropyro-Rumicion: Armeniş (Boşcaiu N., 1971,!), Boldur, Bucoşniţa (!), Borlova (Boşcaiu N., 1971), Caransebeş, Giulvăz (!), Ilova (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966), Marga, Măgura, Obreja (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Rusca, Sadova Veche (Boşcaiu N., 1971), Şag, Trei Ape (!), Turnu Ruieni, V. Bistra Mărului, V. Sebeşului, Zăvoi, Zerveşti (Boşcaiu N., 1971); f. ***rivularis*** (Rchb.) Nyar.: Sadova Nouă (Boşcaiu N., 1971 ap. V. Borbas, 1873); f. ***siliculosa*** Neilr.: Sadova Nouă (Flora III, Boşcaiu N., 1971 ap. V. Borbas, 1873); ssp. ***kerneri***: Liebling (Soran V., 1954),

Rorippa x barbareoides **(Tsch.) Celak. (palustris x sylvestris). Armeniş (!); f.** *arenaria* **Knaf: Armeniş (Flora III)**

Salicaceae

Populus alba L.: Mph-mPh, Eua; U3.5T3R3, Salicetalia purpureae: Grănicerii (Ciavoş) (Flora I)

Populus nigra L.: MPh, Eua; U4T3R4, Salicetalia purpureae: Armeniş (Boşcaiu N., 1971), Grănicerii (Ciavoş) (Flora I),
Salix alba L. ssp. ***alba***: Mph-mPh, Eua; U5T3R4, Alno-Padion, Salicion albae: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Belinţ, Bucoşniţa, Caransebeş, Chizătău (!), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Sadova Veche (!), Turnu Ruieni, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971),
Salix cinerea L.: mPh, Eua; U5T3R3, Alnetea glutinosae, Alno-Padion: Armeniş (Boşcaiu N., 1971,!), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Glimboca (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966), Măgura, Obreja, Poiana Mărului, Sadova Veche (Boşcaiu N., 1971), Trei Ape (!), V. Bistra, V. Bistra Mărului, var. (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)
Salix daphnoides Vill.: mPh, Eua; U4.5T2.5R4.5, Salicion eleagni: V. Bistra beside Măgura (Boşcaiu N., 1971)
Salix fragilis L.: mPh-MPh, Eua; U4.5T3R4, Alno-Padion, Salicion albae, Salicion triandrae: Armeniş, Borlova (Boşcaiu N., 1971), Bucoşniţa, Caransebeş (!), Liebling (Neacşu A. et al., 2008), Pâr. Hidegu, Rusca (Boşcaiu N., 1971), Trei Ape (!), Turnu Ruieni, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971)
Salix purpurea L. ssp. ***purpurea***: mPh, Eua; U5T3R4.5, Salicetalia purpureae: Armeniş (Boşcaiu N., 1971, !), Borlova, Izvorul Sebeşului (Boşcaiu N., 1971), Caransebeş (!), Lugoj (Boşcaiu N., 1966), Pâr. Hidegu, Măgura, Rusca, Turnu Ruieni, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971), Sadova Veche (Boşcaiu N., 1971, !)
Salix triandra **L. emend. Ser. ssp.** *triandra***: mPh, Eua; U5T3R0, Salicion triandrae: Armeniş (!) pe Râul Lung, Borlova, Izvorul. Sebeşului (Boşcaiu N., 1971), Lugoj (Boşcaiu N., 1966), Măgura, Obreja, Pâr. Hidegu, Rusca (Boşcaiu N., 1971), Trei Ape (!) Turnu Ruieni, V. Bistra, V. Bistra Mărului, Zerveşti (Boşcaiu N., 1971)**
Salix viminalis L.: mPh, Eua; U5T2.5R4.5, Salicion triandrae: Măgura on Bistra (Boşcaiu N., 1971)
Salix x rubens Schrank. (alba x fragilis): Armeniş on Râul Alb, Borlova, Glimboca, Măgura, Turnu Ruieni (Boşcaiu N., 1971)
Salix x undulata Ehrh. (alba x triandra): Măgura on Bistra (Boşcaiu N., 1971)

Cucurbitaceae
Sicyos angulatus L.: Th, Adv; U4.5T3R4, Calystegion: Lugoj (Boşcaiu N., 1966)

Primulaceae
Lysimachia nummularia L.: Ch, Eua; U4T3R0, Alnetea glutinosae, Alno-Padion, Bidentetea tripartiti, Calthion palustris, Filipendulo-Petasition, Molinietalia, Phragmitetea, Plantaginetea majoris, Querco-Fagetea, Salicion albae: Armeniş (Boşcaiu N., 1971,!), Belinţ (!), Borlova (Boşcaiu N., 1971), Caransebeş, Giulvăz (!), Glimboca, Ilova (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Măgura, Obreja (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Pâr. Hidegu, Poiana Mărului, Râul Alb, Rusca, Sadova Veche, Turnu Ruieni, V. Bistra, V. Bistra Mărului, Var, Vălişoara, Vârciorova, Zerveşti, Zlagna, (Boşcaiu N., 1971), Trei Ape (!)

Lysimachia vulgaris L.: H(-Hh), Eua; U5T0R0, Alnetea glutinosae, Molinietalia, Phragmitetea, Salicetea purpureae, Scheuchzerio-Caricetea nigrae: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Glimboca (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (!), Marga, Măgura, (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971, !), Pâr. Hidegu (Boşcaiu N., 1971), Petroşniţa (!),Poiana Mărului, Rusca, Sadova Veche (Boşcaiu N., 1971), Tapia (Boşcaiu N., 1966), V. Bistra, V. Bistra Mărului, (Boşcaiu N., 1971), Trei Ape (!), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965)

Gentianaceae

Centaurium pulchellum (Swartz) Druce: Th-TH, Eua; U4T3.5R4, Isoeto-Nanojuncetea: Buziaş, Lugoj (Flora VIII), Obreja, V. Bistra, var. (Boşcaiu N., 1971)
Gentiana pneumonanthe L.: H, Eua; U4T3R0, Molinion: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Sadova Veche (Boşcaiu N., 1971) between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971), Zlagna (Boşcaiu N., 1965, 1971)

Solanaceae

Solanum dulcamara L.: Ch (nPh), Eua; U4.5T3R4, Alnetea glutinosae, Alno-Padion, Bidentetea tripartiti, Calystegion, Epilobietalia angustifolii, Phragmition australis: Caransebeş (!), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Pădureni on Timişul Mort (Soran V., 1956), Trei Ape (!), Urseni (Soran V., 1956)

Convolvulaceae

Calystegia sepium **(L.) R.Br.: G(H), Eua; U4,5T3R4, Calystegion, Salicion albae, Arction lappae: Armeniş (Boşcaiu N., 1971, !), Borlova (Boşcaiu N., 1971), Bucoşniţa (!), Caransebeş, Giulvăz (!), Glimboca (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966), Măgura, Obreja (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Petroşniţa (!), Rusca, Sadova Veche, Turnu Ruieni, V. Bistra, Var, Zerveşti, (Boşcaiu N., 1971)**

Menyanthaceae

Menyanthes trifoliata L.: Hh, Cp; U5T0R0, Magnocaricion elatae, Scheuchzerio-Caricetalia nigrae: Lugoj (Boşcaiu N., 1966 ap. J. Heuffel, 1858)

Boraginaceae

Myosotis scorpioides **L. (M. palustris (L.) Hill): H(Hh), Eua; U5T3R0, Alnetea glutinosae, Calthion palustris, Molinietalia, Phragmitetea: Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Liebling (Neacşu A. et al., 2008), Marga, Măgura, Obreja, Pâr. Hidegu, Rusca, (Boşcaiu N., 1971), Trei Ape (!), Var, (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971); var.** *elatior* **Opiz: Mt. Semenic (Flora VII)**
Symphytum officinale L. ssp. ***officinale***: H, Eua; U4T3R0, Molinietalia, Phragmitetea: Armeniş (Boşcaiu N., 1971, !), Borlova (Boşcaiu N., 1971), Caransebeş, Giulvăz (!), Glimboca, Ilova (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj, Tapia (Boşcaiu N., 1966,!), Marga, Măgura, Pâr. Hidegu (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Petroşniţa (!), Rusca, Sadova Veche (Boşcaiu N., 1971), Trei Ape (!)Turnu Ruieni, V. Bistra, V. Bistra Mărului, V. Sebeşului, Zerveşti (Boşcaiu N., 1971)

Lamiaceae

Lycopus europaeus **L.: H (Hh), Eua; U5T3R0, Bidentetea tripartiti, Phragmitetea, Salicetea purpureae: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş, Gărâna (!), Glimboca, Ilova (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Oţelul Roşu (Boşcaiu N., 1971,!), Obreja, Pâr. Hidegu, Rusca (Boşcaiu N., 1971), Pădureni on Timişul Mort (Soran V., 1956), Petroşniţa (!), Tapia (Boşcaiu N., 1966), Teregova (!), Trei Ape (!), Turnu Ruieni, V. Bistra, V. Bistra Mărului, Zerveşti, (Boşcaiu N., 1971)**

Lycopus exaltatus L. fil: H(Hh), Eua-C; U5T3R0, Bidentetea tripartiti, Phragmitetea, Salicion albae: Lugoj in the lake from Str. Bocşei (Boşcaiu N., 1966)

Mentha aquatica L.: H (Hh), E; U5T3R0, Alnetea glutinosae, Molinietalia, Phragmitetea, Salicion albae: Armeniş (Boşcaiu N., 1971,!), Caransebeş (!), Liebling (Neacşu A. et al., 2008), Obreja (Boşcaiu N., 1971), Urseni (Soran V., 1956), V. Bistra Mărului, Zerveşti, (Boşcaiu N., 1971); var. ***stagnalis*** Top.: Liebling (Flora VIII)

Mentha arvensis **L. ssp.** *arvensis* **(ssp. agrestis (Sole) Briq.): H(G), Cp; U4T3R0, Calthion palustris, Molinietalia, Phragmitetea, Secalietea: Armeniş (Boşcaiu N., 1971,!), Gărâna (!), Izvorul Sebeşului, Marga, Obreja (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Trei Ape (!), Zerveşti, (Boşcaiu N., 1971)**

Mentha longifolia **(L.) Hudson ssp.** *longifolia***: H(G), Eua; U4,5T3R0, Agropyro-Rumicion, Bidentetea tripartiti, Chenopodietea, Filipendulo-Petasition, Glycerio-Sparganion, Molinietalia: Armeniş (Boşcaiu N., 1971,!), Bolvaşniţa, Borlova (Boşcaiu N., 1971), Bucoşniţa (!), Gărâna, Giulvăz (!), Ilova (Boşcaiu N., 1971), Oţelul Roşu (!), Petroşniţa (!), Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Sadova Nouă, Sadova Veche (Boşcaiu N., 1971), Şag, Teregova (!), Trei Ape (!), Turnu Ruieni, V. Bistrei, V. Bistra Mărului, V. Sebeşului, var. (Boşcaiu N., 1971)**

Mentha pulegium L.: H, Eua (sM); U4T3R5, Isoeto-Nanojuncetea, Nanocyperion flavescentis: Armeniş (Boşcaiu N., 1971,!), Caransebeş (!), Cruceni, Foeni (Stere G., 1971a), Giulvăz (!), Ivanda (Stere G., 1971a), Jebel, Liebling (Soran V., 1956), Lugoj (!) beside Complexul I and V. Cinca beside Boldur (Boşcaiu N., 1966), Obreja, (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Petroşniţa (!), Pâr. Hidegu (Boşcaiu N., 1971), Rudna (Stere G., 1971a), Rusca, Sadova Veche (Boşcaiu N., 1971), Şag, Teregova (!), Turnu Ruieni (Boşcaiu N., 1971), Urseni (Stere G., 1971a), V. Bistrei, V. Bistra Mărului, Var, Zerveşti, (Boşcaiu N., 1971)

Mentha x verticillata L. (aquatica x arvensis): V. Ştiuca beside Tapia locality (Boşcaiu N., 1966)

Scutellaria galericulata L.: H, Cp; U4T3R4, Magnocaricion elatae, Molinietalia, Phragmitetea: Glimboca (Boşcaiu N., 1971,!), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966), Marga, Obreja, Oţelul Roşu (Boşcaiu N., 1971), Trei Ape (!), V. Bistrei, Zerveşti (Boşcaiu N., 1971)

Stachys palustris: Armeniş (Boşcaiu N., 1971,!), Bucoşniţa (!), Caransebeş (!), Liebling (Neacşu A. et al., 2008), Lugoj at the brick yard Bartoş (Boşcaiu N., 1966), Obreja (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Sadova Veche (Boşcaiu N., 1971), Trei Ape (!), Zerveşti (Boşcaiu N., 1971)

Callitrichaceae

Callitriche cophocarpa Sendtner (C. polymorpha Lonnr.): Th-H (Hh), Eua; U6T3R0, Nanocyperion flavescentis, Potamion: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Glimboca (Flora II, Boşcaiu N., 1971), Lugoj (Flora II), Obreja (Flora II, Boşcaiu N., 1971)

Callitriche palustris L. (C. verna L.): Th-H (Hh), Cp; U6T3R0, Nanocyperion flavescentis, Potamion: Mt. Mic (Boşcaiu N., 1971, 1971a), Mt. Ţarcu, Pâr. Hidegu, Poiana Mărului, Râul Alb, Râul Lung (Boşcaiu N., 1971), Rusca (Flora II, Boşcaiu N., 1971), Trei Ape (!), V. Bistra Mărului (Boşcaiu N., 1971)

Scrophulariaceae

Gratiola officinalis L.: H, Cp; U4.5T3R4, Magnocaricion elatae, Molinion coeruleae, Nanocyperetalia, Phragmitetea: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Jebel (Soran V., 1956), Liebling (Neacşu A. et al., 2008, Soran V., 1956), Lugoj (Boşcaiu N., 1966), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965)

Lindernia procumbens (Krocker) Philcox (L. pyxidaria L. p.p.): Th, Eua; U4.5T4R0, Nanocyperion flavescentis: Jebel, Liebling (Soran V., 1954, 1956, Flora VII), Lugoj (Boşcaiu N., 1966, Flora VII), Obreja (Boşcaiu N., 1971), Pădureni (Flora VII), Urseni (Soran V., 1954)

Scrophularia umbrosa Dumort: H, Eua; U5T3,5R4,5, Alno-Padion, Glycerio-Sparganion: Armeniş, Pâr. Hidegu (Boşcaiu N., 1971), Urseni (Soran V., 1956)

Veronica anagallis-aquatica L.: H (Hh), Cp; U5T0R4, Bidentetea tripartiti, Glycerio-Sparganion, Phragmitetea : Bucoşniţa (!), Teregova (Boşcaiu N., 1971), V. Sebeşului (Boşcaiu N., 1971a)

Veronica beccabunga **L.: H (Hh), Eua; U5T3R4, Bidentetea tripartiti, Glycerio-Sparganion, Salicetalia purpureae: Armeniş (!), Mt. Ţarcu (Boşcaiu N., 1971a), Măgura, Pâr. Hidegu, Poiana Mărului (Boşcaiu N., 1971), Trei Ape (!), V. Bistra Mărului (Boşcaiu N., 1971)**

Veronica scutellata **L.: H (Hh), Cp; U4T3R4, Agrostion stoloniferae, Caricion canescenti-nigrae, Magnocaricion elatae: Lugoj (Flora VII), Trei Ape (!)**

Tozzia alpina L. ssp. ***carpatica*** (Woloszczak) Hayek: H, Carp-B; U3.5T2R4.5, Adenostyletalia, Cardamini-Montion: Mţii Semenic, Mt. Ţarcu în V. Bistra (Flora VII, Boşcaiu N., 1971)

Lentibulariaceae

Utricularia vulgaris L.: Hh, Cp; U6T0R3,5, Nymphaeion, Lemnion-Hydrocharition: Belinţ, Chizătău, Foeni (Stere G., 1971a), Lugoj in the lake in Str. Bocşei and at the brick yard Bartoş (Boşcaiu N., 1966), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Rudna, Uliuc, Urseni (Stere G., 1971a)

Rubiaceae

Galium palustre L. ssp. ***palustre***: H, Cp; U5T3R0, Magnocaricion elatae, Molinietalia: Armeniş (Boşcaiu N., 1971,!), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Glimboca (Boşcaiu N., 1971), Lugoj (Boşcaiu N., 1966,!), Marga, Măgura, Pâr. Hidegu, Obreja, (Boşcaiu N., 1971) Trei Ape (!), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)

Galium uliginosum L.: H, Eua; U4.5T3R4, Calthion palustris, Magnocaricion elatae, Molinietalia, Scheuchzerio-Caricetalia nigrae: Armeniş, Marga (Boşcaiu N., 1971), Mt. Mic (Boşcaiu N., 1971a), Obreja, Rusca, Turnu Ruieni, V. Bistra Mărului, var. (Boşcaiu N., 1971)

Valerianaceae

Valeriana officinalis L.: H, Eua(sM); U4T3R4, Alnetea glutinosae, Alno-Padion, Filipendulo-Petasition, Magnocaricion elatae, Molinietalia; Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965); f. ***altissima*** (Hornem.) Koch: Armeniş, Borlova, Izvorul Sebeşului, Măgura, Oţelul Roşu, Pâr. Hidegu, Poiana Mărului, Rusca, Turnu Ruieni, V. Bistra Mărului, Zărneşti (Boşcaiu N., 1971 under V. exaltata Mikan)

Valeriana sambucifolia Mikan fil. (V. officinalis L. ssp. sambucifolia (Mikan fil.) Celak.): H, Ec; U4T2R3.5, Adenostyletalia, Fagion, Filipendulo-Petasition: Izvorul Sebeşului, Mt. Mic, Poiana Mărului, V. Bistra Mărului (Boşcaiu N., 1971)

Dipsacaceae

Succisa pratensis Moench: H, Eua; U4T3R0, Molinietalia, Molinion coeruleae: Borlova (Boşcaiu N., 1971), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Feneş (Boşcaiu N., 1971), Gărâna (!), Lugoj, in V. Ştiuca beside Tapia (Boşcaiu N., 1966), Marga, Obreja, Oţelul Roşu, Pâr. Hidegu (Boşcaiu N., 1971), Trei Ape (!), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965), Zlagna (Boşcaiu N., 1965)

Asteraceae

Achillea ptarmica L.: H, Eua; U4,5T0R2,5, Molinietalia: Borlova (Boşcaiu N., 1971), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Obreja, Oţelul Roşu, Poiana Mărului, V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971)

Aster x salignus Willd. (lanceolatus x novi belgii): Liebling (Flora IX)

Bidens cernua L.: Th, Eua; U5T0R0, Bidention: Râul Lung, V. Bistra (Boşcaiu N., 1971)

Bidens tripartita L.: Th, Eua; U4.5T3R0, Bidentetea tripartiti, Chenopodio-Scleranthetea, Nanocyperion flavescentis: Armeniş (Boşcaiu N., 1971,!), Bucoşniţa (!), Caransebeş, Giulvăz (!), Ilova (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Obreja (Boşcaiu N., 1971), Petroşniţa (!), Teregova (!), Rusca, Sadova Veche (Boşcaiu N., 1971,!), Trei Ape (!), V. Bistra, V. Sebeşului (Boşcaiu N., 1971)

Bidens vulgata E. L. Greene: Th, Adv; U5T0R0, Bidention: Armeniş (!), Bucoşniţa (!), Sadova Veche (!), Criciova (Flora XIII)

Carduus personatus (L.) Jacq. ssp. ***personatus****:* H, Ec; U4.5T2.5R4.5, Adenostylion alliariae, Alno-Padion, Filipendulo-Petasition: Borlova, Groapa Bistrei, Mt. Mic, Pâr. Hidegu, Poiana Mărului, Râul Alb, Râul Lung (Boşcaiu N., 1971), Trei Ape (!), V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971)

Cirsium brachycephalum Juratzka: TH, Pn; U4T3R4, Agrostion stoloniferae, Magnocaricion elatae: Moşniţa (Flora IX)

Cirsium canum (L.) All.: G, Eua-C; U4.5T3R4.5, Alno-Padion, Magnocaricion elatae, Molinietalia: Armeniş (Boşcaiu N., 1971, !), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Glimboca (Boşcaiu N., 1971, !), Liebling (Neacşu A. et al., 2008), Obreja, Oţelul Roşu, Pâr. Hidegu, Sadova Veche, V. Bistra (Boşcaiu N., 1971)

Cirsium erisithales (Jacq.) Scop.: H, Ec (mont); U3,5T3R4.5, Fagetalia silvaticae, Filipendulo-Petasition: Groapa Bistrei, Pâr. Hidegu, Poiana Mărului, Râul Alb, Râul Lung, Rusca, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971)

Cirsium oleraceum (L.) Scop.: H, Eua; U4T3R4, Alno-Padion, Calthion palustris, Filipendulo-Petasition, Molinietalia: Armeniş (!) pe Râul Lung, Pâr. Hidegu, Poiana Mărului, V. Bistra Mărului, Voislova (Boşcaiu N., 1971)

Cirsium palustre (L.) Scop.: TH, Eua; U4.5T3R2.5, Alnetea glutinosae, Epilobietalia angustifolii, Molinietalia, Phragmitetea: Gărâna (!), Liebling (Neacşu A. et al., 2008), Pâr. Hidegu, Poiana Mărului, Râul Alb, Râul Lung, Rusca, Sadova Nouă (Boşcaiu N., 1971), Trei Ape (!), V. Bistra, V. Bistra Mărului, V. Sebeşului, Zlagna (Boşcaiu N., 1971)
Cirsium waldsteinii Rouy: H, Alp-Carp; U4T2R2, Adenostylion alliariae, Caricion curvulae, Filipendulo-Petasition: Poiana Mărului (Boşcaiu N., 1971)
Crepis paludosa (L.) Moench: H, E (mont); U4.5T0R4.5, Adenostyletalia, Alnetea glutinosae, Alno-Padion, Calthion palustris, Montio-Cardaminetea: Armeniş on Râul Alb and Râul Lung, Pâr. Hidegu, Poiana Mărului, Sadova Nouă, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971), V. Sebeşului (Boşcaiu N., 1971, 1971a), Trei Ape (!)
Eupatorium cannabinum L.: H, Eua; U4T3R0, Alnion glutinosae, Epilobietea angustifolii, Filipendulo-Petasition, Phragmitetea, Salicetalia purpureae: Armeniş (!) on Râul Alb and Râul Lung, Borlova (Boşcaiu N., 1971), Bucoşniţa, Caransebeş (!), Liebling (Flora IX), Lugoj (Boşcaiu N., 1966,!), Mt. Semenic (Flora IX), Marga, Măgura, Obreja (Boşcaiu N., 1971), Pădureni (Flora IX), Petroşniţa (!), Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Sadova Veche (!) Turnu Ruieni, V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971)
Gnaphalium uliginosum L.: Th, Eua; U5T3R4, Nanocyperetalia: Armeniş, Glimboca (Boşcaiu N., 1971), Lugoj (Boşcaiu N., 1966), Măgura, Obreja, Oţelul Roşu, Pâr. Hidegu, Rusca, Turnu Ruieni, V. Bistra Mărului, Voislova, Zerveşti (Boşcaiu N., 1971)
Helianthus decapetalus L.: H, Adv; U3.5T3R4.5, Calystegion, Salicion albae: Bucoşniţa (!), Petroşniţa (!), Sadova Veche (!)
Helianthus tuberosus L.: G, Adv; U3.5T3R4, Calystegion: Uliuc, Urseni (Grigore Stere, 1971)
Petasites albus (L.) Gaertner: G, Eua; U3.5T0R0, Alno-Padion, Fagion: Pâr. Hidegu, Rusca (Boşcaiu N., 1971), V. Sebeşului (Boşcaiu N., 1971a)
Petasites hybridus (L.) P. Gaertner, B. Meyer et Scherb.: G, Eua; U5T3R3, Adenostyletalia, Alno-Padion, Filipendulo-Petasition: Armeniş (!) on Râul Alb and Râul Lung, Borlova, Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Trei Ape (!), Turnu Ruieni, V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971)
Petasites kablikianus (L.) Tausch.: G, Carp-B; U4T0R0, Galio-Urticetea: Poiana Mărului, V. Bistra Mărului (Boşcaiu N., 1971)
Pulicaria dysenterica (L.) Bernh.: H, Ec; U4T3.5R0, Agropyro-Rumicion, Molinietalia: Armeniş (Boşcaiu N., 1971, !), Caransebeş (!), Cruceni, Foeni (Stere G., 1971a), Giulvăz (Stere G., 1971a,!), Ivanda (Stere G., 1971a), Ilova (Boşcaiu N., 1971), Liebling (Flora IX), Lugoj (Boşcaiu N., 1966, !), Obreja (Boşcaiu N., 1971), Rudna (Stere G., 1971a), Şag, Teregova (!), Urseni (Stere G., 1971a)
Pulicaria vulgaris Gaertner: Th, Eua; U4T3R3, Agropyro-Rumicion, Bidention tripartiti, Isoeto-Nanojuncetea: Armeniş (Boşcaiu N., 1971,!), Bucova (Flora IX), Liebling (Flora IX), Lugoj (Boşcaiu N., 1966), Obreja (Boşcaiu N., 1971), Oţelul Roşu (Boşcaiu N., 1971,!), Zerveşti (Boşcaiu N., 1971)
Rudbeckia laciniata L.: H, Adv; U4.5T3.5R4, Calystegion, Senecion fluviatilis: Bucoşniţa (!), between Lugoj and Careansebeş (Flora IX)
Serratula tinctoria L.: H, Eua; U3.5T3R0, Molinion coeruleae: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Faţa Sadovei (Boşcaiu N., 1965, 1971), Lugoj (Boşcaiu N., 1966), Obreja, Pâr. Hidegu, Rusca, Sadova Nouă, Sadova Veche, Vălişoara (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971), Zlagna (Boşcaiu N., 1965, 1971); var. ***lancifolia*** S. F. Gray: Bucova (Flora IX), Liebling (Flora IX)
Sonchus palustris L.: G, E; U4.5T3.5R4, Calystegion, Filipendulo-Petasition: Liebling, Pădureni, Timişul Mort (Flora X)

Taraxacum bessarabicum (Hornem.) Hand.-Mazz.: H, Eua-C; U4T3R4, Puccinellietalia: Jebel, Liebling (Flora IX)
Telekia speciosa (Schreber) Baumg.: H, Carp-B-Cauc-Anat; U4T2R0, Alnion glutinosae-incanae, Filipendulo-Petasition, Telekion: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Gărâna (!), Mt. Ţarcu, Pâr. Hidegu, Poiana Mărului, Rusca, V. Bistra, V. Bistra Mărului, V. Sebeşului, Zerveşti (Boşcaiu N., 1971)

Alismataceae
Alisma lanceolatum Wither: Hh, Eua; U6T0R4, Phragmitetea: Liebling (Neacşu A. et al., 2008), Moşniţa (Flora XI)
Alisma plantago-aquatica L.: Hh, Cp; U6T0R0, Phragmitetea: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Bucoşniţa, Caransebeş (!),Diniaş (Stere G., 1971a), Giulvăz (Stere G., 1971a,!), Glimboca (Boşcaiu N., 1971,!), Jebel, Liebling in Balta Mare and Balta Mică (Soran V., 1956), Lugoj at the brick yard Bartoş (Boşcaiu N., 1966), Oţelul Roşu, Pâr. Hidegu (Boşcaiu N., 1971), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Peciu Nou (Stere G., 1971a,!), Rusca (Boşcaiu N., 1971), Tapia (Boşcaiu N., 1966), Trei Ape (!), Turnu Ruieni (Boşcaiu N., 1971), Urseni (Stere G., 1971a), V. Bistra, V. Bistra Mărului, Var, Zerveşti (Boşcaiu N., 1971)
Şagittaria Şagittifolia L.: Hh, Eua; U6T3R4, Phragmition australis, Potamion: Moşniţa, Urseni (Flora XI), Tapia in V. Ştiuca (Boşcaiu N., 1966)

Butomaceae
Butomus umbellatus L.: Hh, Eua; U6T3R0, Phragmitetea: Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966)

Hydrocharitaceae
Hydrocharis morsus-ranae L.: Hh, Eua; U6T3.5R3.5, Hydrocharition, Lemnion minoris: Chizătău, Cruceni, Giroc, Ivanda (Stere G., 1971a), Liebling the fen Tofaia (Soran V., 1956), Lugoj in the lake in Str. Bocşei and at the brick yard Bartoş (Boşcaiu N., 1966), Moşniţa, Pădureni (Flora XI) on Timişul Mort (Soran V., 1956), Uliuc, Urseni (Stere G., 1971a)
Stratiotes aloides L.: Hh, Eua; U6T4R4, Hydrocharition, Lemnion minoris: Moşniţa (Flora XI), Uliuc (Stere G., 1971a)

Juncaginaceae
Triglochin palustris L.: H, Cp; U5T0R0, Molinietalia, Puccinellio-Salicornietea, Scheuchzerio-Caricetalia nigrae: Moşniţa (Flora XI)

Potamogetonaceae
Potamogeton berchtoldii Fieber: Hh, Eua(sM); UTR, U6T3R4, Potamion: Caransebeş (FRE, 1946)
Potamogeton compressus L.: Hh, Cp; U6T3R4, Potamion: Lugoj in the lake in Str. Bocşei (Boşcaiu N., 1966)
Potamogeton crispus L.: Hh, Cosm; U6T3.5R4, Potametalia: Liebling (Neacşu A. et al., 2008) in Balta Mare and Balta Mică (Soran V., 1956), Lugoj at the brick yard Bartoş and in lakes at Complexul III (Boşcaiu N., 1966), between Şag and Urseni (Soran V., 1956)
Potamogeton lucens L.: Hh, Eua; U6T0R4, Potamion: Lugoj, the lake in Str. Bocşei (Boşcaiu N., 1966)

Potamogeton natans L.: Hh, Cp; U6T2.5R4, Nymphaeion, Potamion: Bazoş (Stere G., 1971a,!), Chizătău, Cruceni (Stere G., 1971a), Costeiu (Flora XI), Liebling (Flora XI, Neacşu A. et al., 2008) in Balta Mare and Balta Mică (Soran V., 1956), Lugoj, lake in Str. Bocşei and at the brick yard Bartoş (Boşcaiu N., 1966), between Lugoj and Tapia on Pâr. Ştiuca (Boşcaiu N., 1966), Peciu Nou, Rudna, Şag (Stere G., 1971a), Urseni (Flora XI)
Potamogeton nodosus Poiret (P. fluitans Roth): Hh, Cp; U6T3.5R4, Potametalia: Cruceni, Diniaş, Foeni (Stere G., 1971a), Lugoj (Boşcaiu N., 1966), Moşniţa Veche, Rudna (Stere G., 1971a)
Potamogeton obtusifolius Mert. et Koch: Hh, Cp; U6T3R3.5, Potamion: Lugoj, lake in Str. Bocşei (Boşcaiu N., 1966), Obreja (Flora XI, Boşcaiu N.,1971); f. ***elongatum*** Cham. et Schl.: Obreja (Flora XI)
Potamogeton pectinatus L.: Hh, Cosm; U6T3,5R4,5, Potamion: Liebling in Balta Mare and Balta Mică (Soran V., 1956)
Potamogeton perfoliatus L.: Hh, Cosm; U6T0R4, Potamion: Lugoj in the lakes at Complexul III (Boşcaiu N., 1966)
Potamogeton pusillus L.: Hh, Cosm; U6T3R4, Potamion: Liebling (Flora XI) in Balta Mare (Soran V., 1956), Lugoj (Flora XI); f. ***acuminatum*** Fieb.: Lugoj (Flora XI), Otelec, Uliuc (Grigore Stere, 1971)

Najadaceae
Najas marina L. ssp. ***marina****:* Hh (Th), Cosm; U6T4R4, Potamion, Ruppion: Lugoj (Flora XI)
Najas minor All: Hh, Eua; U6T4,5R4,5, Potamion: Lugoj, Lugojel (Boşcaiu N., 1966 ap. J. Heuffel, 1858), Liebling (Flora XI) in Balta Mare and Balta Mică (Soran V., 1956), Lugoj, Pădureni, Slatina (Flora XI), between Şag and Urseni (Soran V., 1956)

Zannichelliaceae
Zannichellia palustris L. ssp. ***pedicellata*** (Wahlenb et Rosen.) Arcang.: Hh, Cosm; U6T0R4, Potamion: V. Cinca beside Boldur (Boşcaiu N., 1966), Liebling (Flora XI) in Balta Mare and Balta Mică (Soran V., 1956), Pădureni (Flora XI), Rudna (Stere G., 1971a), Uliuc (Stere G., 1971)

Liliaceae
Fritillaria meleagris L.: G, E; U4T3.5R4, Agrostion stoloniferae, Calthion palustris: Buziaş, Liebling (Flora XI)
Veratrum album L.: G, Eua; U4T2,5R4, Molinion, Adenostyletalia: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Mt. Mic, Mt. Ţarcu, Obreja, Pâr. Hidegu, Poiana Mărului, Râu Lung, V. Sebeşului (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)

Amaryllidaceae
Narcissus poëticus L. ssp. ***radiiflorus*** (Salisb.) Baker (N. radiiflorus Salisb., N. angustifolius Curt. N. stellaris Haw.): G, Ec; U3.5T2.5R0, Cynosurion cristati, Molinietalia, Triseto-Polygonion: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Faţa Sadovei (Boşcaiu N., 1965, 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971), Zlagna (Boşcaiu N., 1965, 1971)

Iridaceae
Gladiolus imbricatus L.: G, Eua-C; U3,5T3R3, Alno-Padion: Borlova (Boşcaiu N., 1971), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Obreja, Pâr. Hidegu, Rusca, V. Bistra, (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)
Iris pseudacorus L.: G (Hh), E; U5.5T0R0, Alnetea glutinosae, Phragmitetea: Lugoj in V. Ştiuca beside Tapia (Boşcaiu N., 1966), Glimboca (Boşcaiu N., 1971), Obreja, Turnu Ruieni (Boşcaiu N., 1971), Urseni (Soran V., 1956), Var, Zerveşti (Boşcaiu N., 1971)
Iris sibirica L.: G, Eua(C); U4,5T3,5R4,5, Molinion: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971),
Iris spuria L.: G, Pn-D; U4T3,5R5, Molinietalia, Puccinellietalia: Albina (Grigore Stere, 1971), Liebling (Pop I., 1968)
Orchidaceae
Dactylorhiza cordigera (Fries) Soo (Orchis cordigera Fries) ssp. cordigera: G, Carp-B; U4.5T2R2, Montio-Cardaminetalia, Scheuchzerio-Caricetalia nigrae: Mt. Mic (Flora XII, Boşcaiu N., 1971a); f. ***macrobracteata*** Schur: Groapa Bistrei (Flora XII)
Dactylorhiza incarnata (L.) Soo: G, Eua(M); U4,5T0R4, Calthion, Molinion: Borlova, Coşova, Jdioara, Lugoj (Flora XII)
Epipactis palustris (L.) Crantz: G, Eua; U4.5T3R4.5, Caricetalia davallianae, Eriophorion latifolii, Molinion coeruleae: Armeniş, Borlova (Flora XII), Obreja, Pâr. Hidegu, Poiana Mărului (Boşcaiu N., 1971)
Orchis laxiflora Lam. ssp. ***elegans*** (Heuff.) Soo: G, Eua(M); U4T3R0, Molinietalia, Magnocaricion, Eriophorion latifolii: between Ţiglărie-Caransebeş and Racoviţa railwaistations, Pâr. Hidegu, Poiana Mărului, Rusca, V. Bistra (Boşcaiu N., 1971)

Juncaceae
Juncus alpinoarticulatus Chaix: H, Cp; U4T2R2, Caricion canescenti-fusci, Eriophorion latifolii: Mt. Ţarcu (Boşcaiu N., 1971, 1071a)
Juncus articulatus L. (J. lampocarpus Ehrh.): H, Cp; U5T2R0, Agropyro-Rumicion, Calthion palustris, Nanocyperion flavescentis: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Bucoşniţa (!), Lugoj (Boşcaiu N., 1966), Petroşniţa (!), Pâr. Hidegu, Poiana Mărului, Râul Lung, Rusca (Boşcaiu N., 1971), Trei Ape (!), Tapia (Boşcaiu N., 1966), Teregova (!), Trei Ape (!), V. Bistra, V. Sebeşului, Var, Zerveşti (Boşcaiu N., 1971)
Juncus atratus Krocker: H, Eua-C; U4T3R4, Agrostion stoloniferae: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Jebel, Mţii Semenic (Flora XI), Lugoj (Boşcaiu N., 1966)
Juncus bufonius **L.: Th, Cosm; U4.5T0R3, Bidentetea tripartiti, Nanocyperetalia, Plantaginetalia majoris: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Bucoşniţa (!), Liebling (Neacşu A. et al., 2008), Poiana Mărului, Râul Alb, Rusca, V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971)**
Juncus compressus **Jacq.: G, Eua; U4T3R4, Agropyro-Rumicion, Agrostion stoloniferae, Nanocyperion flavescentis, Plantaginetea majoris, Puccinellio-Salicornietea: Caransebeş (!), Liebling (Flora XI), Trei Ape (!)**
Juncus conglomeratus L.: H, Cp; U4.5T3R3, Calthion palustris, Molinietalia, Molinion coeruleae, Scheuchzerio-Caricetalia nigrae: Armeniş (Boşcaiu N., 1971,!), Caransebeş (!), Lugoj (Boşcaiu N., 1966), Pâr. Hidegu, Poiana Mărului, Râul Alb, Rusca, V. Bistra, V. Bistra Mărului, Var, Zerveşti (Boşcaiu N., 1971)

Juncus effusus L.: H, Cosm; U4.5T3R3, Alnetea glutinosae, Bidentetea tripartiti, Calthion palustris, Molinietalia, Plantaginetea majoris: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş, Gărâna, Giulvăz (!), Liebling (Neacşu A. et al., 2008), Lugoj (!), Pâr. Hidegu, Poiana Mărului, Râul Alb, Rusca, Sadova Veche (Boşcaiu N., 1971), Tapia (Boşcaiu N., 1966), Teregova (!), Trei Ape (!), V. Bistra, V. Bistra Mărului, V. Sebeşului, Var, Zerveşti (Boşcaiu N., 1971)
Juncus filiformis L.: H (G), Cp (arct-alp); U4.5T2.5R2.5, Caricion canescenti-nigrae: Mţii. Semenic (Flora XI); var. *transsilvanicus* (Schur) A. et G.: Mt. Mic (Boşcaiu N., 1971a), Mt. Ţarcu (Boşcaiu N., 1971)
Juncus inflexus **L.: H, Eua; U4T3.5R4, Agropyro-Rumicion: Armeniş (Boşcaiu N., 1971,!), Caransebeş (!), la Gara Ţiglărie (Boşcaiu N., 1965), Lugoj (Boşcaiu N., 1966,!), Rusca, (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)**
Juncus thomassii **Ten.: H(G), Cp; U4T2,5R3, Molinietalia: Groapa Bistrei (Boşcaiu N., 1971)**

Cyperaceae
Bolboschoenus maritimus (L.) Palla (Scirpus maritimus L.) ssp. ***maritimus***: G (Hh), Cosm; U6T0R4.5, Bolboschoenion maritimi: Diniaş (Stere G., 1971a), Giulvăz (Stere G., 1971a,!), Ivanda (Stere G., 1971a), Liebling (Neacşu A. et al., 2008), Lugoj beside Complexul I (Boşcaiu N., 1966), Peciu Nou (Stere G., 1971a,!), Rudna (Stere G., 1971a), Tapia on Pâr. Ştiuca (Boşcaiu N., 1966)
Carex acuta L. (C. gracilis Curtis): G (Hh), Cp; U5T3R0, Caricion gracilis, Magnocaricion, Alno-Padion: Peciu Nou (Stere G., 1971a,!), Rudna (Stere G., 1971a)
Carex acutiformis Ehrh.: Hh, Eua; U6T3R4, Magnocaricion, Caricion gracilis: Diniaş, Rudna, Uliuc (Stere G., 1971a), Zlagna (Boşcaiu N., 1965)
Carex curta Good. (C. canescens auct. non L.): H, Cp (bor); U5T0R2, Caricion canescenti-nigrae: Borlova, Izvorul Sebeşului (Boşcaiu N., 1971), Mt. Mic (Boşcaiu N., 1971a), Mt. Ţarcu (Flora XI, Boşcaiu N., 1971, 1971a), Mţii Semenic (Flora XI); f. ***fallax*** F. Kurtz.: Mt. Semenic (Flora XI)
Carex distans **L.: H, Eua (sAtl-sM); U4T3R4, Agrostion stoloniferae, Eriophorion latifolii, Molinion coeruleae: Liebling (Neacşu A. et al., 2008), Pâr. Hidegu, Rusca, Turnu Ruieni, Zerveşti (Boşcaiu N., 1971)**
Carex echinata Murray (C. stelllulata Good.): H, Cp; U5T2R1, Calthion palustris, Caricion canescenti-nigrae, Magnocaricion elatae: Mt. Mic, Mt. Ţarcu (Boşcaiu N., 1971a), Mţii Semenic (Flora XI), Poiana Mărului, V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971); var. ***gypos*** (Schk.) Koch: Groapa Bistrei (Flora XI, Boşcaiu N., 1971)
Carex flava L.: H, Cp; U4.5T3R0, Calthion palustris, Caricetalia davallianae, Eriophorion latifolii, Tofieldietalia: Borlova (Boşcaiu N., 1971), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Groapa Bistrei (Boşcaiu N., 1971), Poiana Mărului, V. Bistra, (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)
Carex lasiocarpa Ehrh.: Hh, Cp; U5T2,5R2,5, Caricion lasiocarpae: Mţii Semenic (Flora XI)
Carex nigra (L.) Reichard (C. fusca All.) ssp. ***dacica*** (Heuffel.) Soo (C. dacica Heuffel, Carex bigelowii Torrey et Schwein.): G, Carp-B; U0T2R2,5; Caricion canescenti-nigrae: Mt. Ţarcu (Flora XI, Boşcaiu N., 1971, 1971a)
Carex ovalis Good. (C. leporina auct. non L.): H, Cp; U4T2.5R3, Caricion canescenti-nigrae, Molinietalia, Nardetalia: Armeniş (Boşcaiu N., 1971,!), Caransebeş (!), Gara Ţiglărie (Boşcaiu N., 1965), Mt. Mic, Obreja, Pâr. Hidegu, Poiana Mărului, Poiana Nedeii, Râul Lung, Rusca (Boşcaiu N., 1971), Trei Ape (!), V. Bistra, V. Bistra Mărului, Zerveşti (Boşcaiu N., 1971)

Carex pallescens L.: H, Cp; U3.5T3R3, Molinio-Arrhenatheretea, Nardetalia: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Groapa Bistrei, Ilova (Boşcaiu N., 1971), Mt. Mic (Boşcaiu N., 1971a), Obreja, Pâr. Hidegu, Poiana Mărului, Rusca, Sadova Veche, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965,1971)
Carex pauciflora Lightf.: G, Cp (bor); U5T2.5R1, Oxycocco-Sphagnetea, Sphagnion fusci: Mt. Ţarcu (Flora XI, Boşcaiu N., 1971)
Carex pseudocyperus L.: H (Hh), Cp; U6T3R3.5, Alnetea glutinosae, Caricion rostratae, Magnocaricion elatae: Lugoj, the lake in Str. Bocşei (Boşcaiu N., 1966), Pădureni, V. Timişului Mort (Flora XI, Soran V., 1956)
Carex remota L.: H, Cp; U4.5T3R3, Alno-Padion, Fagetalia silvaticae: between Mt. Mic and Mt. Ţarcu (Flora XI, Boşcaiu N., 1971), Rusca (Boşcaiu N., 1971)
Carex riparia L: Hh, Eua; U5T4R4, Magnocaricion, Caricion gracilis: Liebling (Neacşu A. et al., 2008)
Carex rostrata Stokes ssp. ***rostrata***: H (Hh), Cp; U5T2R0, Caricion rostratae, Magnocaricion elatae: Mţii Semenic (Flora XI), Trei Ape (!)
Carex vesicaria L.: Hh, Cp; U6T3R4, Caricion gracilis, Magnocaricion elatae: Caransebeş (XI)
Carex vulpina L.: H, Eua; U4T3R4, Agropyro-Rumicion, Caricion gracilis, Magnocaricion elatae, Phragmition australis: Armeniş (Boşcaiu N., 1971,!), Bazoş (Stere G., 1971a,!), Caransebeş (!), Foeni (Stere G., 1971a), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Rusca, Sadova Veche, V. Bistra, Var, Zerveşti (Boşcaiu N., 1971)
Carex x tetrastachys Trauntst. (curta x echinata): Mţii Semenic (Flora XI)
Cyperus flavescens Jacq. (Pycreus flavescens (L.) Reichenb.): Th, Cosm; U4.5T0R4, Nanocyperion flavescentis: Armeniş, Borlova (Boşcaiu N., 1971), Caransebeş (!), Cruceni (Stere G., 1971a), Pădureni (Flora XI), Rudna, Şag, (Stere G., 1971a), Turnu Ruieni (Boşcaiu N., 1971), Urseni (Stere G., 1971a), V. Bistra, Zerveşti (Boşcaiu N., 1971)
Cyperus fuscus L.: Th, Eua; U6T3R4, Nanocyperion flavescentis: Bucoşniţa (!), Liebling Liebling (Flora XI, Neacşu A. et al., 2008), Pădureni on Timiş (Flora XI)
Cyperus glaber L. (Chlorocyperus glaber (L.) Palla): Th, Eua (M); U5T3R4,5, Nanocyperion: Liebling, Şipet (Flora XI)
Cyperus glomeratus L. (Chlorocyperus glomeratus (L.) Palla): Hh, Eua (M); U5T3R4, Nanocyperion: Pădureni onTimiş (Flora XI)
Eleocharis acicularis **(L.) Roemer et Schultes: H (Hh), Cp; U5.5T0R0, Nanocyperion flavescentis: Albina, Dragşna (Stere G., 1971a), Lugoj beside Complexul I and V. Cinca beside Boldur (Boşcaiu N., 1966), V. Bistra beside Oţelul Roşu (Boşcaiu N., 1971), Uliuc, Urseni (Stere G., 1971a)**
Eleocharis carniolica **Koch: Th, Alp-Carp-B; U5T0R5, Nanocyperion: Caransebeş to Turnu Ruieni (Boşcaiu N., 1971, Flora XI), Obreja, V. Bistra (Boşcaiu N., 1971)**
Eleocharis ovata **(Roth) Roem. et Schult.: Th, Cp; U4,5T4R0, Nanocyperion: Lugoj (FRE), Obreja (Boşcaiu N., 1971)**
Eleocharis palustris (L.) Roemer et Schultes: G (Hh), Cosm; U5T0R4, Molinietalia, Nanocyperetalia, Phragmitetea: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş (!), Giulvăz (Stere G., 1971a,!), Liebling in Balta Mare and Balta Mică (Soran V., 1956), Lugoj (Boşcaiu N., 1966), Peciu Nou (Stere G., 1971a,!), Pâr. Hidegu, Poiana Mărului, Rusca (Boşcaiu N., 1971), Trei Ape (!), Turnu Ruieni (Boşcaiu N., 1971), Urseni (Stere G., 1971a), V. Bistra, Var, Zerverşti (Boşcaiu N., 1971),

Eriophorum latifolium Hoppe: H, Cp; U5T0R4.5, Caricion davallianae, Eriophorion latifolii, Scheuchzerio-Caricetalia nigrae, Tofieldietalia: Mt. Mic (Boşcaiu N., 1971), Mt. Ţarcu (Boşcaiu N., 1971a), Poiana Mărului, Râul Lung, Rusca, Sadova Nouă, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971),
Eriophorum vaginatum L.: H, Cp; U4.5T0R1.5, Sphagnion fusci: Izvorul Râului Lung, Mt. Ţarcu (Boşcaiu N., 1971)
Schoenoplectus lacustris (L.) Palla (Scirpus lacustris L.): G (Hh), Cosm; U6T3R4, Phragmition australis: Liebling (Neacşu A. et al., 2008) in Balta Mare (Soran V., 1956), Lugoj (Boşcaiu N., 1966,!), Pădureni on Timişul mort (Soran V., 1956), Peciu Nou, Uliuc (Stere G., 1971a)
Schoenoplectus tabernaemontanus: Ivanda, Rudna, Uliuc, Urseni (Stere G., 1971a)
Scirpus supinus L. (Isolepis supina (L.) R. Br.): Th (Hh), Cosm; U4,5T3R0, Nanocyperion: Giroc (Stere G., 1971a), Jebel (Flora XI, Soran V., 1956), Liebling (Soran V., 1956), Peciu Nou (Stere G., 1971a)
Scirpus sylvaticus L.: G, Cp; U4.5T3R0, Alno-Padion, Calthion palustris, Molinietalia, Phragmitetea: Armeniş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Gărâna (!), Lugoj (Boşcaiu N., 1966,!), Pâr. Hidegu, Poiana Mărului, Râul Alb, Râul Lung, Rusca (Boşcaiu N., 1971), Trei Ape (!), Turnu Ruieni, V. Bistra, V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971),

Poaceae
Agrostis canina **L. ssp.** *canina*: **H, Eua; U4T3R3, Caricion canescenti-nigrae, Molinio-Arrhenatheretea: Pâr. Hidegu, Poiana Mărului (Boşcaiu N., 1971)**
Agrostis gigantea **Roth ssp.** *gigantea*: **H(G), Eua; U4,5T0R4, Phragmitetalia, Calthion: Borlova (Boşcaiu N., 1971)**
Agrostis stolonifera L. ssp. ***stolonifera***: H, Cp; U4T0R0, Agropyro-Rumicion, Agrostion stoloniferae, Alno-Padion, Magnocaricion elatae, Molinion coeruleae: Armeniş, Bolvaşniţa (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Bucoşniţa (!), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Gărâna, Giulvăz (!), Glimboca, Oţelul Roşu, (Boşcaiu N., 1971,!), Ilova (Boşcaiu N., 1966), Jebel (Soran V., 1956), Liebling (Neacşu A. et al., 2008, Soran V., 1956), Lugoj (Boşcaiu N., 1966), Obreja, Pâr. Hidegu, Rusca, Sadova Veche, (Boşcaiu N., 1971), Tapia (Boşcaiu N., 1966), Şag, Trei Ape (!), V. Bistra, V. Bistra Mărului, V. Sebeşului, Vârciorova (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971), Zlagna (Boşcaiu N., 1965)
Alopecurus aequalis Sobol.: Th-TH, Cp; U5T3R4, Agrostion stoloniferae, Bidentetalia tripartiti, Nanocyperion flavescentis: Liebling (Neacşu A. et al., 2008) in Balta Mare and Balta Mică (Soran V., 1956)
Alopecurus geniculatus L.: Th-TH, Cosm; U5T0R4, Agropyro-Rumicion, Agrostion stoloniferae, Plantaginetea majoris: Mt. Mic (Boşcaiu N., 1971,1971a); f. *natans:* Lugoj (Boşcaiu N., 1966)
Alopecurus pratensis L. ssp. ***pratensis***: H, Eua; U4T3R0, Agrostion stoloniferae, Calthion palustris, Filipendulo-Petasition, Molinio-Arrhenatheretea: Armeniş, Bolvaşniţa (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Caransebeş (!), Gara Ţiglărie (Boşcaiu N., 1965), Giulvăz (!), Ilova (Boşcaiu N., 1971), Liebling (Neacşu A. et al., 2008), Oţelul Roşu (!), Obreja, Pâr. Hidegu, Râul Alb, Râul Lung, Rusca, Sadova Veche, (Boşcaiu N., 1971), V. Bistra, V. Bistra Mărului, V. Sebeşului, Var, Vârciorova, Zlagna (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971)
Beckmannia eruciformis (L.) Host: H, Cp; U4,5T3R4, Beckmannion: Ciacova (Flora XII)

Calamagrostis canescens (Weber) Roth: H, Eua; U5T3R3, Alnion, Phragmitetea: Liebling (Neacşu A. et al., 2008)
Calamagrostis pseudophragmites (Haller fil.) Koeler: H, Eua-C; U5T3R5, Salicion eleagni: Armeniş, V. Bistra (Boşcaiu N., 1971)
Catabrosa aquatica **(L.) Beauv.: H, Cp; UTR, Bidentetea, Glycerio-Sparganion: Armeniş, Rusca, Sadova Veche, Turnu Ruieni, V. Bistra, Zerveşti (Boşcaiu N., 1971)**
Deschampsia caespitosa (L.) Beauv. ssp. ***caespitosa***: H, Cosm; U4T0R0, Betulo-Adenostyletea, Molinietalia, Phragmitetalia: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Gărâna (!), Trei Ape (!), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965), Mt. Mic, Mt. Ţarcu, V. Bistra Mărului (Boşcaiu N., 1971, 1971a)
Glyceria maxima (Hartman) Holmberg (G. aquatica (L.) Wahlb.): H (Hh), Cp; U5T3R4, Phragmition australis: Bazoş, Chizătău (Stere G., 1971a,!), Liebling (Neacşu A. et al., 2008), between Lugoj and Tapia on Pâr. Ştiuca (Boşcaiu N., 1966), Peciu Nou, Urseni (Stere G., 1971a)
Glyceria fluitans (L.) R.Br. H(Hh), Eua; U5T3R0, Glycerio-Sparganion : Liebling in Balta Mare and Balta Mică (Soran V., 1956), Urseni (Stere G., 1971a)
Glyceria nemoralis (Uechtr.) Uechtr. et Koernicke: H, Ec; U5T3R3, Cardamini-Montion: Mt. Mic (Boşcaiu N., 1971a), Poiana Mărului (Boşcaiu N., 1971)
Glyceria notata Chevall. (G. plicata (Fries) Fries): H (Hh), Cp; U6T3R4.5, Glycerio-Sparganion: Armneiş (Boşcaiu N., 1971,!), Borlova (Boşcaiu N., 1971), Moşniţa Veche, Peciu Nou (Stere G., 1971a), Trei Ape (!), Turnu Ruieni, V. Bistra, V. Bistra Mărului (Boşcaiu N., 1971)
Crypsis alopecuroides (Piller et Mitterp.) Schrad. (Heleochloa alopecuroides (Piller et Mitterp.) Host: Th, Eua; U4T4R4,5,Cypero-Spergularion : Jebel, Liebling (Soran V., 1956)
Leersia oryzoides (L.) Swartz: G (Hh), Cp; U6T3R0, Bidentetea tripartiti, Glycerio-Sparganion: Glimboca, Obreja, V. Bistra (Boşcaiu N., 1971); f. ***patens*** Wiesb.: Lugoj (Flora XII), V. Ştiuca beside Tapia (Boşcaiu N., 1966)
Molinia coerulea (L.) Moench ssp. ***coerulea***: H, Eua; U4T3R0, Molinion coeruleae: Borlova (Boşcaiu N., 1971), Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Faţa Sadovei (Boşcaiu N., 1965, 1971), Lugoj at the brick yard Bartoş (Boşcaiu N., 1966, Flora XI), Pâr. Hidegu, Poiana Mărului, Rusca, V. Bistra, (Boşcaiu N., 1971), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965, 1971), Zlagna (Boşcaiu N., 1965, 1971)
Phalaris arundinacea L. (Typhoides arundinacea (L.) Moench): Hh, Cp; U5T3R0, Agrostion stoloniferae, Caricion gracilis: Bazoş (!), Chizătău, Giroc (Stere G., 1971a), Liebling (Neacşu A. et al., 2008), Peciu Nou (Stere G., 1971a,!), Rusca, Turnu Ruieni (Boşcaiu N., 1971), Urseni (Stere G., 1971a), V. Bistra (Boşcaiu N., 1971), V. Ştiuca beside Tapia (Boşcaiu N., 1966)
Phragmites australis (Cav.) Steudel ssp. ***australis***: G (Hh), Cosm; U6T0R4, Phragmition australis: Bazoş, Belinţ, Bucoşniţa (!), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Chizătău, Coşteiu (!), Cruceni, Diniaş, Foeni, Giroc (Stere G., 1971a), Giulvăz (!), Ivanda (Stere G., 1971a), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Lugojel (!), Peciu Nou, Rudna (Stere G., 1971a), Sacu (!), Şag (Stere G., 1971a,!), Uliuc, Urseni (Stere G., 1971a); f. ***subuniflora*** DC.: V. Timişului (jud. Timiş) (Flora XII)
Poa palustris L.: H, Cp; U5T3R4, Alnetalia glutinosae, Calthion palustris, Magnocaricion elatae, Phragmition australis: Armeniş (Boşcaiu N., 1971), Giroc (Al. Buia, 1942), Liebling

(Neacşu A. et al., 2008), Lugoj, Tapia (Boşcaiu N., 1966), V. Bistra (Boşcaiu N., 1971); var. ***effusa*** Rchb.: Giroc (Al. Buia, 1942); var. ***fertilis*** Rchb.: Giroc (Al. Buia, 1942)

Sparganiaceae
Sparganium erectum L. (S. ramosum Hudson) ssp. ***erectum***: G (Hh), Eua; U5.5T3.5R0, Glycerio-Sparganion, Phragmition australis: Liebling in the fen Tofaia and Balta Mare (Soran V., 1956), Lugoj (Boşcaiu N., 1966), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Urseni (Soran V., 1956); ssp. ***neglectum*** (Beeby) K. Richter: G, Hh, Ec: Armeniş (Boşcaiu N., 1971), Obreja, Sadova Veche (Boşcaiu N.,1971), Urseni (Stere G., 1971a), V. Bistra, var. (Boşcaiu N.,1971); ssp. ***oocarpum*** (Celak) Domin: Urseni (Grigore. Stere, 1971)

Typhaceae
Typha angustifolia L.: G (Hh), Cp; U6T4R0, Phragmition australis: Glimboca (Boşcaiu N.,1971), Liebling (Neacşu A. et al., 2008), in fen Tofaia (Soran V., 1956), Lugoj (Boşcaiu N., 1966), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Urseni (Soran V., 1956, Stere G., 1971a)
Typha latifolia L.: G (Hh), Cosm; U6T3.5R0, Phragmition australis: Belinţ, Bucoşniţa (!), Caransebeş, Giulvăz (!), Glimboca (Boşcaiu N.,1971), Liebling (Neacşu A. et al., 2008) in fen Tofaia (Soran V., 1956), Lugoj (Boşcaiu N., 1966), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Urseni (Soran V., 1956, Stere G., 1971a), Trei Ape (!)
Typha shuttleworthii Koch et Sonder: G (Hh), E (mont); U6T3R0, Phragmition australis: Izvorul Bistrei Mărului, Iyvorul Sebeşului (Boşcaiu N.,1971), Moşniţa (Flora XI), Râul Lung, Rusca (Boşcaiu N.,1971)

Araceae
Acorus calamus L. G (Hh), Adv; U6T3,5R4, Phragmitetalia: Lugoj (Flora XII)

Lemnaceae
Lemna gibba L.: Hh, Cosm; U6T3,5R4, Lemnion minoris: Liebling (Flora XII) in Balta Mare and Balta Mică (Soran V., 1956)
Lemna minor L.: Hh, Cosm; U6T0R0, Lemnion minoris: Albina (Stere G., 1971a), Bazoş (Stere G., 1971a,!), Belinţ, Caransebeş, Criciova (!), Chizătău (Stere G., 1971a,!), Cruceni, Foeni, Giroc, Giulvăz (!), Ivanda (Stere G., 1971a), Liebling (Neacşu A. et al., 2009) in fen Tofaia and Balta Mare and Balta Mică (Soran V., 1956), Lugoj (Boşcaiu N., 1966,!), Lugojel (!), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Peciu Nou, Rudna (Stere G., 1971a), Şag (Stere G., 1971a,!), Tapia (Boşcaiu N., 1966), Uliuc, Urseni (Stere G., 1971a)
Lemna trisulca L.: Hh, Cosm; U6T0R4, Lemnion minoris: Giroc, Foeni (Stere G., 1971a), Lugoj, the lake in Str. Bocşei and at the brick yard Bartoş (Boşcaiu N., 1966), Pădureni on Timişul Mort (Soran V., 1956), Uliuc, Urseni (Stere G., 1971a)
Spirodela polyrhiza (L.) Schleiden: Hh, Cosm; U6T3.5R0, Lemnion minoris: Bazoş, Giulvăz, (Stere G., 1971a), Liebling (Neacşu A. et al., 2008) in fen Tofaia and Balta Mare (Soran V., 1956), Lugoj in Pâr. Ştiuca (Boşcaiu N., 1966), Pădureni on Timişul Mort and in puddles (Soran V., 1956), Peciu Nou (!), Şag, Uliuc, Urseni (Stere G., 1971a)
Wolffia arrhiza (L.) Horkel: Hh, Cosm; U6T0R4, Lemnion minoris: lunca Timişului la Albina, Giroc (Stere G., 1971a), Liebling (Flora XII), Liebling in puddle Balta Mare (Soran V., 1956), Lugoj (Flora XII), lake in Str. Bocşei (Boşcaiu N., 1966), Pădureni on Timişul Mort (Soran V., 1956), Uliuc, Urseni (Stere G., 1971a)

Vegetation

Agrostidetum stoloniferae (Ujvárosi 1941) Burduja et al. 1956: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Liebling (Neacşu A. et al., 2009)
Bolboschoenetum maritimi (Soo 1957) Eggler 1933: Diniaş (Stere G., 1971a), Giulvăz (Stere G., 1971a,!), Ivanda (Stere G., 1971a), Lugoj (Boşcaiu N., 1966), Peciu Nou, Rudna (Stere G., 1971a)
Calthaetum laetae Krajina 1933: Mt. Mic, Mt. Ţarcu, V. Bistra Mărului (Boşcaiu N., 1971a)
Cardaminetum opicii Szafer, Pawl. Kulcz. 1923: Groapa Bistrei, Mt. Mic (Boşcaiu N., 1971a)
Caricetum acutiformis Eggler 1933 (Caricetum acutiformis-ripariae Soo (1938) 1947): Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Diniaş, Rudna, Uliuc (Stere G., 1971a)
Caricetum gracilis (Graebn. et Hueck 1931) Almquist 1929: Peciu Nou (Stere G., 1971a,!), Rudna (Stere G., 1971a)
Caricetum rostratae Rubel 1912: Trei Ape (!)
Caricetum vulpinae (Nowinski 1928) Soo 1927: Caransebeş (!), Bazoş, Foeni (Stere G., 1971a)
Ceratophyllo-Hydrocharitetum Pop I., 1962: Chizătău (Stere G., 1971a), Lugoj (Boşcaiu N., 1966)
Ceratophylletum demersi Hild 1956: Liebling (Neacşu A. et al., 2009)
Chrysosplenio-Cardaminetum (Tx. 1937) Maas 1959: V. Bistra Mărului, V. Sebeşului (Boşcaiu N., 1971a)
Cyperetum flavescentis W. Koch 1926: Caransebeş (!), Cruceni, Rudna, Şag (Stere G., 1971a,!), Urseni (Stere G., 1971a)
Deschampsietum caespitosae Hayek ex Horvatic 1930: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965)
Eleocharidetum acicularis (W. Koch 1926) R. Tx. 1937: Albina, Dragşna (Stere G., 1971a), Boldur, Lugoj (Boşcaiu N., 1966), Uliuc, Urseni (Stere G., 1971a)
Eleocharitetum palustris (Schennikow 1919) Ubrizsy 1948 (Alismato-Eleocharetum Mathe et Kovacs 1967): Caransebeş (!), Cruceni, Diniaş, Giulvăz, Peciu Nou (Stere G., 1971a,!), Urseni (Stere G., 1971a)
Filipendulo-Geranietum palustris W. Koch 1926 subas. ***filipenduletosum***: Trei Ape (!), Gărâna (!)
Galio palustris-Caricetum ripariae Balatova-Tulačkova el al. 1993 (Caricetum ripariae soo 1928; Knapp et Stoffer 1962): Liebling (Neacşu A. et al., 2009)
Glycerietum fluitantis Eggler 1933 (Sparganio-Glycerietum fluitantis Br.-Bl. 1925, Glycerio-Sparganietum neglecti Koch 1926): Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965) Pădureni on Timişul Mort (Soran V., 1956), Urseni (Soran V., 1956, Stere G., 1971a)
Glycerietum maximae (Nowinski 1930) Hueck 1931): Bazoş, Chizătău (Stere G., 1971a), Liebling (Neacşu A. et al., 2009), Lugoj (Boşcaiu N., 1966), Peciu Nou, Urseni (Stere G., 1971a)
Glycerietum plicatae Kulczynski 1928 (Oberd. 1954): Moşniţa Veche, Peciu Nou (Stere G., 1971a)
Helianthetum decapetali Morariu 1967: Bucoşniţa (!), Petroşniţa (!)
Hydrochari-Stratiotetum (Langend. 1935) Westhoff 1942: Uliuc (Stere G., 1971a)
Iridetum pseudacori Eggler 1933: Liebling (Neacşu A. et al., 2009)
Juncetum effusi Soo (1931) 1949: Teregova (!)

Junco (inflexi)-Menthetum longifoliae Lohm. 1953.: Trei Ape (!)
Lemnetum minoris Oberd. 1957 ex Muller et Gors 1960: Albina (Stere G., 1971a), Bazoş (Stere G., 1971a,!), Belinţ, Caransebeş, Criciova (!), Chizătău (Stere G., 1971a,!), Cruceni, Foeni, Giroc, Giulvăz (!), Ivanda (Stere G., 1971a), Liebling (Neacşu A. et al., 2009) Lugoj (Boşcaiu N., 1966,!), Peciu Nou, Rudna (Stere G., 1971a), Şag (Stere G., 1971a,!), Tapia (Boşcaiu N., 1966), Uliuc, Urseni (Stere G., 1971a)
Lemno-Utricularietum Soo (1928) 1947: Belinţ, Chizătău, Foeni, Giroc (Stere G., 1971a), Lugoj (Boşcaiu N., 1966), Rudna, Uliuc, Urseni (Stere G., 1971a); facies cu *Spirodela polyrrhiza***:** Liebling in fen Tofaia and in Balta Mare (Soran V., 1956), Pădureni in Timişul Mort (Soran V., 1956); facies cu *Salvinia natans***:** Pădureni in Timişul Mort (Soran V., 1956); facies cu *Wolfia arrhiza***:** Pădureni in Timişul Mort (Soran V., 1956)
Lindernio-Isolepetum Morariu 1943 (Eleochatis acicularis-Schoenoplectus supinus Soo 1951 p.p., Eleocharetum ovatae Hayek 1923 p.p.): Cerna, Folia (Soran V., 1956) Giroc (Stere G., 1971a), Jebel, Lebling (Soran V., 1956), Peciu Nou, Şag (Stere G., 1971a)
Lythro-Calamagrostetum epigeii Pop I. 1968: Lugoj (Boşcaiu N., 1966)
Myriophyllo-Potametum Soo 1934: Liebling (Neacşu A. et al., 2009) in Timiş and in Balta Mare and Balta Mică (Soran V., 1956), Lugoj (Boşcaiu N., 1966), Moşniţa Veche, Rudna (Stere G., 1971a), between Şag and Urseni (Soran V., 1956), Urseni (Stere G., 1971a) cu subas. ***marsileetosum*** Soo 1957 şi ***myriophylletosum spicati*** Soo 1957
Nupharetum albo-luteae Nowinski 1928 (Potameto-Nupharetum T. Müller et Görs. 1960): Lugoj, Tapia (Boşcaiu N., 1966)
Oenantho aquaticae-Rorippetum amphibiae (Soo 1927) Lohm. 1950: în lunca Timişului la Rudna, Uliuc, Urseni (Stere G., 1971a)
Parvipotamo-Zannichellietum W. Koch 1926: Boldur in V. Cinca (Boşcaiu N., 1966), Liebling in Balta Mare and Balta Mică (Soran V., 1956), Rudna (Stere G., 1971a)
Petasitetum hybridi (Dostal 1933) Soo 1940: Trei Ape (!)
Peucedano rocheliani-Molinietum coeruleae Boşcaiu, 1965: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), between Zerveşti and Turnu Rueni (Boşcaiu N., 1965), Zlagna (Boşcaiu N., 1965)
Phalaridetum arundinaceae (Horvatiè 1931) Libbert 1931: Bazoş (!), Chizătău, Giroc (Stere G., 1971a), Liebling (Neacşu A. et al., 2009), Peciu Nou (Stere G., 1971a,!), Tapia (Boşcaiu N., 1966), Urseni (Stere G., 1971a)
Philonotido-Saxifragetum stellaris Horv. 1949: Groapa Bistrei, Mt. Mic (Boşcaiu N., 1971a)
Phragmitetum vulgaris Soo 1927 (Scirpo-Phragmitetum W. Koch 1926): Bazoş, Belinţ, Bucoşniţa (!), Caransebeş (!) at Gara Ţiglărie (Boşcaiu N., 1965), Chizătău, Coşteiu (!), Cruceni, Diniaş, Foeni, Giroc (Stere G., 1971a), Giulvăz (!), Ivanda (Stere G., 1971a), Liebling (Neacşu A. et al., 2008), Lugoj (Boşcaiu N., 1966,!), Lugojel (!), Peciu Nou, Rudna (Stere G., 1971a), Sacu (!), Şag (Stere G., 1971a,!), Uliuc, Urseni (Stere G., 1971a)
Poëtum pratensis Rãv., Cãzãc. et Turenschi ex Răv. et Mititelu 1958 : Liebling (Neacşu A. et al., 2009)
Polygonetum cuspidati Tüxen et Raabe 1950: Armeniş (!), Bucoşniţa (!), Petroşniţa (!), Sadova Veche (!)
Polygono hydropiperi-Bidentetum tripartiti Lohm. 1950 (Bidentetum tripartiti W. Koch 1926, Polygonetum hydropiperi Passarge 1965): Bucoşniţa (!)
Polygono – Potametum natantis Soó 1964: Chizătău (Stere G., 1971a,!), Cruceni (Stere G., 1971a), Liebling (Neacşu A. et al., 2009), Peciu Nou, Rudna, Şag (Stere G., 1971a); subas. ***potametosum natantis*** Soo 1964: Bazoş (!), Lugoj (Boşcaiu N., 1966); subas. ***polygonetosum amphibii*** Soo 1924: Boldur, Lugoj (Boşcaiu N., 1966)

Potamo-Ceratophylletum Pop I., 1962: Cruceni, Diniaş, Foeni, Giroc, Moşniţa Veche, Rudna (Stere G., 1971a)
Pulicario vulgaris-Menthetum pulegii Slavnic 1951: Caransebeş (!), Cruceni, Foeni, Giroc (Stere G., 1971a), Giulvăz (Stere G., 1971a,!), Ivanda (Stere G., 1971a), Lugoj (Boşcaiu N., 1966,!), Rudna (Stere G., 1971a), Şag, Teregova (!), Urseni (Stere G., 1971a)
Ranunculo trichophylli-Callitrichetum cophocarpae (Soo 1927) Pocs 1958: Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965)
Ranunculetum aquaticae Gehu 1961: Dragşna, Foeni (Stere G., 1971a)
Ranunculetum lateriflori Pop I. 1962: Diniaş, Giulvăz (Stere G., 1971a)
Ranunculetum repentis Knap 1946 emend. Oberd. 1957: Belinţ, Caransebeş, Chizătău, Giulvăz, Lugoj, Peciu Nou (!)
Ranunculo repenti-Alopecuretum pratensis Ellmauer et Mucina 1993 (Alopecuretum pratensis Regel 1925, Agrosti-Alopecuretum pratensis Ubrizsi 1955): Caransebeş-Gara Ţiglărie (Boşcaiu N., 1965), Liebling (Neacşu A. et al., 2009)
Rubo – Salicetum cinereae Sonasak 1963 : Liebling (Neacşu A. et al., 2009)
Salicetum albae Issler 1926: Bucoşniţa (!)
Salvinio-Hydrocharitetum (Oberd. 1957) Boşcaiu 1966: Cruceni, Chizătău, Giroc, Ivanda (Stere G., 1971a), Lugoj (Boşcaiu N., 1966), Uliuc, Urseni (Stere G., 1971a)
Salvinio-Spirodeletum Slav. 1956: Bazoş (Stere G., 1971a), Peciu Nou (!), Şag, Uliuc, Urseni (Stere G., 1971a)
Saxifragetum aizoidis Horv. 1935: Dunga Gropii Bistra under Vf. Ţarcu (Boşcaiu N., 1971a)
Scirpetum lacustris Chouard 1924 (Schoenoplectetum lacustris Eggler 1933): Liebling (Neacşu A. et al., 2009), Lugoj (Boşcaiu N., 1966), Peciu Nou, Uliuc (Stere G., 1971a)
Scirpetum silvatici Ralski 1931: Gărâna (!), Trei Ape (!)
Scirpetum tabernaemontani (Soo 1949) Pass. 1964: Ivanda, Rudna, Uliuc, Urseni (Stere G., 1971a)
Lemno-Spirodelatum polyrhizae W. Koch 1926 (Spirodeletum polyrrhizae W. Koch 1954): Liebling (Neacşu A. et al., 2009), Lugoj on Pâr. Ştiuca (Boşcaiu N., 1966)
Stellario nemorum-Alnetum glutinosae Lohmeyer 1957 (Aegopodio-Alnetum glutinosae J. Karpati et Jurko 1961): Armeniş (!), Gărâna (!), Teregova (!), Trei Ape (!)
Trapetum natantis (Müller et Görs 1960) V. Karpati 1963: Liebling (Neacşu A. et al., 2009), Lugoj (Boşcaiu N., 1966)
Typhaetum angustifoliae Pignatti 1953: Liebling (Neacşu A. et al., 2009), Lugoj (Boşcaiu N., 1966)
Typhaetum latifoliae G. Lang 1973: Caransebeş (!), Cruceni (Stere G., 1971a), Giulvăz (!), Liebling (Neacşu A. et al., 2009), Lugoj (!), Trei Ape (!), Urseni (Stere G., 1971a)
Wolffietum arrhizae Miyawaki et J. Tx. 1960: Albina, Giroc (Stere G., 1971a), Lugoj, the lake in Str. Bocşei (Boşcaiu N., 1966), Uliuc, Urseni (Stere G., 1971a)

CONCLUSIONS

In the Timiş River drainage basin, the aquatic and paludal flora and vegetation are quite numerous, as a consequence of the multitude of ponds, lakes and swamps.

Out of the 285 species identified, more than twenty are either rare or protected. Between them there are typical water macrophytes, species prevalent in sites with changing water levels, or temporary dry ares as well as species of swamps and of meadows with changing wetness (e.g. *Thelypteris palustris, Marsilea quadrifolia, Nuphar lutea, Myosurus minimus, Ranunculus lateriflorus*, *Ranunculus lingua, Ranunculus ophioglossifolius, Montia* *minor, Rumex x gayeri, Ludwigia palustris, Apium nodiflorum, Peucedanum rochelianum, Elatine hexandra, Tozzia alpina* ssp. *carpatica, Cirsium brachycephalum, Taraxacum bessarabicum, Stratiotes aloides, Fritillaria meleagris, Gladiolus imbricatus, Narcissus poëticus* ssp. *radiiflorus, Wolffia arrhiza*).

Beside the larger spread plant coenoses coenenoses, in the area there are found plant communities with a limited distribution in Romania such are Eleocharidetum acicularis, Lindernio-Isolepetum, Peucedano rocheliani-Molinietum coeruleae, Ranunculetum lateriflori and Wolffietum arrhizae.

ACKNOWLEDGEMENTS

A part of this work resulted from the scientific study of the quality of the Timiş River water, "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of "Lucian Blaga" University, Faculty of Sceinces, financed by the European Community.

SELECTED REFERENCES

1. Arvat N., 1977 – Flora şi vegetaţia dintre râurile Timiş, Pogoniş şi Bârzava, Teză de doctorat, Iaşi. (in Romanian)
2. Borbás V., 1884 – Flora comitatus temesiensis, Timişoara, 53. (in Hungarian)
3. Boşcaiu N., 1942 – Flora luncii Sebeşului de lângă Zerveşti, *Natura*, 31, 64-66. (in Romanian)
4. Boşcaiu N., 1944 – Contribuţii la flora şi vegetaţia Muntelui Mic din Banat, Primăvara Banatului, Lugoj, 5, 8-13. (in Romanian)
5. Boşcaiu N., 1965 – Cercetări fitocenologice asupra asociaţiei Peucedano - Molinierum coeruleae din Banat şi Ţara Haţegului, *Contribuții Botanice Cluj*, 251-264. (in Romanian)
6. Boşcaiu N., 1966 – Vegetaţia acvatică şi palustră din împrejurimile oraşului Lugoj, *Contribuții Botanice Cluj*, II, 69-80
7. Boşcaiu N., 1971 – Flora şi vegetaţia Munţilor Ţarcu, Godeanu şi Cernei, Edit. Academiei Române, Bucureşti, 494. (in Romanian)
8. Boşcaiu N., 1971a – Vegetaţia fontinală din Munţii Ţarcu, Godeanu şi Cernei, *Studii şi Comunicări Muzeul Brukenthal Sibiu, Ştiințele Naturii*, 16, 124-133.
9. Buia A., 1942 – Contribuţii la flora Timişoarei, *Buletinul Grădinii Botanice Cluj*, XXII, 57-62
10. Bujorean G., 1959 – Montia verna în flora Banatului, *Studii şi cercetări de Biologie, Seria ştiințe agricole*, Timişoara, VI, 3-4, 91-95.
11. Stere G. 1971 – Flora şi vegetaţia din interfluviul Timiş-Bega, Teză de doctorat, Institutul Agronomic „Ion Ionescu de la Brad", Iaşi.
12. Stere G., 1971a – Vegetaţia acvatică şi palustră din interfluviul Timiş-Bega, *Studii şi cercetări de Biologie*, *Seria Botanică*, 23, 1, 13-46.
13. Heuffel J., 1858 – Enumeratio plantarum in Banatu Temesiensis sponte crescentium et frequentius cultorum, Vindobonae. (in Francais)
14. Neacşu A., Arsene G. -G., Fărcăşescu A., Faur F. and Stroia C., 2008 – Aquatic and paludicolous vegetation from some Banat sites, *Lucrări ştiinţifice,* Timişoara, 40, 55-60
15. Neacşu A., Arsene G. -G., Fărcăşescu A. and Faur F., 2009 – The vegetation of the lake Liebling (Timiş County), *Lucrări ştiinţifice Facultatea de Agronomie*, Timişoara, 41, 2, 279-284.
16. Pop A., 1977 – Flora şi vegetaţia din Câmpia joasă a Timişului. Studiu floristic, ecologic şi geobotanic, Teză de doctorat, Universitatea Cluj-Napoca.
17. Pop I., 1968 – Plante noi şi rare din Banat, Studia Universitatis Babeş-Bolyai Cluj, 3-6.
18. Rochel A., 1823 – Plantae Banatus rariores, Pestinii.
19. Săvulescu T. (ed.), l952-1976 – Flora R. P. R. I- XIII, Edit. Academiei Române, Bucureşti.
20. Soran V. 1954 – Flora de la Liebling şi împrejurimi, *Studii şi cercetări de Biologie*, Cluj, 5, 1-2.
21. Soran V., 1956 – Câteva asociaţii de plante acvatice şi palustre din Banat, *Studii şi cercetări de Biologie*, Cluj, 7, 1-4, 107-124
22. Vicol E. C., 1974 – Flora şi vegetaţia Piemontului Lugojului, Teză de doctorat, Universitatea Cluj-Napoca.

NEW DATA CONCERNING THE FRESHWATER MOLLUSCS FROM THE ROMANIAN SECTOR OF TIMIŞ RIVER (BANAT, ROMANIA)

Ioan SÎRBU * and *Monica SÎRBU* **

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Environmental Sciences and Physics, 5-7 Raţiu St., RO-550012 Sibiu, Romania, meosirbu@yahoo.com
** "*Andrei Şaguna*" Pedagogical National College, 2 Aleea Turnu Roşu St., RO - 550361 Sibiu, Romania, monisirbu70@yahoo.com

DOI: 10.2478/trser-2013-0035

KEYWORDS: chorology, bioindication, human impact, community, invasive species.

ABSTRACT

In the Romanian sector of the Timiş River, 31 species of freshwater molluscs have been found up to the present. Among them are 17 gastropod and 14 bivalve species (including all seven species of Unionidae that live in Romania, these found in the lower sector of the river – something that is extremely rare in our waters). The present synthesis used the results of a screening type field investigation carried out in 2011, as well as all the available data from the literature and our previous studies. All these data prove the ongoing degradation of the river's ecological state and its sheltered communities. This paper presents the annotated systematic and chorological checklist of the mollusc species from this area, some of its ecological characteristics and the main environmental issues related to human impact. Changes in species distribution and the structure of communities as an answer to increased human pressure during the last decades are also thus demonstrated. New data about some alien invasive species are given, including the first encounter with *Corbicula fluminea*, a species formerly known only in Romanian inland waters from the Danube, in the Timiş River lower sector.

RÉSUMÉ: Nouvelles données sur les mollusques d'au douce du secteur roumain de la rivière Timiş (Banat, Roumanie).

Dans le secteur roumain de la rivière Timiş, 31 espèces de mollusques d'eau douce ont été trouvées jusqu'à présent. Parmi celles-ci se trouvent 17 espèces de gastéropodes et 14 espèces de bivalves (y compris les sept espèces d'unionidae roumaines se trouvant dans le secteur inférieur de la rivière - ce qui est extrêmement rare dans nos eaux). Dans la présente synthèse, les résultats d'une campagne de terrain faite en 2011, les résultats de nos études antérieures et toutes les données disponibles dans la littérature ont été utilisés. Toutes ces données confirment la dégradation continue de l'état écologique de la rivière ainsi que de ses communautés. Cet article présente la liste systématique et chorologique des espèces de mollusques de cette zone, certaines de leurs caractéristiques écologiques et les principaux problèmes environnementaux liés à l'impact des activités humaines. Les changements de la distribution des espèces et de la structure des communautés, comme une réponse à l'augmentation de la pression humaine au cours des dernières décennies, sont également indiqués dans cette synthèse. De nouvelles données sur certaines espèces exotiques invasives sont présentées, y compris le premier relevé de *Corbicula fluminea* dans le secteur inférieur de la rivière Timiş, une espèce autrefois connus dans les eaux intérieures roumaines du Danube.

REZUMAT: Noi date cu privire la moluştele dulcicole din sectorul românesc al râului Timiş (Banat, România).

În sectorul râului Timiş din Banat, România, au fost identificate până în prezent 31 de specii de moluşte dulcicole, dintre care 17 specii de gastropode şi 14 de bivalve (inclusiv toate cele şapte specii de Unionidae care trăiesc în România au fost identificate în sectorul inferior al râului, fapt care se constată extrem de rar în apele noastre). În sinteza de faţă sunt utilizate toate datele originale şi bibliografice, la care se adaugă rezultatele unei campanii de cercetare desfăşurate în 2011, toate acestea demonstrând continua degradare a stării ecologice a râului şi a comunităţilor adăpostite de acesta. Lucrarea de faţă prezintă o listă actualizată sistematică şi corologică a speciilor, unele observaţii cu privire la ecologia lor, precum şi principalele probleme legate de impactul antropic în aria de referinţă. Modificări spaţiale şi temporale ale distribuţiei speciilor şi ale structurii comunităţilor, ca răspuns la presiunile antropogene, sunt de asemenea prezentate. Noi date privind unele specii alohtone invazive sunt prezentate, inclusiv prima semnalare a speciei *Corbicula fluminea* în sectorul inferior al Timişului, cunoscută anterior în România numai din apele Dunării.

INTRODUCTION

The Banat is the southwestern province of Romania, bordered by the Mureş River in the North, the Danube in the South and the Southern Carpathian mountains in the East. The Timiş River drains a significant part of its central and northern area. It is the largest interior river from Banat, originating from Semenic Mountains, with a length of 339.7 km (241.2 km on Romanian territory) and a surface of the hydrographic basin of 13.085 km^2. It passes outside the Romanian border at Grăniceri locality, which is the last sampling station concerning the present paper. The remaining 100 km are on Serbian territory and at the level of the Pančevo locality it flows into the Danube. Some scattered material and information regarding the freshwater Mollusca from Banat date back to the XIXth Century. Most naturalists studied terrestrial molluscs, especially from mountain areas, the aquatic species being only seldom quoted. The few mentions usually give no exact toponyms. However, some data are available from the collections of Bielz, Kimakowicz, Licherdopol, Grossu, and others. These collections are preserved mainly in the Museum of Natural History in Sibiu and the "Grigore Antipa" National Museum of Natural History in Bucharest. Some published historical data are available from Bielz (1867), Kimakowicz (1883-1884), and Clessin (1887). In the XXth Century, the faunistical data become more numerous. Most papers from the middle part of the century, concerning also the freshwater Mollusca, belong to Grossu and were synthesized in his tomes concerning the bivalves (1962) and the gastropods (1986, 1987) from Romania. Beginning with 1998 the authors of the present paper organized several sampling trips in the Romanian Banat, inclusively the Timiş River, which was researched three times along its entire Romanian course, from the source area down to the point it passes outside the border. Some published papers, with references to this subject and area, dealt with the distribution of the *Pisidium* species in Banat (Sîrbu, 2002; Sîrbu and Benedek, 2004), data regarding the diversity of the freshwater species from Banat (Bănărescu and Sîrbu, 2002), the Mollusca fauna from Timiş River (Sîrbu, 2004), data regarding the distribution and ecology of several groups from the regional molluscs' fauna (Sîrbu et al., 2006; Sîrbu et al., 2010; Sîrbu, 2011). The freshwater molluscs from this river are better known compared to those from most of the Romanian running waters. However, during the screening type field survey, carried out by the authors in 2011, some new and remarkable features of mollusc communities have been discovered. Among them, the propagation of a new invasive species, changes in the longitudinal species distribution and in communities structure, in the presence and magnitude of the human impact. Thus, based on new evidence, the authors highlight the changes that occurred in the ecological state of the river and its freshwater molluscs during the last decade. The field survey from August 2011 was done in the frame of a study concerning the quality of the Timiş River, from the springs down to the border with Serbia, as a part of a Romanian-Serbian partnership program.

STUDY AREA AND METHODS

The annotated checklist of freshwater molluscs from the Timiş River (Romanian territory) is based on all available references and collections, as well as on the authors' research accomplished since 1998. The new data are coming from a field survey, carried on in August 2011. The sampling sites were selected according to geomorphologic and hydrologic features, but also to the presence of human impact sources. The molluscs were sampled by hand, by sieves or dredges. The naiads (Unionidae bivalves) were random sampled, studied, measured, weighted and released in their natural habitat. Experimental and sampling designs were adapted adequately to the local features of each station.

The sampling stations from 2011 are localized, codified and characterized according to table 1 (the GPS coordinates are given in terms of degrees and decimal minutes).

Table 1: Sampling stations along the Timiş River, during August 2011 field survey.

Code	GPS coordinates	Sampling station's toponime and features
S1	$45^0$11.994' N/ $22^0$08.408' E Elevation = 862 m	Timiş riverbed (Semenic Valley), as well as ponds and brooks in the flood area.
S2	$45^0$13.139' N/$22^0$06.204' E Elevation = 850 m	Grădişte brook tributary of the Trei Ape Lake, between the villages of Gărâna and Brebu Nou, as well as brooklets and helokrenik springs.
S3	$45^0$13.679' N/ $22^0$08.904' E Elevation = 847 m	Brook tributary of the Trei Ape Lake, 100 m upstream its flow, at the level of Brebu Nou Village.
S4	$45^0$12.648' N/$22^0$08.879' E Elevation = 847 m	Brooklets and springs near the banks of the Trei Ape Lake.
S5	Transect between: $45^0$13.137' N/$22^0$07.688' E and $45^0$12.914' N/$22^0$08.693' E Elevation = 847 m	The Trei Ape Lake (artificially built dam-lake; transect done by boat and dredging)
S6	$45^0$12.823' N/ $22^0$09.204' E Elevation = 819 m	Timiş River, downstream the Trei Ape Lake
S7	$45^0$09.595' N/ $22^0$16.528' E Elevation = 436 m	Timiş River, upstream the Teregova locality, close to the exit from the mountains narrows, upstream its entrance in the Timiş-Cerna corridor.
S8	$45^0$13.101' N/ $22^0$18.277' E Elevation = 333 m	Timiş River in the Timiş-Cerna corridor, close to the Piatra Scrisă Monastery.
S9	$45^0$22.494' N/ $22^0$13.580' E Elevation = 234 m	Timiş River, upstream the town of Caransebeş, at Buchini Village.
S10	$45^0$29.129' N/ $22^0$11.070' E Elevation = 177 m	Timiş River 9 km downstream the town of Caransebeş
S11	$45^0$40.239' N/$21^0$58.064' E Elevation = 128 m	Timiş River at Lugojel Village
S12	$45^0$44.290' N/ $21^0$51.263' E Elevation = 117 m	Entrance in the Timiş-Bega channel, about 300 - 400 m along the banks, downstream the dam, at Coşteiu..

Table 1 (continuing): Sampling stations along the Timiş River, during August 2011 field survey.

Code	GPS coordinates	Sampling station's toponime and features
S13	$45^0$44.290' N/ $21^0$51.263' E Elevation = 117 m	Timiş riverbed, downstream the dam at Coşteiu locality.
S14	$45^0$43.682' N/ $21^0$31.678' E Elevation = 99 m	500 m sector of the Timiş River, centered in the specified coordinates, at the bridge between Topolovăţu Mare and Hitiaş localities.
S15	$45^0$42.702' N/ $21^0$24.555' E Elevation = 91 m	Timiş River at the bridge towards Albina Village; about 500 m researched sector of the riverbed.
S16	$45^0$38.661' N/ $21^0$11.035' E Elevation = 88 m	Timiş River at Şag, upstream the dam.
S17	$45^0$29.508' N/ $21^0$00.995' E Elevation = 76 m	Timiş River at Rudna Village
S18	$45^0$26.843' N/ $20^0$53.289' E Elevation = 73 m	Timiş River at the bridge from Grănceri Village, upstream the border with Serbia.

The systematics is given according to Glöer (2002), Glöer and Meier-Brook (2003), than to Fauna Europaea v. 2.6.2, namely the lists compiled by Bank (v. 2.4, updated on 27 January, 2011) for gastropods, and by Araujo (v. 2.0, updated on 10 December 2009) for bivalves, as well as Welter-Schultes (2012). The aim of both the field investigations carried out in 2011 and this paper is to trace the recent changes in environmental quality and human pressure, by using the freshwater molluscs as bioindicators of the river's ecological state

The annotated checklist of freshwater molluscs from the Timiş River (Romanian sector) is given below. Only the new data (i.e. from the investigation carried out in 2011) are explicitly detailed, the former information from references have already been gathered and published in the synthesis of Sîrbu et al. (2010). Thus, only the related sources of older data are given. If only the paper published by Sîrbu et al. (2010) is quoted, this mean that the species was found during the field investigations carried out between 1998 and 2002, and more information is available in that synthesis only (available on www.travaux.ro).

The annotated checklist of the freshwater molluscs' species found in the Timiş River

Classis Gastropoda Cuvier, 1795

Ordo Architaenioglossa Haller, 1890

Familia Viviparidae J. E. Gray, 1847 (1883)

1. *Viviparus acerosus* (Bourguignat, 1862)

References: Sîrbu et al. (2010).

Ordo Neotaenioglossa Haller, 1892

Familia Hydrobiidae Troschel, 1857

2. *Lithoglyphus naticoides* (Pfeiffer, 1828)

References: Bănărescu leg. (in the years of 1980), Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): in the Timiş riverbed at Hitiaş (S14), downstream of Albina (S15), Şag (S16), Rudna (S17) downstream to Grădinari (S18).

3. *Bythinella dacica* Grossu, 1946

References: Grossu (1946, 1986).

New data (leg. Sîrbu I. and Sîrbu M., 2011): brooks in the Semenic Valley (S1), springs and brooks close to the Trei Ape (S4), and springs near the riverbed, in the valley, upstream Teregova (S7).

Ordo Ectobranchia P. Fischer, 1884
Familia Valvatidae J. E. Gray, 1840

4. *Valvata piscinalis* (Müller, 1774)

References: Sîrbu et al. (2010).

Ordo Pulmonata Cuvier in Blainville, 1814
Familia Lymnaeidae Lamarck, 1812

5. *Galba truncatula* (Müller, 1774)

References: Sîrbu et al. (2010).
New data (leg. Sîrbu I. and Sîrbu M., 2011): along the Timiş riverbanks at Grăniceri (S18).

6. *Radix auricularia* (Linnaeus, 1758)

New data (leg. Sîrbu I. and Sîrbu M., 2011): Timiş River at Hitiaş (S14) and Rudna (S17).

7. *Radix labiata* (Rossmässler, 1835)

References: Sîrbu et al. (2010).
New data (leg. Sîrbu I. and Sîrbu M., 2011): brook at Brebu Nou (S3), brooks and puddles near the Trei Ape Lake (S4), Timiş River downstream Trei Ape Lake (S6); brooks and springs upstream Teregova (S7);

8. *Radix balthica* (Linnaeus, 1758)

New data (leg. Sîrbu I. and Sîrbu M., 2011): Trei Ape Lake (S5).

9. *Lymnaea stagnalis* (Linnaeus, 1758)

References: Sîrbu et al. (2010).

Familia Physidae Fitzinger, 1833

10. *Physella acuta* (Draparnaud, 1805)

References: Sîrbu et al. (2010).
New data (leg. Sîrbu I. and Sîrbu M., 2011): Timiş River at Piatra Scrisă Monastery (S8)

Familia Planorbidae Rafinesque, 1815

11. *Planorbarius corneus* (Linnaeus, 1758)

References: Clessin (1887), Sîrbu et al. (2010).

12. *Planorbis planorbis* (Linnaeus, 1758)

References: Sîrbu et al. (2010).

13. *Anisus spirorbis* (Linnaeus, 1758)

References: Bielz (1867).

14. *Anisus vortex* (Linnaeus, 1758)

References: Sîrbu et al. (2010).

15. *Gyraulus albus* (Müller, 1774)

References: Sîrbu et al. (2010).
New data (lag. Sîrbu I. and Sîrbu M., 2011): Trei Ape Lake (S5).

16. *Ferrissia wautieri* (Mirolli, 1960)

New data (Sîrbu I. and Sîrbu M., 2011): Trei Ape Lake (S5).

17. *Ancylus fluviatilis* Müller, 1774

References: Sîrbu et al. (2010).
New data (leg. Sîrbu I. and Sîrbu M., 2011): Semenicului Valley (S1), Grădişte brook (S2), brook at Brebu Nou (S3), Timiş riverbed downstream Trei Ape Lake (S6), along its course further to Teregova (S7), in the Timiş-Cerna corridor up to the Piatra Scrisă Monastery. In the rest of its flow, the species was no longer found due to the mechanical damage of the riverbed, caused by anthropic activities.

Classis Bivalvia Linnaeus, 1758
Ordo Unionoida Stoliczka, 1871
Familia Unionidae Rafinesque, 1820

18. *Unio pictorum* (Linnaeus, 1758)

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): empty shells at Hitiaş (S14), living individuals at Albina (S15), Şag (S16), shells at Rudna (S17), scattered individuals at Grăniceri (S18).

19. *Unio tumidus* Philipsson, 1788

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): Timiş riverbed at Şag (S16).

20. *Unio crassus* Lamarck, 1819

References: Grossu (1962), Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): few individuals downstream Caransebeş (S10), at Lugojel (S11), increased number at Hitiaş (S14), highly abundant at Albina (S15) and Şag (S16), only empty shells at Rudna (S17) and several scattered individuals at Grăniceri (S18). Discontinuous distribution along the lower sector of the river.

21. *Anodonta cygnaea* (Linnaeus, 1758)

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): Timiş River at Hitiaş (S14), Albina (S15), Şag (S16) and Grăniceri (S18);

22. *Anodonta anatina* (Linnaeus, 1758)

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): Timiş River at Albina (S15) and Grăniceri (S18)

23. *Sinanodonta woodiana* (Lea, 1834)

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M, 2011): Timiş River at Hitiaş (S14), Albina (S15), Şag (S16) and Grăniceri (S18);

24. *Pseudanodonta complanata* (Rossmässler, 1835)

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): only empty shells at Hitiaş (S14), living individuals at Albina (S15) and Şag (S16).

Ordo Veneroida H. and A. Adams, 1856
Familia Corbiculidae J. E. Gray, 1874

25. *Corbicula fluminea* (O. F. Müller, 1774)

New data (leg. Sîrbu I. and Sîrbu M., 2011): alien invasive species; until the 8th of August 2011 it was known in Romania inhabiting only the Danube River. This is the first finding in other inland waters of the country. Timiş River at Rudna (S17) and Grăniceri (S18).

Familia Sphaeriidae Deshayes, 1855 (1820)

26. *Musculium lacustre* (O. F. Müller, 1774)

New data (leg. Sîrbu I. and Sîrbu M.): Trei Ape Lake (S5);

27. *Pisidium amnicum* (O. F. Müller, 1774)

References: Sîrbu et al. (2010).

28. *Pisidium casertanum* (Poli, 1791)

References: Sîrbu et al. (2010).

New data (leg. Sîrbu I. and Sîrbu M., 2011): brooks and puddles in the Semenic Valley (S1), brooks and springs near Brebu Nou (S3), brooks close to Trei Ape Lake (S4), Timiş River downstream the Trei Ape Lake (S6), brooks close to Teregova (S7).

29. *Pisidium personatum* Malm, 1855
References: Sîrbu et al. (2010).
30. *Pisidium milium* Held, 1836
References: Sîrbu et al. (2010).
31. *Pisidium subtruncatum* Malm, 1855
References: Sîrbu et al. (2010).
New data (leg. Sîrbu I. and Sîrbu M., 2011): Trei Ape Lake (S5), Timiş River downstream Caransebeş (S10).

Up to the present there are 31 species of aquatic molluscs known from the Romanian sector of the Timiş River. Among them are 17 species of gastropods and 14 of bivalves. The main feature of the mollusc communities in this river is the presence in the lower sector of all the seven naiads species that live in our freshwaters, something that is extremely rarely found in Romania. Before 1998, when the authors begun their research, only five species of freshwater molluscs have been quoted in the Timiş River basin. Between 1998 and 2002, 24 species have been found and their location as well as distribution on longitudinal gradient was documented (Sîrbu et al., 2010). In the last field investigation in August 2011, 22 species were found. Among them five are new findings in this basin. Considering the past and new data about the Mollusca and the observations on the ecological state of the river and its surroundings, several sectors can be distinguished along its longitudinal gradient, characterized by specific composition and communities' structure, environmental features, human impact sources and related issues. The changes occurred across time and space, as well as the characterization of the mentioned sectors are discussed below.

Temporal and spatial changes of freshwater molluscs' populations and communities along the Timiş River, due to environmental features and human impact issues. Ecological classification of the Timiş River sectors.

In order to establish a realistic classification of the Timiş River sectors based on reliable basis, a multicriterial system has to be considered. This is based on temporal and spatial (longitudinal gradient analysis) changes in specific composition of freshwater molluscs communities, specific diversity, the type and state of specific habitats, bioindication value of some species, water flow features, Unionidae communities structure and changes in relation to anthropic activities, as well as the placement, types and pressure of impact sources. Based on these criteria and all the available information that could be gathered in the field researches, as well as from references, the main ecological classification of the river sectors' and their specific features and issues are given below.

Sector 1. The mountains sector, between the springs and the Trei Ape Lake

It is inhabited by a characteristic flowing, well oxygenated waters, hard substratum, confined Mollusca fauna, with rheophyllic (*Ancylus fluviatilis*) or krenbiotic species (*Bythinella dacica*), and some species adapted to small stagnant or flowing waters, which can be frozen or dried out most part of the year. The human impact in this sector is generally reduced, being caused by collateral effects of forest exploitation, road developments, tourism facilities, and traditional economical activities.

Sector 2. The Trei Ape Lake

This is an artificial lake, formed by the building of a dam in the spring area, for economic purposes. The main three rivulets that flow together and form the Timiş River supply it. Being a new, atypical habitat for the surrounding mountain landscape, it was surely colonized from outside, by some lentic, psamo-pelophylic and macrophytophylic freshwater mollusc species. It causes also physical and chemical changes in the water features downstream, as well as a fragmentation of the longitudinal distribution of some native species. Some species have been found only in this sector, like *Radix balthica, Ferrissia wautieri,* and *Musculium lacustre.* During the past decades, but especially in the last few years, the tourism has flourished in the area, the high number of facilities and humans, especially during holydays, represent obvious sources of impact, especially linked to habitat degradation, hips of wastes found everywhere, bathing and overfishing, household wastewater discharges in the lake and tributaries from an accelerated growing number of buildings and villas, etc.

Sector 3. The Timiş River between the Trei Ape Lake and Teregova (entrance in the Timiş-Cerna corridor)

This sector is the remaining part of its mountain course, behaving like a typical river for this elevation and landscape, and sheltering the characteristic Mollusca fauna. Downstream the lake its impact is obvious. However, the steep slope and velocity of the water help the self-cleaning processes, and after a short sector it has all the features of a mountain river, sheltering once again the specific Mollusca fauna.

Sector 4. The Timiş River sector in the Timiş-Cerna corridor, downstream to the town of Caransebeş.

Comparing the state of the river witnessed in 2011 to that observed during the 1998 - 2002 field campaigns, a debasemant of its ecological state is obvious along this sector. The main cause is the destruction of the riverbed caused by the so-called recalibration of the valley, and the many ballast excavations along the river's course. The bulldozers, excavators, and shovels operate within the riverbed, and the whole riverscape is destroyed. The trucks are loaded on both sides of the river and displace huge amounts of sediments and ballast. The working points are frequently found along the main part of the lower stretch of this sector. In some areas, there are no living molluscs at all, and most benthic groups are absent, because the whole substratum is or was rummaged and there is no more natural habitat. The rheo-oxyphyllic species *Ancylus fluviatilis* inhabits a much shorter sector than it used during the beginning of this century, and its distribution is discontinuous along the sector where it still lives. Its last sampling point in 2011 along the river was in the Timiş-Cerna corridor at Piatra Scrisă (S8) Monastery. The anthropic destruction of the entire rivers' ecosystems are outraging.

Sector 5. The Timiş River between the town of Caransebeş and Coşteiu Village

This sector is delimited by the main locality of the entire region, Caransebeş town, and the location where the river's water is drained towards the river Bega, by the artificial Timiş-Bega canal. The ecological state of this sector was significantly degraded in 2011 compared to the status recorded in 1998-2002, the causes being the same as those mentioned for the previous sector. The riverbed and its specific habitats are severely denaturized by ballast excavations and hydrotechnical works, the sedimentation is excessive, communities are poor and the longitudinal range of most mollusc species are highly fragmented. There are some patches inhabited by *Unio crassus*, but their number, as well as the abundance of the species, are lower than it was noticed one decade before.

Sector 6. Downstream the dam from Coşteiu Village

The dam was built here in order to capture the water and lead it through the Timiş-Bega canal. The sector downstream this dam, is the most destroyed and degraded, compared to all the other sectors, because the physical damage of the riverbed. No natural features of the valley's river are present. Not a single mollusc species has been found in the river, a fact that proves the extreme damage of the ecosystem.

Sector 7. The Timiş River sector between Hitiaş and Şag villages

An improvement of the ecological status is recorded, proving the river's capacity of self-cleaning and recovering. Although ballast excavations and hydrotechnical works are still present and interrupt the continuity of specific habitats as well as the river's continuum, the mollusc communities are still capable to adequate to this fluctuant environment and to colonize the microhabitats available during the periods of relative stability. The Mollusca fauna and communties' structure indicate a more altered state than one decade before, but the improvement, considering the status of the upstream, as well as the downstream sector, is obvious. In present, it is still the best-preserved sector, in the middle and lower Timiş River.

At Hitiaş the authors sampled in 2011, by simple randomized sampling, 63 individuals of Unionidae, from a sandy layer, close to the riverbank, the specific habitat. The community structure in terms of relative abundance (RA%), as well as relative dominance - ratio of weight (RD%), considering the total mass of living individuals, are given in figure 1, respectively in figure 2. *Unio crassus* is prevailing in terms of abundance (81%), while the alien invasive species *Sinanodonta woodiana* is the dominant species in terms of weight (66%).

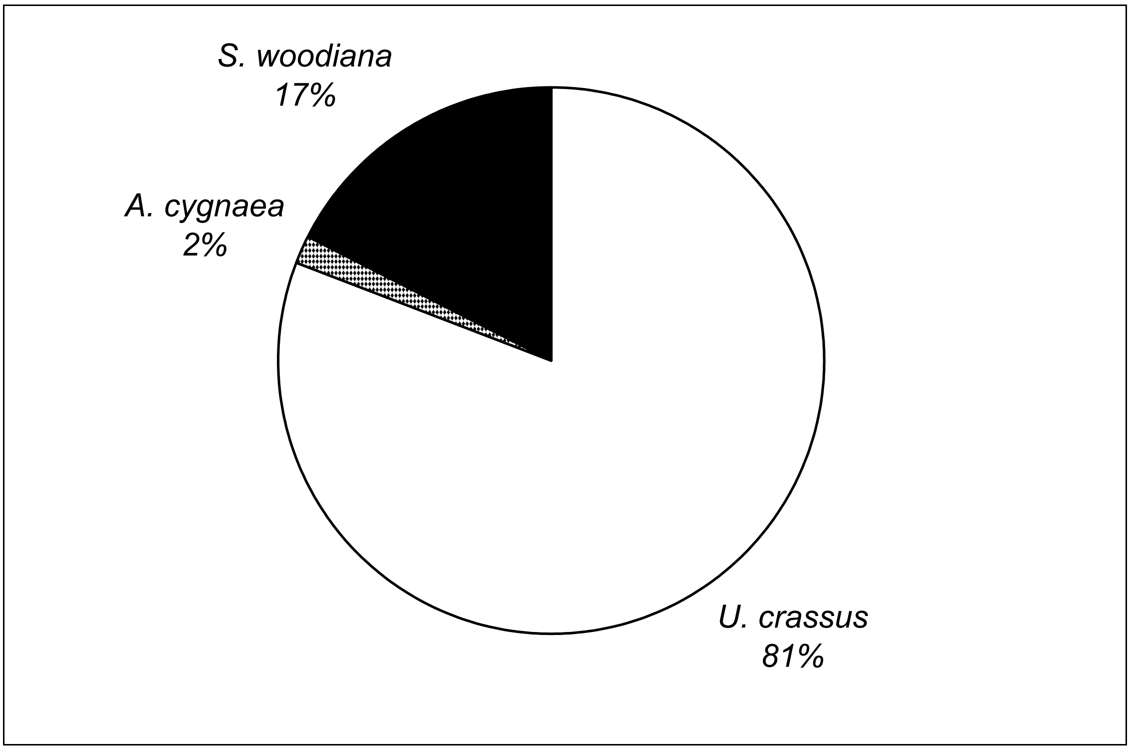


Figure 1: The Unionidae community structure in the Timiş River at Hitiaş (S14), in terms of relative abundance (RA%); 63 individuals were randomized sampled in August 2011.

In the year 2002, at the same level, there were values of 60% RA and 55% RD for *Sinanodonta woodiana*, while for *Unio crassus* the values were of 20% RA and 15% RD (Sîrbu et al., 2006). Comparing the two structures, it is possible that, in time, *U. crassus* became more abundant, while *S. woodiana* is represented by fewer individuals, but these are heavier, consolidating its dominance within the community. This fact might suggest a new phase in the colonizing strategy of the alien invasive species, maybe a switch from the former r-selected invasive level (in 2002 there were many young individuals), towards a K-selection trend of population dynamics.

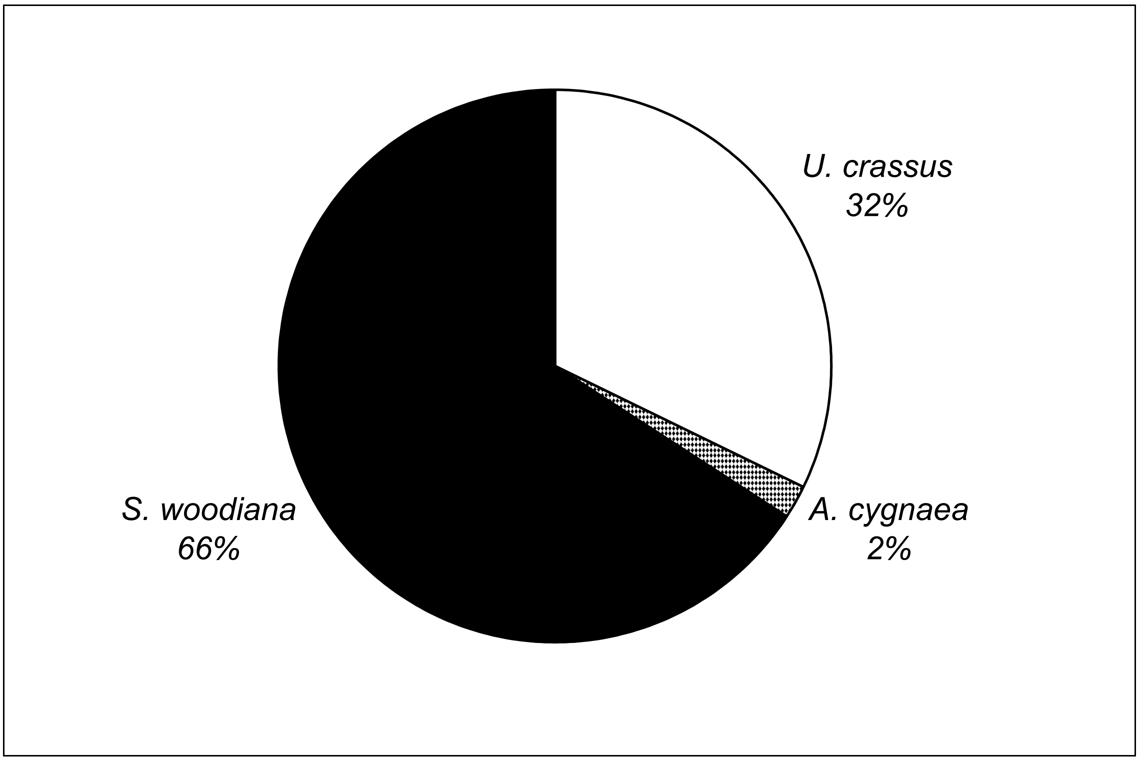


Figure 2: The Unionidae community structure in the Timiş River at Hitiaş (S14), in terms of relative dominance (RD%); the total weight of the 63 sampled individuals was 3876.5 g.

In August 2011, the Unionidae community structure was also studied downstream, close to the village of Albina (S15), by the same means. 95 individuals were randomly sampled. They belong to five species. The relative abundance structure is given in Figure 3 and the relative dominance in Figure 4. Once again, *Unio crassus* is prevailing in terms of individuals' number, while in terms of dominance *U. crassus* and *S. woodiana* are co-dominant (39% and, respectively 37%). The difference between the structures of the last two sampling stations is most probably linked to the river's habitat features, but also to the human impact. At Hitiaş, the river was broad and disturbed by a ballast excavation, while at Albina there are no traceable human activities, at least not in the last few years, and the river is in a more natural condition.

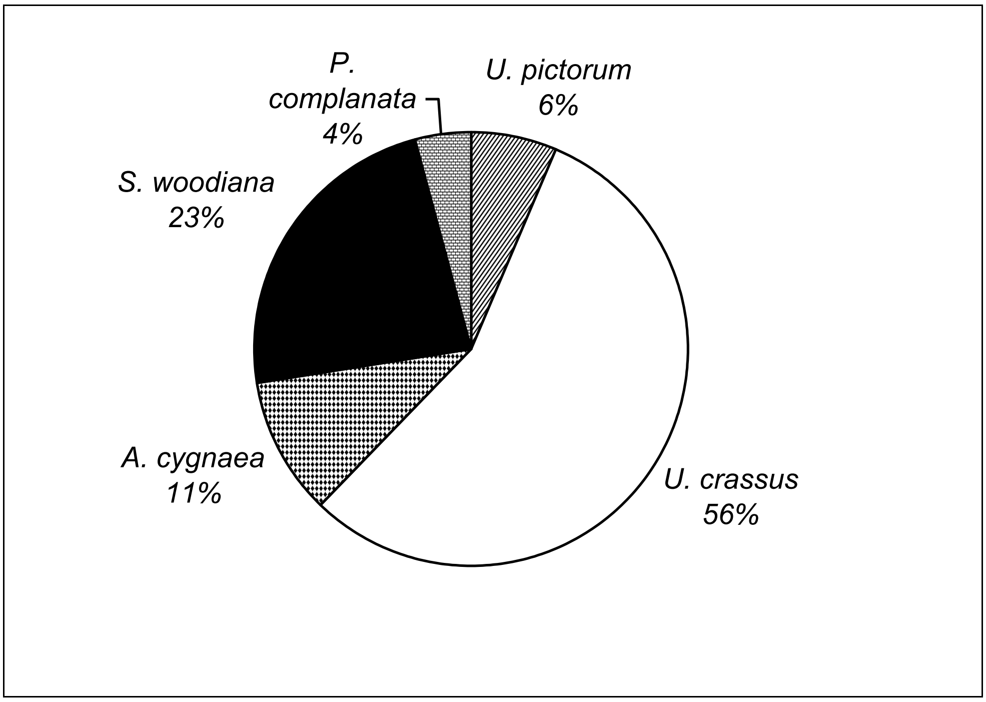


Figure 3: The Unionidae community structure in the Timiş River at Albina (S15) in terms of relative abundance (RA%) - 95 individuals have been randomly sampled in August 2011.

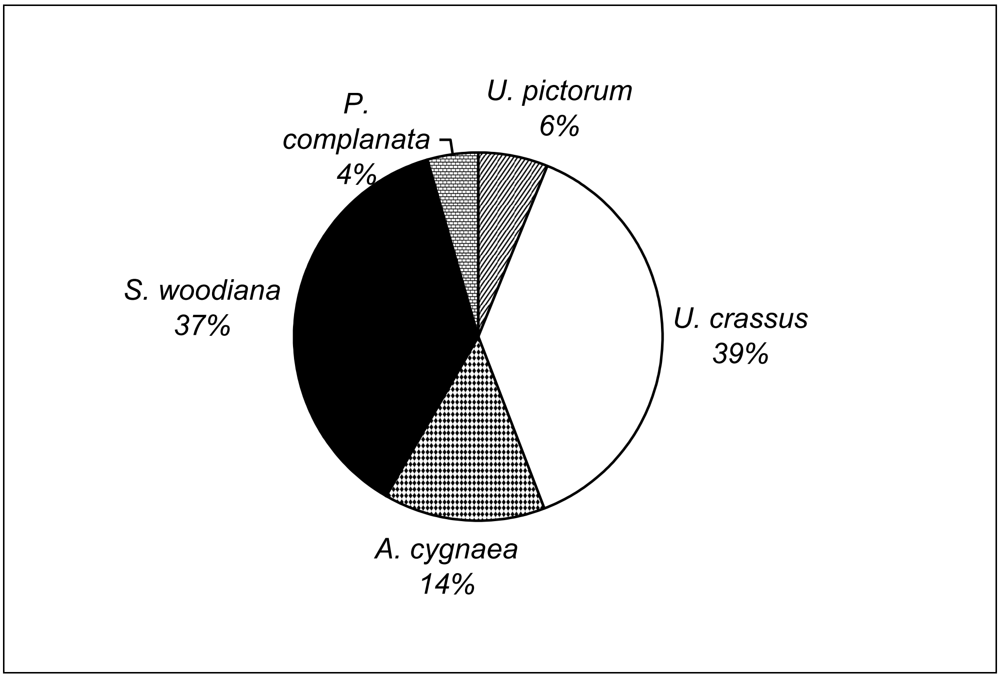


Figure 4: The relative dominance (RD%) structure of the Unionidae community at Albina (S15); the total weight of the 95 individuals was 3622.7 g.

Sector 8. The last sector on Romanian territory, between Şag and Grăniceri.

In this sector occurs a new degradation of the river's ecological state, compared to the upstream adjacent sector. Both the riverbanks and the riverbed are artificially changed, ballast excavations are, or were in the past, placed too close, the hydrotechnical works, channeling and embankments destroy a large part of the river's structure and functions. In most parts, this sector looks almost like a human-made canal. A mass mortality of bivalves was observed, especially in the lower stretch, where specific habitats are scarce, and stable sediments are in small and rare patches distributed along and close to the riverbanks. Still, there are some areas with a relatively high diversity and abundance of molluscs, inclusively Unionidae and prosobranch gastropods. This is the sector in which, during the field survey accomplished in 2011, the authors have first found the alien invasive species *Corbicula fluminea*.

The Unionidae communities' dynamics shows the changes which took place in the last decade in respect of human pressure. In the upper reach of this sector, at Şag (S16), the river was investigated three times, in 2000, 2002 and 2011, by a longitudinal transect of about 1000 m, centered in the bridge of the Timişoara - Deta road. Severe changes were obvious since the beginning of the study. In the year 2000 the river was literally paved with Unionidae, in cross-section, from one riverbank to the other, and all the seven species known form Romania were present (facts extremely seldom encountered in our waters), and their abundance was very high, the maximum exceeding 100 individuals/m^2. Among gastropods *Lithoglyphus naticoides* characteristically inhabited continuously the riverbed, in stripes close to the riverbanks. This sector hosted probably the most diverse and abundant community of naiads in the Romanian Western Plain. In the summer of 2002 the river was crossed by a small dam, built in the meantime, with a narrow opening in the middle part, which changed the whole riverbed structure and water flow features. The Unionidae community spatial dynamics was different than registered before. In order to show the spatial small-scale effect of this dam, we established three sampling stations: the first (1) at about 500 m upstream, the second (2) in the close vicinity of it at about 10-20 m, and the third (3) within of a 400 m line-transect downstream. The data are shown in table 2 and figure 5 (some data were partially published by Sîrbu et al., 2006).

Table 2: The Unionidae community structure at Şag, during the field-survey from 2002.

Parameter and station	*U. tumidus*	*U. pictorum*	*U. crassus*	*A. anatina*	*S. woodiana*	**TOTAL**
1. Above the dam						
No. of individuals	4	3	11	0	0	18
RA%	22.22	16.67	61.11	0	0	100
Total weight (G)	108	26.5	88	0	0	222.5
RD%	48.54	11.91	39.55	0	0	100
2. At the dam						
No. of individuals	2	0	3	4	4	13
RA%	15.38	0	23.08	30.77	30.77	100
Total weight (G)	16	0	24.5	35	39.5	115
RD%	13.91	0	21.30	30.43	34.36	100
3. Downstream						
No. of individuals	0	1	49	0	0	50
RA%	0	2	98	0	0	100
Total weight (G)	0	47.5	1710.5	0	0	1758
RD%	0	2.70	97.30	0	0	100

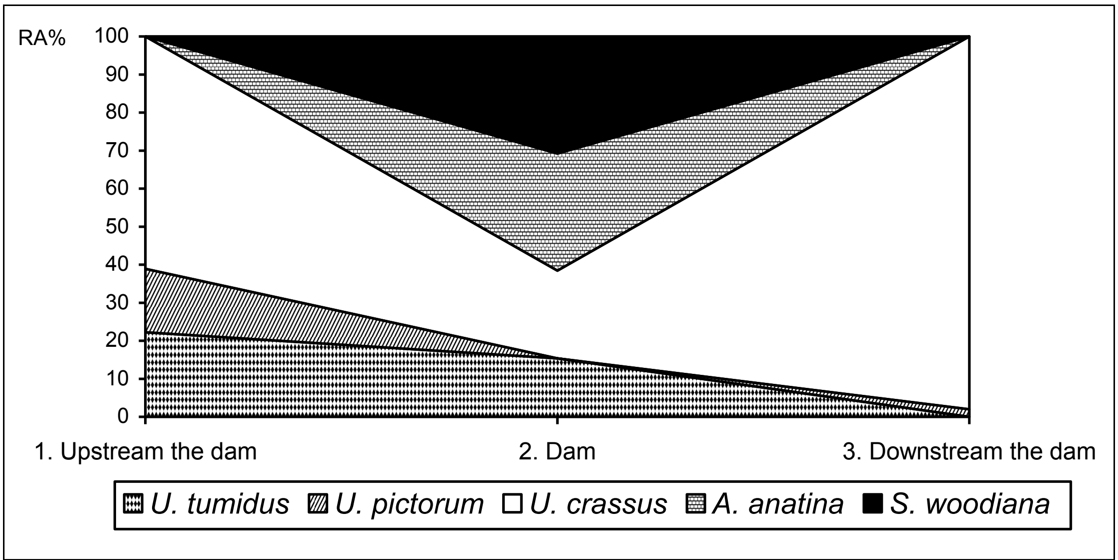


Figure 5: The Unionidae community structure (in terms of relative abundance RA%) and space-dynamics at small-scale in the Timiş River at Şag in the summer of 2002, showing the effect of a newly built dam across the river.

The dam built between the fall of 2000 and the summer of 2002, caused a steep reduction of naiads' abundance as well as diversity (two out of five species have not been found). The slowing of the water flow upstream the dam (station 1), still is prone for all the three *Unio* species; close to the dam the slow speed and muddy sediments, favor the settlement of a lentiphyllous community: the rheophyllic species *U. crassus* shows a low RA% value, being outnumbered by *A. anatina* as well as *S. woodiana*. Downstream the dam, the river flows with high velocity, the favourable sediments are placed in a narrow band along one riverbank, the single microhabitat inhabited by naiads, and the community consists almost only of *U. crassus* (best adapted to these conditions), while only one individual of *U. pictorum* was found within the sampling transect.

This case study has two meanings: showing how a simple human activity in the riverbed causes serious changes in the communities, and how finely tuned the Unionidae may respond, and adequate to this newly formed conditions.

In 2011, the status of the naiads above the dam (also about 500 m upstream), was different. 108 individuals were sampled by simple randomized method, from the specific habitat (0.5 - 2 m from the riverbank). *U. crassus* prevailed both in terms of abundance and weight (Fig. 6 and Fig. 7), while all the other species show values below 10%. Considering the ratios, they seem like those registered in 2002, but the total abundance of the community increased significantly. The naiads were found in densities with maximum values exceeding 100 individuals/m^2, as it was stated in the year of 2000, before the dam was built. During the last decade, the community has recovered and structured adequately. This is a new proof of the river's capacity of resilience, but also a measure of the Unionidae populations and communities' ecological adaptability.

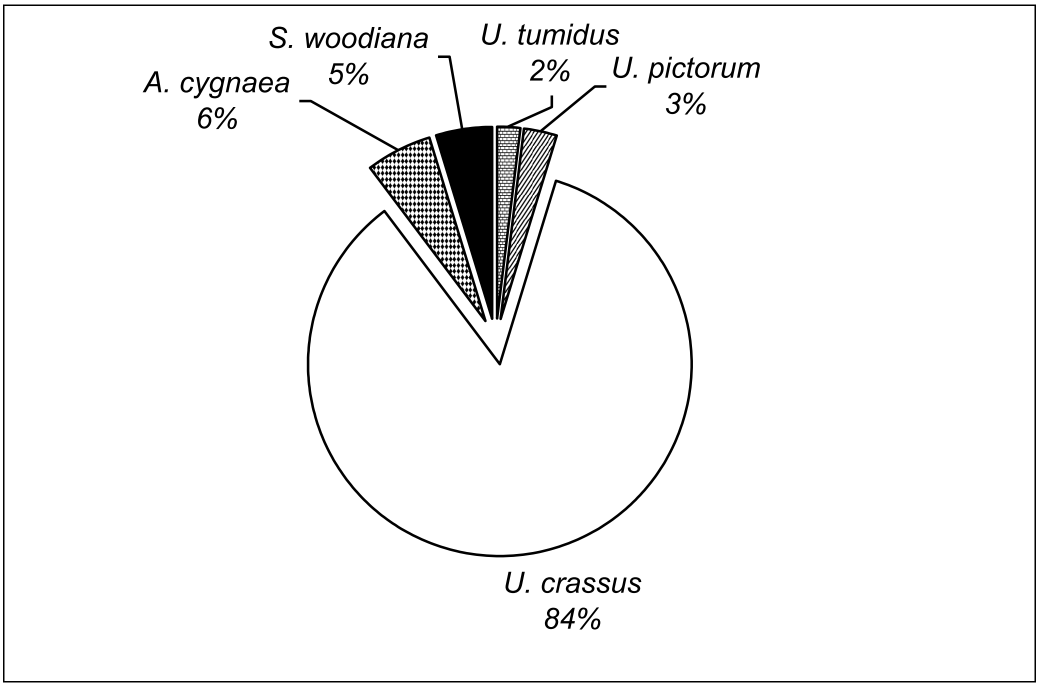


Figure 6: The Unionidae community structure in terms of relative abundance (RA%) in the Timiş River at Şag (S16) in August 2011 - 108 individuals were randomly sampled.

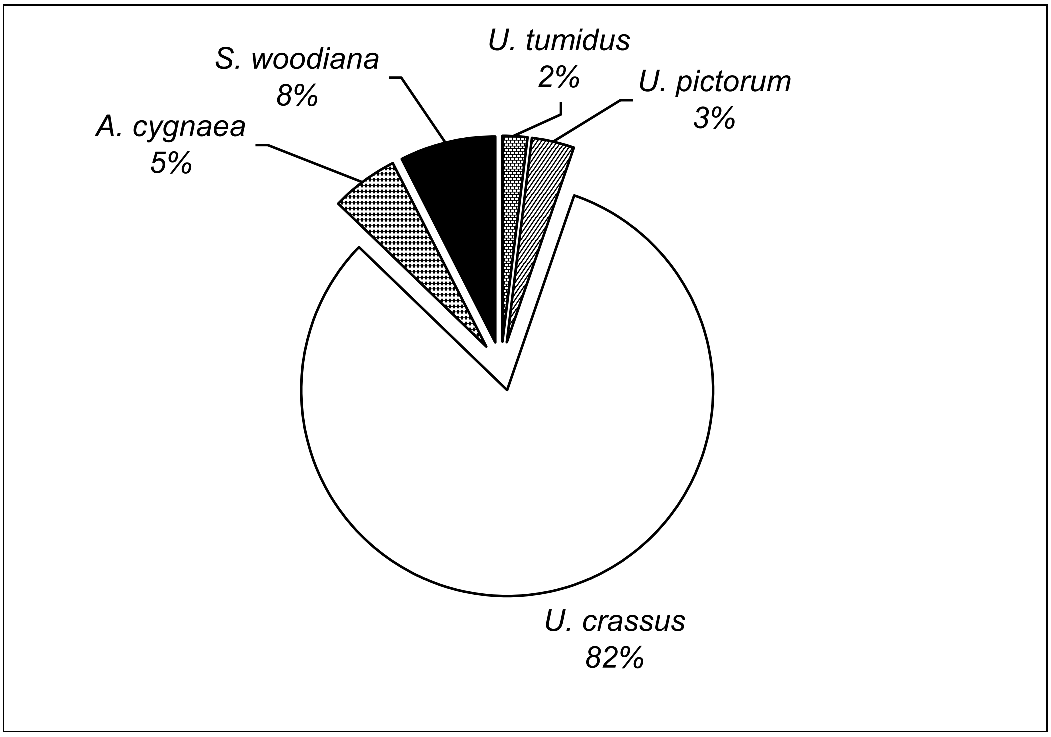


Figure 7: The Unionidae community structure in terms of relative dominance (RD%) in the Timiş River at Şag (S16) in August 2011 - the total weight of the 108 sampled individuals was 2798.5 g.

During the field survey from 2011, downstream Şag Village, at Rudna (S17) and Grăniceri (S18), the last locality on Romanian territory, as well as the final location of this study, the river is once again degraded by ballast excavations, embankments, and hydrotechnical works. At Rudna (S17) a mass-mortality of naiads and a very low diversity of molluscs were noticed. In the last sampling station, at Grăniceri (S18), the river embankment is ongoing, and the water flow is linear between high narrow banks. There is no flood area anymore. Only along one riverbank, less destroyed, a narrow band of sand still shelters scattered individuals of naiads, placed in a single, interrupted row. Along a 200 m transect, a reduced number of Unionidae (34 individuals) were found, sampled, analyzed, and released. The relative abundance structure of this poor community is shown in figure 8. Once again, *U. crassus* prevails in terms of abundance (85% RA), while the other three species show reduced ratios. Most likely these are not confined to this habitat, but drifted from upstream sectors.

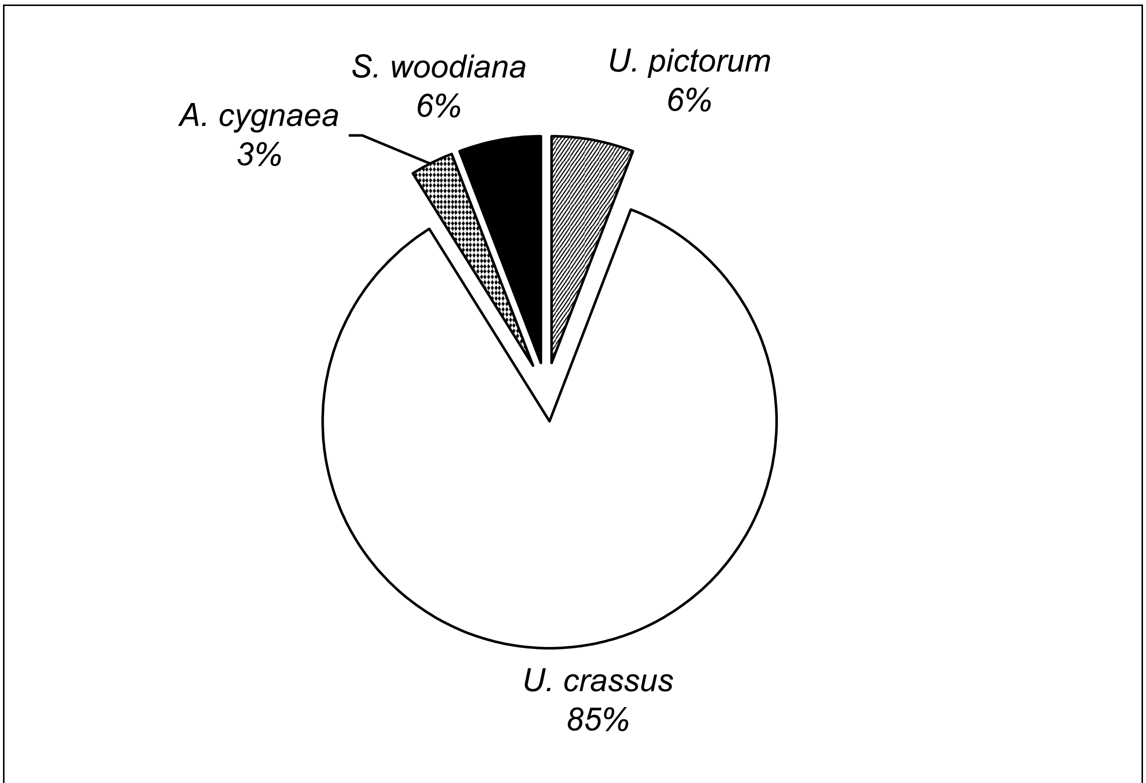


Figure 8: The Unionidae community structure in terms of relative abundance (RA%) in the Timiş River at Grăniceri (S18) during August 2011 - 34 individuals were sampled along a 200 m line transect.

CONCLUSIONS

In the Romanian area of the Timiş River basin, most of its ecological systems are of high quality in their upper sectors (Fig. 9), but prove certain effects of the human impact in their middle and lower sectors.

This river was drastically and unjustifiably degraded, from ecological point of view, during the last decades, and especially in the last years, mainly by mechanical human impact (hydrotechnical plants, embankments, ballast excavations, dams, etc.).

Some sectors are highly damaged (Fig. 10 and Fig. 11), and present a debasement of environmental quality and alteration of the lotic ecosystems' structure and functions.

By contrast to other rivers of Romania, the chemical and biological pollution seem relatively reduced and have a lesser impact.

Despite these facts, the Timiş River still has a remarkable self-cleaning and self-sustaining potential, proved by some sectors with improved ecological state, respectively by the higher parameter values of some freshwater mollusc communities, with certain environmental demands. They have narrow ecological valences, sustaining a series of essential functions of this riverscape (like those of water filtering and cleaning, stabilizing substratum and facilitating the sedimentation, reducing turbidity, being essential resources for other food-levels and links within the tropho-energetic structure, etc.).

Against all odds, this river still shelters high abundances of bivalves and gastropods of ecological and sozological value, but the increasing and ongoing human impact could be a certain menace in the future.

There is still a remarkable and abundant population of *Unio crassus* (Fig. 12), a species included in Annex II of EUHSD (92/43/EEC 1992), also known as the Habitats Directive, which inhabits especially the Hitiaş-Şag river sector, but in full decrease of its ecological quantitative parameters between the localities Caransebeş and Coşteiu, as well as in the last lower sector, until the Romanian - Serbian border.

The lower Timiş River sectors shelters also an abundant population of *Pseudanodonta complanata* (Fig. 13), a species that is strictly protected by the Romanian legislation.

According to the evidence of the field surveys, as well as to the aquatic mollusc communities spatial dynamics, the Romanian sector of the Timiş River can be divided in eight different sectors, delimited by ecological and human impact features.

Figure 9: Dredging in the Trei Ape Lake, in the source area of the Timiş River (August, 2011).

Figure 10: Physical damage of the riverbed along most parts of the middle and lower Timiş sectors is the main threat for the riverscapes' structure and function.
All the hydrotechnical works and ballast excavations should be planned on ecological and environmental friendly basis.

Figure 11: The Timiş River at the last sampling station at Grăniceri (S18), close to the border with Serbia; the anthropic impact is obvious and ongoing (August, 2011). In the sandy bottom the alien invasive species Corbicula fluminea lives in high abundances.

Figure 12: Unio crassus sampled from the Timiş River at Albina Village (S15) in August 2011. It is a flag-species included in Annex II of the EUHSD (92/43/EEC 1992), also known as the Habitats Directive.

Figure 13: Pseudanodonta complanata sampled from the Timiş River at Albina Village (S15) in August 2011. It is a strictly protected species by the Romanian legislation.

ACKNOWLEDGEMENTS

During the past two decades a valuable help and scientific assistance was provided by Mr. Glöer P., which donated us a large part of the literature and revised biological material used also in this paper. Scientific assistance was also provided by the late Mr. Bănărescu P. M. and Sárkány-Kiss A. The field survey from August 2011 was done in the frame of “Study of the quality of Timiş water and registry of polluters source to border” (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of “Lucian Blaga” University, Faculty of Sciences, financed by the European Community. Special regards and gratitude to Ms. Benedek A. M., for all the help provided for the establishing of this paper. To all those mentioned, as well as to the anonymous referees of this paper, the authors owe sincere gratitude.

REFERENCES

1. Araujo R., 2009 − Fauna Europaea v. 2.6.2 (last update August 2013); Mollusca, Bivalvia. Fauna Europaea version 2.0 (updated December, 2009), http://www.faunaeur.org (accessed, September 2013).
2. Bank R. A., 2011 − Fauna Europaea v. 2.6.2 (last update August 2013); Mollusca, Gastropoda. Fauna Europaea version 2.4 (updated January, 2011), http://www.faunaeur.org (accessed, September 2013).
3. Bănărescu P. M. and Sîrbu I., 2002 − Contribution to the knowledge of the Banat aquatic fauna. Studies in Biodiversity - West Romania Protected Areas, Timişoara, 108-115.
4. Bielz A. E., 1867 − Fauna der Land- und Süsswasser-Mollusken Siebenbürgens. Zweite Auflage, Comissions-Verlag v. Filtsch, Hermannstadt, 216. (in German)
5. Clessin S., 1887 − Die Molluskenfauna Oesterreich - Ungarns und der Schweiz, II Theil, Nürnberg, Verlag von Bauer und Raspe, 318. (in German)
6. Glöer P., 2002 − Die Süsswassergastropoden Nord- und Mitteleuropas, Bestimmungsschlüssel, Lebensweise, Verbreitung. *Die Tierwelt Deutschlands*, 73. Teil., ConchBooks, 327. (in German)
7. Glöer P. and Meier-Brook C., 2003 − Süsswassermollusken, DJN - Hamburg, 134. (in German)
8. Grossu A. V., 1962 − Bivalvia. Fauna R.S.R., Edit. Acad., Bucureşti, 3, 3, 427. (in Romanian)
9. Grossu A. V., 1986 − Gastropoda Romaniae, 1; I. Caracterele generale, istoricul şi biologia gastropodelor; II. Subclasa Prosobranchia şi Opistobranchia. Edit. Litera, Bucureşti, 524. (in Romanian)
10. Grossu A. V., 1987 − Gastropoda Romaniae, 2; Subclasa Pulmonata, I. Ordo Basommatophora, II. Ordo Stylommatophora (Suprafamiliile Succinacea, Cochlicopacea, Pupillacea), Edit. Litera, Bucureşti, 5-166. (in Romanian)
11. Kimakowicz M. v., 1883-1884 − Beitrag zur Molluskenfauna Siebenbürgens. *Verhandlungen und Mitteilungen der Siebenbürgischen Vereins für Naturwissenschaften in Hermannstadt*, 33-34**,** 13-83, 57-116.
12. Sîrbu I., 2002 − The genus *Pisidium* C. Pfeiffer, 1821 (Bivalvia, Veneroida, Pisidiinae) in Banat (Romania), *Acta oecologica, Universitatea "Lucian Blaga" Sibiu*, 9, 1-2, 55-66.
13. Sîrbu I., 2004 − Freshwater molluscs communities from the Timiş River Basin (Romania), *Acta oecologica, Universitatea "Lucian Blaga" Sibiu,* 11, 1-2, 185-194.
14. Sîrbu I. and Benedek A. M., 2004 − The genus Pisidium C. Pfeiffer 1821 (Bivalvia: Sphaeriidae: Pisidiinae) in the Romanian Inner Carpathian Basin, *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa",* Bucharest*,* 47, 7-21.
15. Sîrbu I., Sárkány-Kiss A., Sîrbu M. and Benedek A. M., 2006 − The Unionidae from Transylvania and neighboring regions (Romania), *Heldia,* München, 6, 3-4, 151-160.
16. Sîrbu I., Sîrbu M. and Benedek A. M., 2010 − The freshwater mollusca from Banat (Romania). *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa",* Bucharest, 53, 21-43.
17. Sîrbu I., 2011 − Studiu faunistic, chorologic şi ecologic al moluştelor acvatice din râul Timiş (sectorul din România), cu observaţii asupra valorii bioindicatoare şi a efectelor impactului antropic, in Studiu privind calitatea apei râului Timiş, de la izvoare la graniţa cu Serbia. Măsuri de protecţie a râului Timiş - Step II. Contract 411/Primăria Caransebes/90964/30.12.2010/07. Program de cooperare transfrontalieră România - Serbia, 101 - 129 (www.romania-serbia.net). (in Romanian)
18. Welter-Schultes F., 2012 − European non-marine molluscs, a guide for species identification, Planet Poster Editions, Göttingen, 679.

PREWINTERING AQUATIC AND SEMIAQUATIC TRUE BUGS IN THE TIMIŞ RIVER VALLEY: ADAPTATIONS, DIVERSITY, COMMUNITY STRUCTURE AND THE ROLE OF ANTROPIC IMPACT

Horea OLOSUTEAN * and *Daniela ILIE* **

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection and Physics, Dr. Ion Raţiu Street, 5-7 Sibiu County, Romania, RO-550012, mesaje.facultate@yahoo.com

** *"Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection and Physics, Dr. Ion Raţiu Street, 5-7 Sibiu County, Romania, RO-550012, iliedf@yahoo.com

DOI: 10.2478/trser-2013-0036.

KEYWORDS: Aquatic bugs, semiaquatic bugs, Timiş River basin, habitat characteristics, anthropic impact.

ABSTRACT

In November 2011 during a normal overwintering period, a small number of active, aquatic and semiaquatic adult insects were collected from several habitats along the Timiş River basin. This active state for the insects was closely related to higher temperatures found in certain deeper, stagnant water habitats, which also had greater amounts of aquatic vegetation and more stable living conditions. Most such habitats seem to be of anthropic origin, emphasizing the role of human impacts on the life of the discussed group of insects and the need to consider anthropic activities in the conservation of certain species of insects. The state of *Aphelocheirus aestivalis* is also discussed, along with a proposal to study the species on a larger scale and its possible inclusion on the Romanian Red List.

ZUSAMMENFASSUNG: Aquatische und semiaquatische Heteropteren zur beginnenden Winterzeit im Timiș-Tal (Rumänien): Anpassungen, Vielfalt, Struktur ihrer Zönosen und Rolle des menschlichen Einflusses.

Im November 2011 wurde in mehreren Lebensräumen des Timiş-Tales eine geringe Anzahl von Adulten aquatischen und halbaquatischen Heteropteren während deren Überwinterungsphase gesammelt. Ihr aktiver Zustand hängt mit Habitaten tieferer, stehender Gewässer zusammen, in denen eine höhere Abundanz an Gewässervegetation zu verzeichnen ist und stabilere Lebensbedingungen vorherrschen. Der Großteil dieser Habitate ist wohl menschlichen Ursprungs, so dass es möglich war, sowohl den Einfluss des Menschen auf die Arten der untersuchten Gruppe hervorzuheben, als auch seine Rolle für den potentiellen Schutz bestimmter Arten zu erfassen und zu bewerten. Die Situation von *Aphelocheirus aestivalis* wird ebenfalls dargestellt, wobei die Erhebungen zu der Art in größerem Umfang vorgeschlagen werden und ihre mögliche Aufnahme in die Rote Liste besprochen wird.

REZUMAT: Heteroptere acvatice și semiacvatice, în pragul iernii, în Valea Timișului (România): adaptări, diversitate și rolul impactului antropic.

Un număr mic de adulți de heteroptere acvatice și semiacvatice a fost colectat din mai multe habitate de pe Valea Timișului, în noiembrie 2011, în perioada de iernare. Starea lor activă este în relație cu habitate mai adânci și cu apă stagnantă, care au cantități mai mari de vegetație și condiții de viață mai stabile. Majoritatea acestor habitate par să fie de origine antropică, evidențiind rolul impactului antropic în distribuția grupului în discuție, dar și rolul său în potențiala conservare a anumitor specii. Situația speciei *Aphelocheirus aestivalis* este, de asemenea, discutată, propunându-se investigarea specie la o scară mai mare și o posibilă includere în Lista Roșie.

INTRODUCTION

Aquatic and semiaquatic bugs are a polyphyletic group of insects found throughout the globe where water and moisture are present (Andersen, 1982; Jansson, 1986; Damgaard, 2012). Their diversity is consistently higher in the southern hemisphere and in tropical regions (Froeschner, 1981; Andersen, 1982; Aukema and Rieger, 1995; Schuh and Slater, 1995), however, European species have larger ecological valences and wider distributions (Aukema, 2004). For example, insects of a particular species can be found from southern Spain to the proximity of the Arctic Circle, and from sea shores to high altitude mountain lakes and springs (Poisson, 1957; Vepsäläinen, 1974; Ilie, 2009; Olosutean and Ilie, 2010, 2013).

These types of insects have a preference for small ponds, lake shores and rivers (habitats usually covered by ice or frozen solid in the cold season), which forces them to overwinter in the mud or vegetation either at the bottom of the water body where they live or just on the shores of their habitats (Poisson, 1957; Andersen, 1982; Jansson, 1986). Field observations from the authors and from other scientists (Berchi, pers. comm.), however, showed that a small number of adults were still active throughout the winter season, especially aquatic bugs (*Velia* sp., *Plea* sp., *Notonecta* sp., *Hesperocorixa* sp. or *Micronecta* sp.). These insects were observed under thin ice from November to February, a time typically known as the overwintering period.

Information about the ecology of this small group seems to be incomplete. The conditions that cause some individuals to remain in an active state during winter is an important piece of the puzzle, and a first step in determining if physiological aspects are also involved in this particular adaptation. Also, it is important to find out if anthropic influences play a part in providing suitable habitats for the active overwintering of insects, which is an important aspect in possible conservation measures regarding some species of the group.

MATERIAL AND METHODS

Sampling

Biological material was sampled on a single campaign in November 2011 from eleven sampling sites along the entire Timiș River valley (Fig. 1). Sites were coded TM1 to TM11, from the river's source springs to its exit from the Romanian territory.

Insects were evenly sampled in a standardized 45-minute period at each habitat, with as much heterogeneity as possible (for example, vegetation-abundant areas and open-water areas, shaded and sunny areas, deep and shallow waters, and all types of substratum). Specimens were collected using an entomological net with an 800 cm^2 opening and 1 mm mesh, then preserved in 70% ethylic alcohol before their identification using keys from Poisson (1957), Andersen (1993) and Davideanu (1999). A 65x Krüss MSZ5600 stereobinocular was used to identify specimens based on morphological features or, in some cases, by the structure of the genitalia. Species and higher taxa nomenclatures are presented according to Fauna Europaea (Aukema, 2004).

Data analysis

Diversity index values were used in the analysis of the sampled species, namely Species Richness (Hill, 1973), and community heterogeneity, expressed by the inversed values of Simpson's Heterogeneity Index (Simpson, 1949).

Principal Components Analysis (PCA - Pearson, 1901) was conducted in order to point out the relations between the diversity indices and those characteristics of the sampling sites that can be extracted as continuous variables. Such characteristics were water temperature (measured with a Hanna HI 98130 tester), station size, average and maximum depth of the water (all three measured with a tape measure), and shade and vegetation coverage, both expressed as percentages (estimated from photographic material). Prior to the PCA, Pearson Product-Movement Correlation analysis was conducted on the environmental variables.

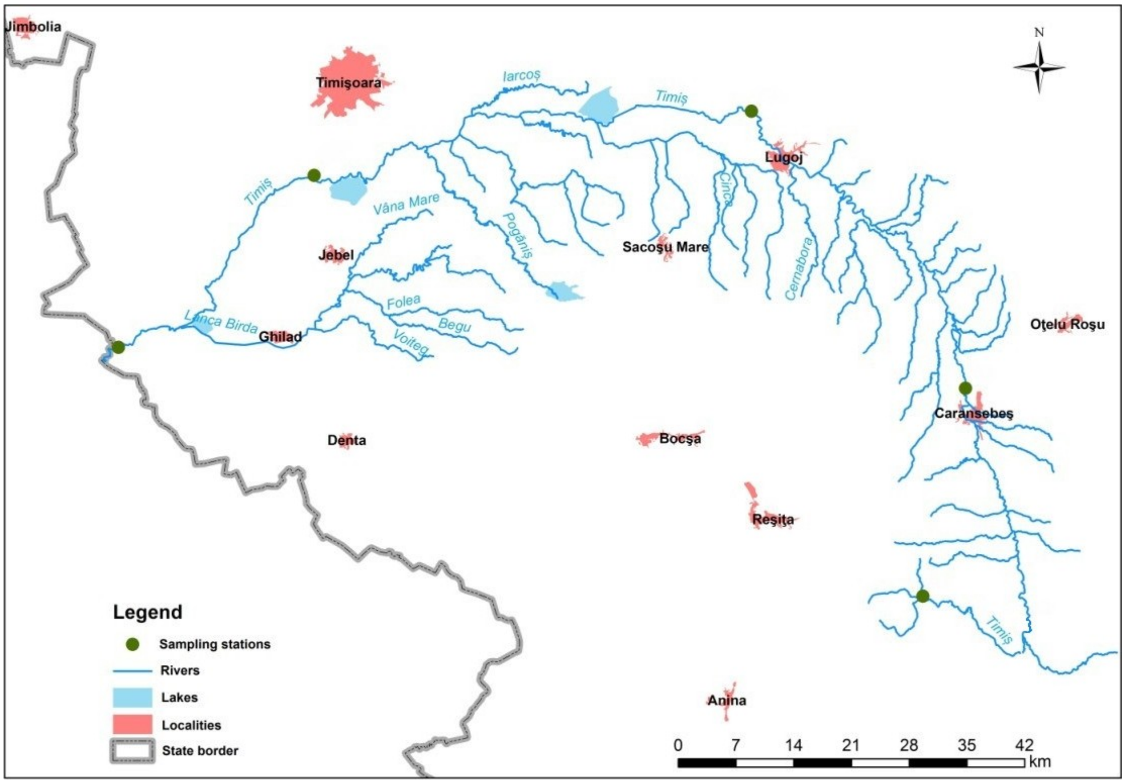


Figure 1: Location of the sampling sites on the Timiş River basin.

Simple logistic regression (LR - Agreşti, 1990) (y = exp(a + b*x)/1 + exp(a + b*x)) was also used to compare diversity index values with presence-absence variables, such as the presence of aquatic and semiaquatic vegetation, water flow or the anthropic genesis of the sampling sites. Both PCA and LR were conducted in STATISTICA v. 10 (StatSoft, 2010).

$$\sum_{i=1}^{R} pi * \log pi \ln S$$

RESULTS AND DISCUSSION

Only nine species of Heteroptera (eight aquatic species and one semiaquatic species) were collected from six of the eleven sampling sites (Tab. 1). Considering there are 70 species of Heteroptera already found in Romania (Davideanu, 1999; Ilie, 2009; Berchi, 2011, 2012), this number is very low for such a large area but can be explained by the weather conditions during the sampling season.

Table 1: List and presence of aquatic Heteroptera species from the Timiş River valley and the values of diversity indices.

Sampling site / Taxa	TM2	TM4	TM5	TM9	TM10	TM11
Notonecta (Notonecta) glauca Linnaeus 1758	★		★	★		★
Notonecta (Notonecta) viridis Delcourt 1909						★
Corixa affinis Leach 1817						★
Sigara (Sigara) striata (Linnaeus 1758)			★			★
Sigara (Vermicorixa) lateralis (Leach 1817)				★		
Subsigara sp. Stichel 1935		★				
Ranatra (Ranatra) linearis (Linnaeus 1758)			★			
Aphelocheirus (Aphelocheirus) aestivalis (Fabricius 1794)					★	
Gerris (Gerris) lacustris (Linnaeus 1758)	★					
Species Richness	2	1	3	2	1	4
Heterogeneity	0.667	0	0.8	1	0	0.768

The number of individuals was also very low. Only 20 adults and one larva were collected. Since almost all species spend winter as adults, the presence of larvae was unusual as the insect community is mainly made up of adults during this time. The low number of individuals is also normal since the large majority of the Heteroptera are already hidden in mud or moist vegetation in preparation for the winter season. The larva we sampled belonged to *A. aestivalis*, which has a unique biological cycle among the Heteroptera and is found as both larvae and adults throughout the cold period (Papáček, 2001; Papáček and Soldán, 2008).

As expected, species richness values were very low, but the heterogeneity of the community was surprisingly high in four of the six stations where Heteroptera were found. Because no more than three individuals from the same species were collected at any given site, the communities are apparently equilibrated, hence the higher heterogeneity.

We would expect to see temperature variations between the average depth and the maximum depth at sampling sites ($r^2 = 0.81$, $p \leq 0.01$). The presumption that the relationship between higher water temperatures and increased vegetation ($r^2 = 0.81$, $p \leq 0.01$) is easily explained by the fact that warmer water allows for greater concentrations of vegetation during the colder periods of the year. However, the close correlation between the maximum depth of sampling sites and the abundance of aquatic vegetation was surprising ($r^2 = 0.71$, $p \leq 0.02$). A probable explanation for this is the relative consistency of the water temperature in deeper stations, which may be preferred by aquatic plant species.

Almost three quarters of the variation of environmental variables (74.35%) was explained by the first two axes of the PCA (Tab. 2). The first factor is strongly correlated with temperature, average and maximum water depth, vegetation, and shading. The second axis is related to station size and, to a lesser extent, average water depth. Biodiversity values are related to the first factor; therefore station size should be not as important as the rest of the environmental variables.

Table 2: Correlation between environmental variables/diversity values and the first two PCA factors.

PCA Factor	Factor 1 (51.1%)	Factor 2 (23.25%)
Environmental variable/diversity		
Temperature	-0.833325	0.308627
Size	-0.136204	0.849203
Average water depth	-0.729873	-0.558915
Maximum water depth	-0.867263	-0.313141
Vegetation coverage percentage	-0.884114	0.107283
Shading percentage	0.535217	-0.395747
Species Richness	*-0.817729*	*0.113962*
Heterogeneity	*-0.765490*	*0.241066*

PCA analysis (Fig. 2) confirmed the correlations that higher values of both species richness and heterogeneity are related to higher temperatures and greater amounts of vegetation. Deeper water depth also positively influences the values of biodiversity, but that influence is not as strong as influences from vegetation or temperature. On the other hand, a higher shading percentage has a negative influence on species diversity, while the size of the station is not important for the group's distribution based on the sampling sites.

In other words, aquatic and semiaquatic bugs prefer deeper, highly-vegetated habitats where water temperatures are warmer than the neighboring water bodies. These insects avoid shaded areas most likely because sunny habitats heat up more quickly during the small period of daily sun exposure during the winter months. Temperature seems to be the most important factor in this equation and it influences all the other variables: deeper stations have a more stable temperature throughout the year, higher amounts of vegetation provides shelter and also regulates the habitat temperature, while shade inhibits temperature increases. From this point of view, the size of the station is not important because station size does not influence the temperature of the water. Two habitats of the same size but with different water temperatures and vegetation amounts would have completely different diversity values.

Logistic regressions showed that anthropic constructed habitats revealed greater species richness ($p \leq 0.01$) and higher heterogeneity ($p \leq 0.1$), while the presence of vegetation was a determinant for higher values of diversity indicators ($p \leq 0.005$ for both species richness and heterogeneity). A comparison between lentic and lotic habitats indicated that stagnant waters fostered more species richness ($p \leq 0.05$), although a relation between water flow and heterogeneity is not significant.

As a general conclusion, warmer habitats demonstrate a higher probability of hosting active, individual aquatic or semiaquatic bugs. Such habitats are mostly small ponds or swampy pools from the river meadows, created by water accumulations in human-made excavations or embankment-related construction. Slow-moving or still water allows for increased vegetation coverage and organic loadings in the water, which leads to higher water temperatures, making these sites the most suitable habitats for active, pre-wintering adults. In all situations, only a small number of individuals are still active in colder waters, the large majority of the populations having already prepared for winter. A consistent explanation for the activity of insects during the cold season is still under study.

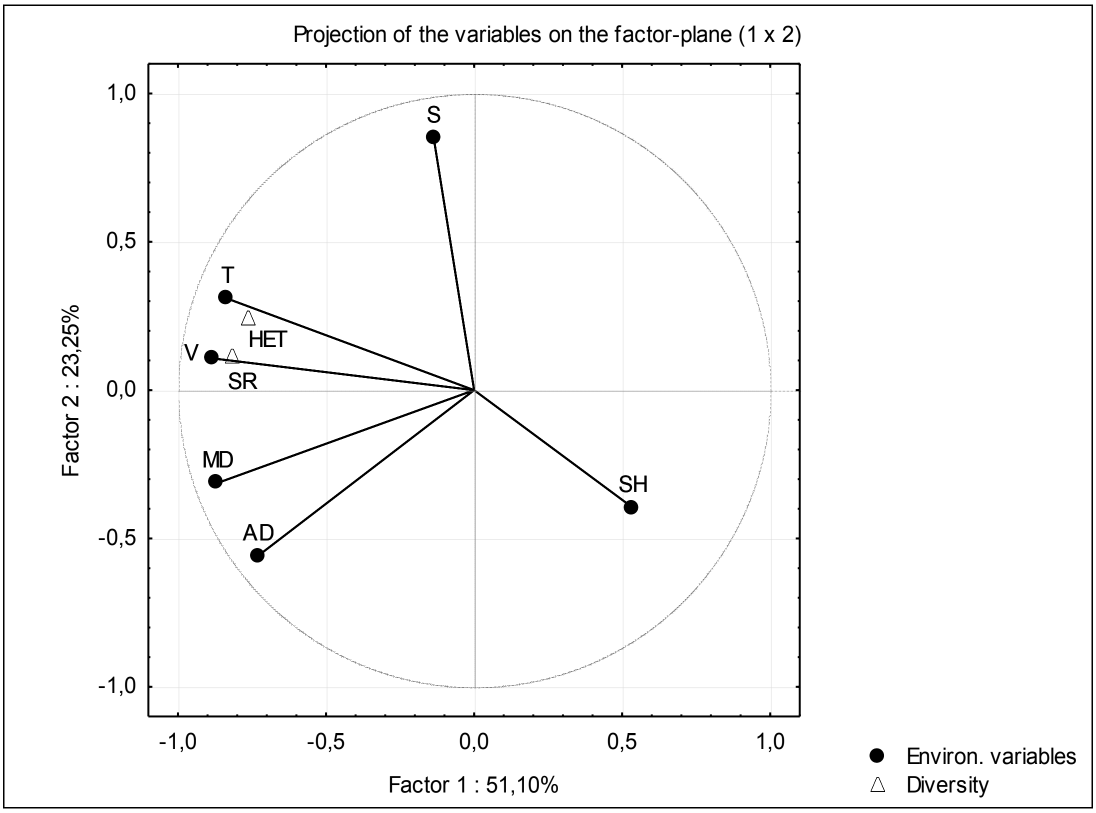


Figure 2: PCA biplot of biodiversity and environmental variables (T - temperature, V - vegetation coverage, MD - maximum water depth, AD - average water depth, S - habitat size, SH - shading percentage, SR - Species Richness, HET - Heterogeneity).

A special discussion should be raised about *A. aestivalis*, a particular member of the group and the only benthic Heteroptera. This species is red listed in some European countries and declining in some areas (Damgaard, 2005). Papáček and Bauer (2006) consider *A. aestivalis* as sensitive to habitat destruction more so than to pollution or other physico-chemical alterations of the water.

The species was found in only one of the 24 benthic samples taken from the Timiș Valley (Bănăduc A., pers. comm.). The Timiș Valley has been strongly affected by the extraction of construction materials (gravel pits are present throughout most of the middle and lower parts of the Romanian section), which frequently change the hydrological conditions (substratum granulation, dissolved oxygen quantity, etc.). *A. aestivalis* strongly prefers a sandy or rocky substratum, high water speed and sufficient oxygen, and the ever-changing conditions along most of Timiș Rivers' course could be the cause for the insect's migration towards the Romanian-Serbian border.

In fact, the Romanian distribution of *A. aestivalis* is highly unknown and it is possible this population is being further reduced by the increase in industrial activities from the river valleys and meadows due to micro-hydro plants, gravel pits, and tourist facilities, etc. This hypothesis could open a discussion for a more comprehensive study of the species and possible inclusion on the Red List of Romanian Fauna.

ACKNOWLEDGEMENTS

This study was funded by "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of "Lucian Blaga" University, Faculty of Sciences, financed by the European Community. Special thanks to Mrs. Bănăduc A. and Mr. Bănăduc D. for the logistic support and for benthic invertebrates information.

REFERENCES

1. Agreşti A., 1990 – Categorical data analysis, John Willey and Sons, New York, 573.
2. Andersen N. M., 1982 – The semiaquatic bugs (Hemiptera, Gerromorpha) phylogeny, adaptations, biogeography and classification, Scandinavian Science Press Ltd., 445.
3. Andersen N. M., 1993 – Classification, phylogeny, and zoogeography of the pond skater genus *Gerris* Fabricius (Hemiptera: Gerridae), *Canadian Journal of Zoology*, 71, 12, 2473-2508.
4. Aukema B., 2004 – Fauna Europaea: Heteroptera - Nepomorpha, *Fauna Europaea version 2.5, http://www.faunaeur.org*.
5. Berchi G. M., 2011 – First record of Anisops sardeus (Hemiptera: Heteroptera: Notonectidae) in Romania, *North-Western Journal of Zoology*, 7, 2, 339-341.
6. Berchi G. M., 2012 – First record of the backswimmer *Notonecta maculata* in Romania, *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, 55, 2, 217-220.
7. Damgaard J., 2005 – Distribution, phenology and conservation status of three rare water bugs: *Aquarius najas* (De Geer, 1773), *Aphelocheirus aestivalis* (Fabricius, 1794) and *Sigara hellensi* (C. R. Sahlberg, 1819) from lotic waters in Denmark (Insecta, Hemiptera-Heteroptera: Nepomorpha and Gerromorpha), *Entomologiske Meddelelser*, 73, 25-38.
8. Damgaard J., 2012 – What do we know about the phylogeny of the semi-aquatic bugs (Hemiptera: Heteroptera: Gerromorpha)? *Entomologica Americana*, 118, 1, 81-98.
9. Davideanu A., 1999 – Contribuţii la studiul heteropterelor acvatice din România, Ph.D. thesis, Babeş-Bolyai Univesity, Cluj-Napoca.
10. Froeschner R. C., 1981 – Heteroptera of true bugs from Ecuador: a partial catalogue, *Smithsonian Contribution to Zoology*, 322, 1-258.
11. Hill M. O., 1973 – Diversity and evenness: a unifying notation and its consequences, *Ecology*, 54, 427-432.
12. Ilie D. M., 2009 – Heteropterele acvatice şi semiacvatice (Heteroptera: Nepomorpha, Gerromorpha) din bazinul mijlociu al Oltului, Edit. Altip, Alba Iulia, 279. (in Romanian)
13. Ilie D. M. and Olosutean H., 2009 – Aquatic and semiaquatic Heteroptera from Arieş River Basin: methods in estimating biodiversity, *Transylvanian Review of Systematical and Ecological Research*, 7, 77-86.
14. Olosutean H., Olosutean C. and Ilie D. M., 2013 – High morphological variability of *Gerris argentatus* Schumel 1832 (Heteroptera: Gerridae) and probably Europe's smallest gerrids, in the Danube Delta, *Transylvanian Review of Systematical and Ecological Research*, 15, 2, 111-116.
15. Jansson A., 1986 – The Corixidae (Heteroptera) of Europe and some adjacent regions, *Acta entomologica fennica*, 47, 1-94.
16. Papáček M., 2001 – Small aquatic and ripiculous bugs (Heteroptera: Nepomorpha) as predators and prey: the question of economic importance, *European Journal of Entomology*, 98, 1-12.
17. Papáček M. and Bauer M., 2006 – Benthic water bug (Aphelocheirus aestivalis) (Heteroptera: Aphelocheiridae) in the upper Lužnice River basin (Czech-Austrian border area), *Beitrage zur Entomofaunistik*, 7, 193-195.
18. Papáček M. and Soldán T., 2008 – Structure and development of the reproductive system in Aphelocheirus aestivalis (Hemiptera: Heteroptera: Nepomorpha: Aphelocheiridae), *Acta Entomologica Musei Nationalis Pragae*, 48, 2, 299-318.
19. Poisson R., 1957 – *Faune de France 61: Hétéroptères Aquatiques*, Librairie de la Faculte des Sciences, Paris, 301. (in French)
20. Savage A. A., 1989 – Adults of the British aquatic Hemiptera Heteroptera – A key with ecological notes, Freshwater Biological Association, Ambleside, 173.
21. Simpson E. H., 1949 – Measurement of diversity, *Nature* 163, 688-688.
22. StatSoft, Inc., 2010 – Electronic Statistics Textbook, Oklahoma, www.statsoft.com/textbook
23. Vepsäläinen K., 1974 – The life cycles and wing lenght of Finnish Gerris Fabr. species (Heteroptera, Gerridae), *Acta Zoologica Fennica*, 141, 1-73.

CONSIDERATIONS REGARDING THE LAND SNAILS FROM THE UPPER TIMIŞ RIVER VALLEY (BANAT, ROMANIA)

Voichiţa GHEOCA *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Ion Raţiu Street 5-7, Sibiu County, Romania, RO - 550012, vgheoca@yahoo.com

DOI: 10.2478/trser-2013-0037

KEYWORDS: Romania, Timiş River, terrestrial gastropods, *Drobacia banatica*.

ABSTRACT

The paper focuses on land snail fauna from the upper Timiş River valley. The analyzed material originates from seven locations starting with the Trei Ape area (Semenic Mountains) and ending with Petroşniţa (upstream Caransebeş). Samplings were made during one campaign in August 2012. A total of 24 species was identified, belonging to 14 families. The area analyzed exhibits a reduced diversity due to the type of substratum represented by crystalline schist, the conifer dominated vegetation in the mountain area, and the anthropogenic impact of tourism, intensive grazing, cutting of woody vegetation in meadows and waste storage. The presence in Sadova Veche of the species *Drobacia banatica*, listed on Annex II of the EU Habitats Directive, underlines the importance of riparian habitat preservation for the conservation and dispersion of land snail species.

RÉSUMÉ: Quelques considérations sur les gastéropodes terrestres de la rivière Timiş (Roumanie).

Le travail présente quelques aspects concernant la faune des gastéropodes terrestres du cours supérieur de la rivière Timiş (Banat, Romania). Le matériel analysé provient des sept points de prélèvement localisés entre Trei Ape (Montagne du Semenic) et Petroşniţa (en amont de Caransebeş). Les prélèvements ont été réalisés au cours d'une seule campagne en août 2012. 24 espèces de gastéropodes terrestres appartenant à 14 familles ont été identifiés. La zone analysée possède une diversité très faible en gastéropodes terrestres, d'une part, en raison de la nature du substrat, représenté par des schistes cristallins dans la région montagneuse, et la végétation dominée par la présence de conifères, d'autre part, à cause de l'impact anthropique caractérisé par le tourisme, le pâturage intensif, la coupe de la végétation ligneuse des prairies et du stockage des déchets. La présence de *Drobacia banatica*, espèce de l'annexe II de la Directive Habitats, à Sadova Veche, souligne l'importance des habitats riverains pour la préservation et la dispersion des espèces de gastéropodes terrestres.

REZUMAT: Consideraţii privind moluştele terestre din valea râului Timiş (România).

Lucrarea prezintă aspecte privind fauna de gastropode terestre din bazinul Timişului superior. Materialul analizat provine din şapte puncte de colectare localizate în zona Trei Ape – Petroşniţa, colectările fiind realizate în cursul unei campanii unice în 2012. În urma analizei materialului au fost identificate 24 specii de gastropode terestre, aparţinând la 14 familii. Zona analizată prezintă o divesitate foarte scăzută, datorată tipului de substrat reprezentat de şisturi cristaline şi vegetaţiei din zona montană dominată de prezenţa coniferelor, dar şi modificărilor de origine antropică - turism, păşunat intensiv, tăieri ale vegetatiei lemnoase din lunci, depozitare de deşeuri. Prezenţa speciei *Drobacia banatica*, specie din anexa II a Directivei Habitate la staţia Sadova Veche, subliniază importanţa conservării habitatelor ripariene pentru conservarea şi dispersia speciilor de gastropode terestre.

INTRODUCTION

The humidity is one of the major factors affecting land snails, with essential effect on their distribution pattern. Some of the terrestrial gastropod species have developed physiological mechanisms to overcome desiccation, but most of them need large amounts of water in order to survive (Burton, 1983; Ward and Slotow, 1992). As they are animals with low mobility, the land snails are among the most vulnerable to the habitat fragmentation, process that has been rapidly accelerated by human activities (Nekola, 1999; Lindenmayer and Fischer, 2006; Mysák and Horsák, 2011). The development of agriculture has substantially reduced the extent of the habitats which are suitable for land snails especially in plains and plateau areas. Among these areas, the river valleys are between the habitats that are the most likely to preserve suitable conditions for land snails presence and therefore they are very important both for conservation and dispersion of land snail species.

The south western area of Romania has one of richest land snail faunas of Romania, due to the Mediterranean climatic influence. Nevertheless, the presence of extended limestone substratum, as in some areas like the Semenic Mountains, which are build on crystalline schist, offer different conditions to land snail development. The present study focuses on land snail fauna of the upper Timiş River valley (Banat, Romania).

MATERIAL AND METHODS

Samples were taken from seven sampling points, located in the upper course of the Timiş River, starting in Semenic Mountains near the spring (Trei Ape) at 870 m altitude and ending in Petroşniţa (near Caransebeş), in the plateau area at 250 m altitude. The sampling points are represented in figure number 1.

Semi quantitative samples were taken by collecting all the snails found in one hour (Cameron and Pokrysko, 2005). All the living snails and fresh shells were considered. The biologic material was identified using Grossu (1981, 1983 and 1987). The results were used to build the list of land snail species. Nomenclature follows Fauna Europaea v. 2.4 (Bank, 2011). Cluster analysis was performed using SYSTAT v 12.0 (Systat Software, 2009).

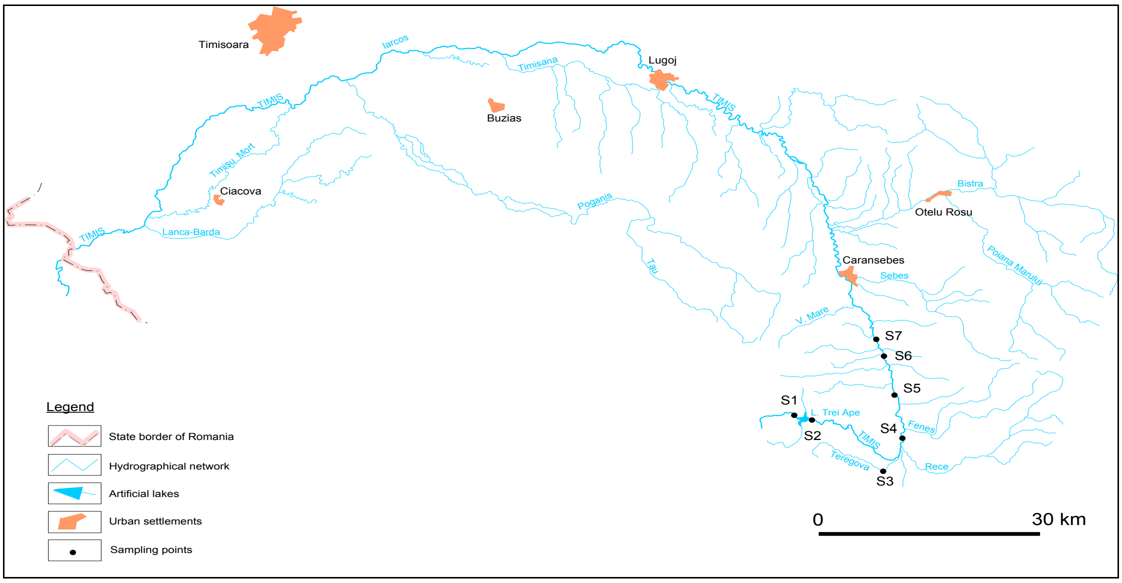


Figure 1: Sampling: S1 - Trei Ape upstream the lake; S2 - Trei Ape downstream the lake; S3-Teregova; S4 - Armeniş; S5 - Sadova Veche; S6 - Bucoşniţa; S7 - Petroşniţa.

RESULTS AND DISCUSSION

A number of 24 land snail species were found in the seven sampling stations, their occurrence is presented in table number 1. The seven analyzed sampling stations can be grouped considering their geographic location in three distinct groups.

Table 1: The distribution in the area, ecology, and zoogeography of the terrestrial gastropods from Upper Timiş River valley. Abbreviation: humidity preferences: H - hygrophylous, MH - mesohygrophylous, M - mesophylous; *old empty shells.

Taxa	zoogeography	humidity preferences	sampling stations
Fam. Carychiidae Jeffreys, 1830			
Carychium tridentatum (Risso, 1826)	European	H	1, 2, 4
Fam. Cochlicopidae Pilsbry, 1900			
Cochlicopa lubrica (O. F. Müller, 1774)	Holarctic	H	4
Fam. Valloniidae Morse, 1864			
Acanthinula aculeata (O. F. Müller, 1774)	European	M	4
Fam. Punctidae Morse, 1864			
Punctum pygmaeum Draparnaud, 1801	European	M	3,4
Fam. Clausilliidae A. Schmidt, 1857			
Cochlodina laminata (Montagu, 1803)	European	MH	3,4
Alinda viridana (Rossmässler, 1836)	Endemic	MH	1
Alinda biplicata (Montagu, 1803)	European	MH	4
Fam. Arionidae Gray, 1841			
Arion circumscriptus Johnston, 1828	European	MH	2
Fam. Vitrinidae Fitzinger, 1833			
Vitrina pellucida (O. F. Müller, 1774)	Holarctic	M	1
Fam. Gastrodontidae Tryon, 1866			
Zonitoides nitidus (O. F. Müller, 1774)	Holarctic	H	4
Fam. Pristilomatidae Cockerell, 1891			
Vitrea diaphana (Studer, 1820)	European	MH	3
Vitrea crystallina (O.F. Müller, 1774)	European	MH	1, 2
Fam. Oxychilidae Hesse, 1927 (1879)			
Aegopinella pura (Alder, 1830)	European	M	**1**
Aegopinella minor (Stabile, 1864)	Central-South E	MX	4
Morlina glabra (Rossmässler, 1835)	European	MH	1
Carpathica langi (Pfeiffer, 1846)	Carpathic	MH	1
Fam. Euconulidae H. B. Baker, 1928			
Euconulus fulvus (O. F. Müller, 1774)	Holarctic	MH	4
Fam. Bradybaenidae Pilsbry, 1939			
Fruticicola fruticum (O. F. Müller, 1774)	Palearctic	MH	3, 5, 6, 7
Fam. Hygromiidae Tryon 1866			
Euomphalia strigella Draparnaud, 1801	European	M	3, 4, 5, 6, 7
Monachoides incarnatus (O. F. Müller, 1774)	European	M	1, 2
Fam. Helicidae Rafinesque, 1815			
Arianta arbustorum (Linnaeus, 1758)	European	M	2
Drobacia banatica (Rossmässler, 1838)	Central-Eastern European	M	1*, 2*, 5
Cepaea vindobonensis (Pfeiffer, 1828)	European	MX	3, 5, 6, 7
Helix pomatia Linnaeus, 1758	Central-Eastern European	M	2, 3, 4, 5, 6, 7

The first two sampling points are located in the Semenic Moutains (a subdivision of the Banat Mountains), near Trei Ape Lake. The area is built on crystalline schist, with a complex system of crevices that in the clay absence allow the rapid runoff of rainwater. The presence of spruce forests considerable decreases the occurrence of land snails. The area is the subject of a strong anthropogenic pressure represented by tourism and infrastructure construction, as well. The land snail fauna of this area is much poorer than it generally is in this type of habitat. A number of 12 species were present. Some species occurring most often in forests were found only in the area of the first two sampling points, as is the case of *Alinda viridana, Vitrea crystalina, Aegopinella pura, Morlina glaber, Carpathica langi, Monachoides incarnatus, Arianta arbustorum.* There were also found empty shells of *Drobacia banatica*, in an advanced state of degradation that cannot confirm the presence of the species in the area. These shells might have been carried by water or they can simply be the evidence of its previous presence in the area, probably before the increase of anthropogenic pressure.

The second sector is located in the Timiş-Cerna corridor whith a broad range of landscapes and a larger number of human settelments. Two sampling points were located in this area, S3 Teregova and S4 Armeniş. The first one is located upstream Teregova Gorges in a hilly area. A number of seven land snail species were found here, most of them ubiquiste like *Helix pomatia, Cepaea vindobonensis, Fruticicola fruticum*, *Euomphalia strigella,* but also *Cochlodina laminata*. This low diversity is most probably caused by grazing activities. The second sampling station of this sector was located in Teregova Gorges (upstream Armeniş), near the road but in a relatively izolated area. Remnants of the road development activities are present, but covered by vegetation able to preserve a certain degree of humidity and to serve as a food source for phytophagous species. Species like *Carychium minimum, Cochlicopa lubrica, Punctum pygmaeum, Cochlodina laminata, Alinda biplicata, Zonitoides nitidus* were found here, bringing this community more closely to the typical ones found in valleys from Transylvania (Gheoca 2005, 2007), yet presenting a relatively low diversity (nine species).

The third sector is located in the Caransebeş Plateau where the Timiş River has dug a broad valley with floodplain and well-developed terraces. This area has numerous human settlements with major impact on the river valley. The last three sampling points are located in this area near villages, with strongly modified river sides by tree cutting and waste deposits. The snail diversity in this area is very low, only some ubiquist species being present, as is the case of *Helix pomatia, Fruticicola fruticum, Euomphalia strigella* and *Cepaea vindobonensis*. Among them, some species develop large populations, considering the microhabitat conditions. Therefore *Fruticicola fruticum* and *H. pomatia* are dominant in habitats in which humidity is most likely to be preserved, while in habitats with large variations of humidity a mixed snail community is present including the mentioned species and *C. vindobonensi,* as well.

One specimen of *Drobacia banatica* and several fresh empty shells were found in S5 – Sadova Veche, despite the strong anthropogenic pressure produced by the fact that the station is located in the vicinity of a waste storage. A cluster analysis was carried out using the relative abundance of land snail species in each one of them (Fig. 2).

Four of the clusters make evident the heterogeneity of the studied area. The most similar are the sampling stations located in the plateau area in highly perturbed habitats (S5, S6 and S7). A second one groups two sampling locations: one from the mountain area (S2) and the second from Teregova Gorges (S4), while the remaining two stations are independent, with a particular land snail community structure in Semenic Mountains (S1), and a disturbed condition by pasture in S3.

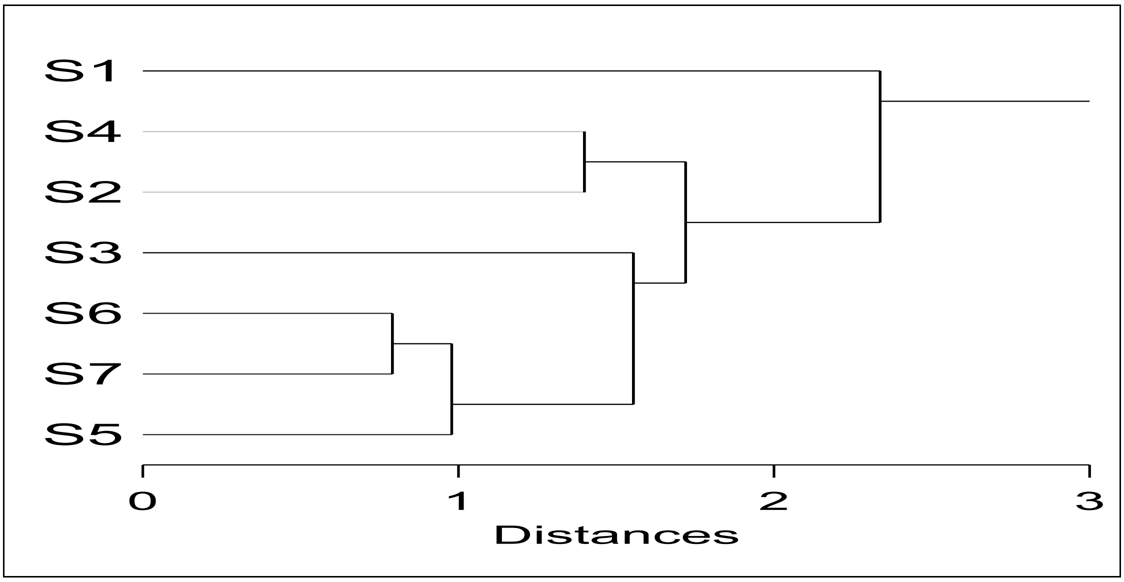


Figure 2: Cluster analysis based on the relative abundance of land snail species in the seven sampling stations (S1- S7).

CONCLUSIONS

The geology, vegetation and also the extent of the human impact shape the diversity of malacofauna in the area. The reduced diversity underlines the degree of perturbation and the absence of suitable conditions for snail presence. The most common species in the area are ubiquities, like *Helix pomatia, Fruticicola fruticum* and *Euomphalia strigella*.

The Banat area is considered the distribution center for *Drobacia banatica,* a distribution that covers Transylvania, Banat, Crişana, Maramureş (Grossu, 1983; Gheoca et al., 2008; Cameron et al., 2011), eastern Hungary (Fintha et al., 1993; Szabó and Fintha, 1999; Solymlos and Feher, 2005) and western Ukraine (Pelbárt, 1999). The species is generally present in moderated humid forests starting the mountain area up to 1000-1100 m altitudes, but also in lowlands. Regarding this species, we can notice two distinct aspects. First its absence in an area from its distribution center is most likely caused by the increasing human pressure during the recent years. On the other hand we find its presence in the vicinity of a village, near waste deposits, which is quite unexpected. The species presence in such highly anthropized area is probably an evidence of the river's contribution to the land snails dispersion. Such dispersed specimens can survive if they find appropriate conditions, which makes improbable the species long-term survival in the mentioned area.

ACKNOWLEDGEMENTS

A part of this results came from the scientific study of the quality of the Timiş River water, "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS contract, no. 411 - 90964/30.12.2010/07 of "Lucian Blaga" University, Faculty of Sceinces, financed by the European Community.

REFERENCES

1. Bank R. A., 2011 – Fauna Europaea: Mollusca, Gastropoda. Fauna Europaea. Version 2.4, http://faunaeur.org (accessed 18.V.2013)
2. Burton R. F., 1983 – Ionic regulation and water balance, The Mollusca (Saleuddin, A.S.M. and Wilbur K. (eds), 5, *Physiology*, 2, Academic Press, New York, 291-352.
3. Cameron R. A. D. and Pokrysko B. M. 2005 – Estimating the species richness and composition of land mollusk communities, *Journal of Conchologyi*, 38, 529-547.
4. Cameron R. A. D., Pokryszko B. M., Horsak M., Sîrbu I. and Gheoca V., 2011 – Forest snail faunas from Transylvania (Romania) and their relationship to the faunas of Central and Northern Europe, *Biological Journal of the Linnean Society*, 104, 2, 471-479.
5. Fintha I., Sümegi P. and Szilágyi G., 1993 – A new biotope of Chilostoma banaticum (Rossmässler 1838) in Hungary and its nature conservation aspects, *Malakológiai Tájékoztató*, 12, 29-33.
6. Gheoca V., 2005 – Preliminary note concerning the terrestrial mollusksfauna of the Târnava hydrographic basin, *Transylvanian Review of Systematical and Ecological Research*, 2, 61-66.
7. Gheoca V., 2007 – Aspects regarding the terestrial malacofauna of the Saxon Villages of Southern Transylvania area, *Transylvanian Review of Systematical and Ecological Research*, 2, "The Târnava Rivers Basin", 127-134.
8. Gheoca V., Sîrbu M. and Sîrbu I., 2008 – Data concerning the terrestrial gastropod fauna of Muntii Maramureşului Natural Park, *Transylvanian Review of Systematical and Ecological Research*, 4, 53-58.
9. Grossu A. V., 1981 – Gastropoda Romaniae., Ordo Stylommatophora, 3, Suprafamiliile Clausiliacea şi Achatinacea, Bucureşti, 1-269. (in Romanian)
10. Grossu A. V., 1983 – Gastropoda Romaniae, 4, Ordo Stylommatophora, Suprafamiliile: Arionacea, Zonitacea, Ariophantacea şi Helicacea, Edit. Litera, Bucureşti. (in Romanian)
11. Grossu A. V., 1987 – Gastropoda Romaniae 2, Subclasa Pulmonata, Ord. Basommatophora şi Ord. Stylommatophora: Suprafam. Succineacea, Cochlicopacea, Pupillacea, Edit. Litera, Bucureşti. (in Romanian)
12. Lindenmayer D. B. and Fischer J., 2006 – Habitat Fragmentation and Landscape Change: an Ecological and Conservation Synthesis. Island Press, Washington, DC.
13. Myšák J. and Horsák M., 2011 – Floodplain corridor and slope effects on land mollusc distribution patterns in a riverine valley, *Acta Oecologica* 37, 2, 146-154.
14. Nekola J. C., 1999 – Paleorefugia and Neorefugia: the influence of colonization history on community pattern and process. Ecology 80, 2459-2473.
15. Pelbárt J, 1999 – Data to the mollusc fauna of the Carpathian Biosphere Reserve, Ukraine (Mollusca), *Miscellanea Zoologica Hungarica*, 13, 2 T, 85-90.
16. Solymlos P. and Feher Z., 2005 – Conservation Prioritization Based on Distribution of Land Snails in Hungary, *Conservation Biology*, 19, 1084-1094. Doi: 10.1111/j.1523-1739.2005.00193.x
17. Szabó A. and Fintha I. 1999 – The third and most significant record of *Chilostoma banatica* (Rossmässler, 1838) / = *Helicigona banatica*/ in Hungary (Tiszabecs) flood plain of River Tisza, *Tiscia monograph series*, 4, 479-480.
18. Ward D. and Slotow R., 1992 – The effects of water availability on the life span of the desert snail, Trochoidea seetzeni, *Oecologia*, 90, 572-580.
19. Systat Software, 2009 – Systat 12 Getting Started. San Jose, CA.

TIMIŞ RIVER (BANAT, ROMANIA) BENTHIC MACROINVERTEBRATE COMMUNITIES STRUCTURE SPATIAL DINAMIC

Angela CURTEAN-BĂNĂDUC * and *Adina Nicoleta FARCAŞ* *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection and Physics, Applied Ecology Research Center, Dr. Ion Raţiu Street 5-7, Sibiu County, Romania, RO-550012, ad.banaduc@yahoo.com, adinafarcas87@yahoo.com

DOI: 10.2478/trser-2013-0038

KEYWORDS: benthic macroinvertebrate communities, Timiş River.

ABSTRACT

This study presents the description of the structure of benthic macroinvertebrate communities of the Timiş River (Danube Watershed) in correlation with environmental parameters. The results are based on quantitative benthic macroinvertebrates (105 samples) taken in 2011 (June-September) from 21 stations of the the Timiş River, situate between its sources and the Romanian-Serbian border (241 km). The assessed biotope variables were: altitude, slope, riverbed width, depth, substratum types, channel modification and water physico-chemical caracteristics. The results of the study reveal that the spatial structure of benthic macroinvertebrates is induced by the substrate type, by the minor riverbed modifications in comparison with the natural conditions and the quantities of oxidable matters in the water.

RÉSUMÉ: La dynamique spatiale de la structure des communautés de macroinvertébrés de la rivière Timiş (Banat, Roumanie).

Cette étude présente la description de la structure de la communauté des macroinvertébrés benthiques de la rivière Timiş (Danube, ligne de partage des eaux) en corrélation avec les paramètres environnementaux Les résultats sont basés sur la quantité de macroinvertébrés benthiques (105 échantillons) relevée en 2011 (Juin-Septembre) sur 21 stations de la rivière Timiş, situées entre sa source et la frontière serbo-roumaine (241 km). Les variables évaluées pour les biotopes sont: l'altitude, la pente, la largeur du lit, la profondeur, les types de substrat, les modifications du chenal et les caractéristiques physico-chimiques. Les résultats de l'étude révèlent que la structure spatiale des macroinvertébrés benthiques est induite par le type de substrat, par la modification du lit mineur de la rivière en comparaison avec les conditions naturelles et la quantité de matière oxydable dans l'eau Dans le cas de la rivière Timiş.

REZUMAT: Dinamica spaţială a structurii comunităților de macronevertebrate bentonice din râul Timiş (Banat, România).

Lucrarea prezintă descrierea structurii comunităţilor de macronevertebrate bentonice din râul Timiș (bazinul hidrografic Dunăre) în corelație cu caracteristicile de biotop. Rezultatele se bazează pe probe cantitative de bentos (105 probe), colectate în 2011 (perioada iunie-septembrie) din 21 stații de colectare situate de-a lungul râului, de la izvoare până la granița României cu Serbia (241 km). Variabilele de biotop considerate au fost: altitudinea, panta, lățimea și adâncimea albiei minore, tipul de substrat, gradul de modificare al al albiei minore față de condițiile naturale, parametri fizico-chimici ai apei. Rezultatele studiului arată că variabilitatea structurală spațială a comunităților de macronevertebrate bentonice este condiționată de tipul de substrat, gradul de modificare a structurii albiei minore față de condițiile naturale și de cantitatea de materii oxidabile din apă.

INTRODUCTION

The benthic macroinvertebrates communities has an important role in rivers' ecological processes (Allan, 1995; Rawer-Jost et al., 2000; Leunda et al., 2009; Dudgeon, 2010), these are adequately structured for an efficient use of the available environment resources (Kreatzweiser et al., 2005; Curtean-Bănăduc, 2008; Infante et al., 2009; Diggins and Newman, 2009; Abdul-Aziz et al., 2010; Theiling, Nestler, 2010; Jiang et al., 2011; Aura et al., 2011).

The aim of the present study were to analyse the structure of the benthic macroinvertebrate communities in correlation with environmental parameters and to indentify the main biotope factors for the macroinvertebrate communities structure in Timiş River case.

The Timiş Basin is situated in South-West Romania (Fig. 1), it drains a total surface of 7,319 km^2 (5,795 km^2 in Romania and 1,524 km^2 in Serbia) (Badea, 1983). The Timiş River springs area is localized on the eastern part of the Semenic Mountains (1,135 m altitude). With a total length of 359 km (241 km in Romania) it passing mountainous (average slope of 20 m/km), hilly (1.6 m/km) and lowland (1-0.15 m/km) areas (Posea, 1982; Roşu A., 1980).

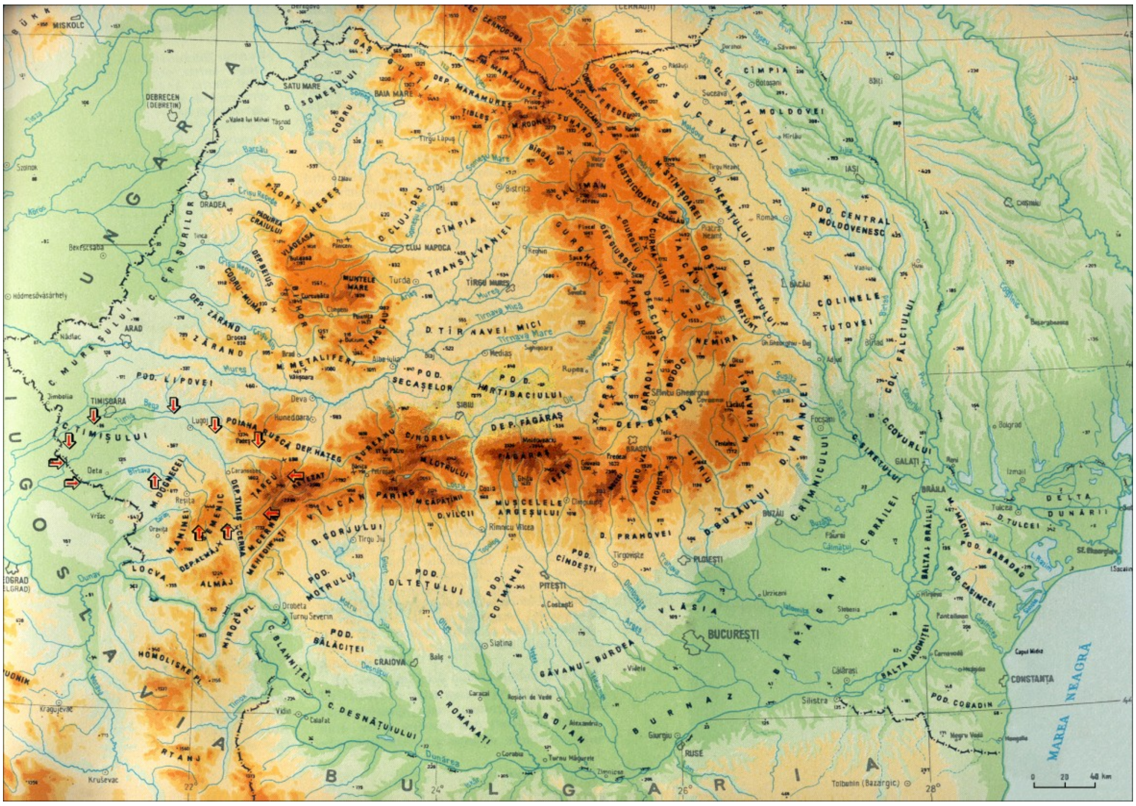


Figure 1: Timiş River basin position.

MATERIAL AND METHODS

The results are based on quantitative benthic macroinvertebrates (105 samples) taken in 2011 (June - September) from 21 stations of the the Timiş River, situate between its sources and the Romanian - Serbian border (241 km) (Fig. 2). The sampling stations were chosen according to the valley morphology, the confluence with the main tributaries and the human impact types and degrees on the river sectors (hydro-technical works, pollution sources, exploitation of the river bed and riverine land use).

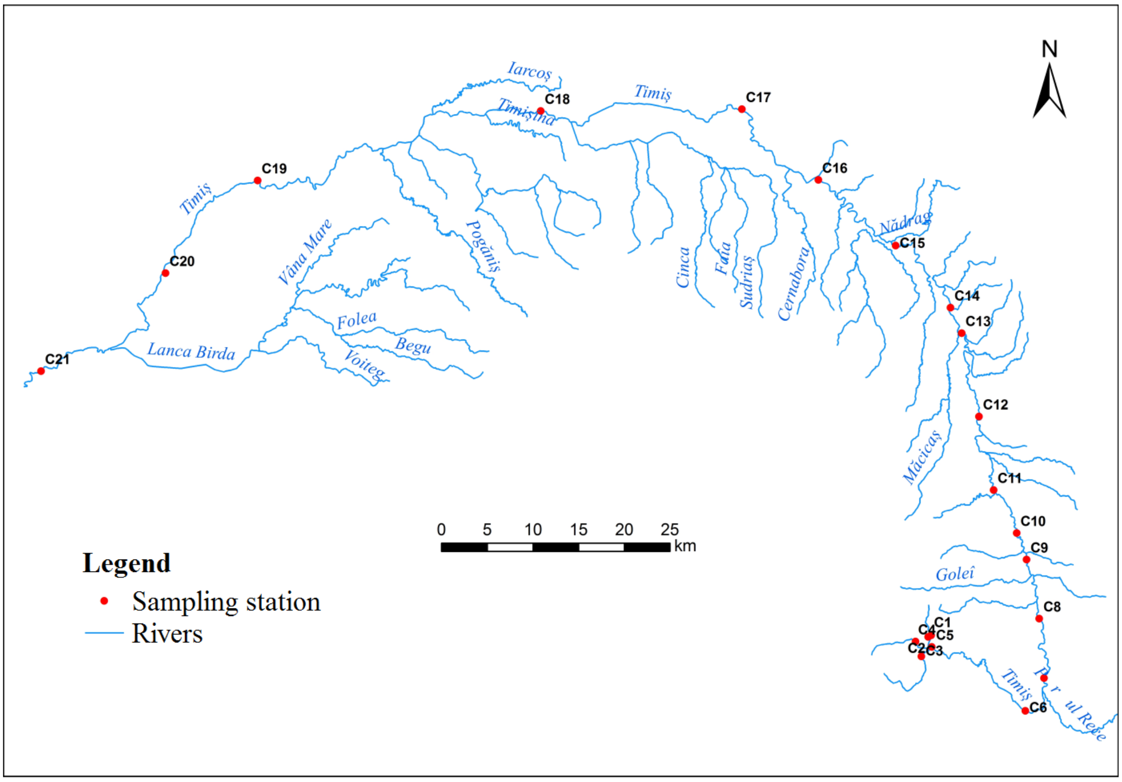


Figure 2: Benthic macroinvertebrate sampling stations location (C1-21) on Timiş River.

In each station, quantitative samples were taken from five separate points, in order to highlight the specific diversity of local micro-habitats. The sampling was carried out with an 887 cm^2 surface Surber Sampler, with a 250 μm mesh net. The sampled biological material was fixed in 4% formaldehyde solution and was analyzed in the laboratory with an Olympus (150X) stereomicroscope. The invertebrate groups were identified to order except subclasses Oligochaeta, Hirudinea and family Chironomidae and the counts were converted to number of individuals per square meter (ind./m^2).

The assessed biotope variables were: altitude, slope, riverbed width, depth, substratum types, channel modification (% in comparison with the natural state) and water physico-chemical caracteristics (pH, fixed residue, dissolved oxygen, biochemical oxygen demand - BOD_5, chemical oxygen demand - COD-Cr, NO_3^-). The substratum types were expressed as percentages of the transversal section surface (20 m length), and transformed into the following categories: sand, gravel, pebbles, cobbles, and boulders.

The conditionalities between habitat factors and the macroinvertebrate communities structure were analyzed using Canonical Correspondence Analysis - CCA (ter Braak, 1986).

RESULTS AND DISCUSSION

The benthic macroinvertebrates groups with the largest distribution along the Timiş River are Oligochaeta, Ephemeroptera, Trichoptera and Chironomidae, present in all the studied river sectors, and with a not so large distribution appear Hirudinea, Tricladida, Gastropoda (*Ancylus fluviatilis*), Bivalvia (*Corbicula fluminea*), Hydracarina, Amphipoda, Odonata, Plecoptera, Heteroptera, Coleoptera, other Diptera than Chironomidae Family (Tab. 1).

Analysis of benthic macroinvertebrates communities similarity of the 21 sectors of river, on the base of relative abundaces values oftaxonomic groups present, shows thar they can be grouped in six classes (Fig. 3): I communities with the highest relative abundace of 17%, there are amphipods, mayfly, chironomids and stoneflies, present in C2 river sector; II comunities where caddisflies and chironomids apear with relative abundances more that 20%, present in C7, C8, C9, C11, C14, C15 and C20 river sectors; III communities where numerically codominant are mayflies, caddisflies and chironomids, present in C12 and C13 river sectors; IV communities where numerically codominant are chironomids, caddisflies, present in C1, C3, C4, C5 and C6 river sectors; V communities where numerically dominant are chironomids, present in C10, C18, C19 and C21 river sectors; VI communities where numerically dominant are Oligochaeta, present in C17 river sector.

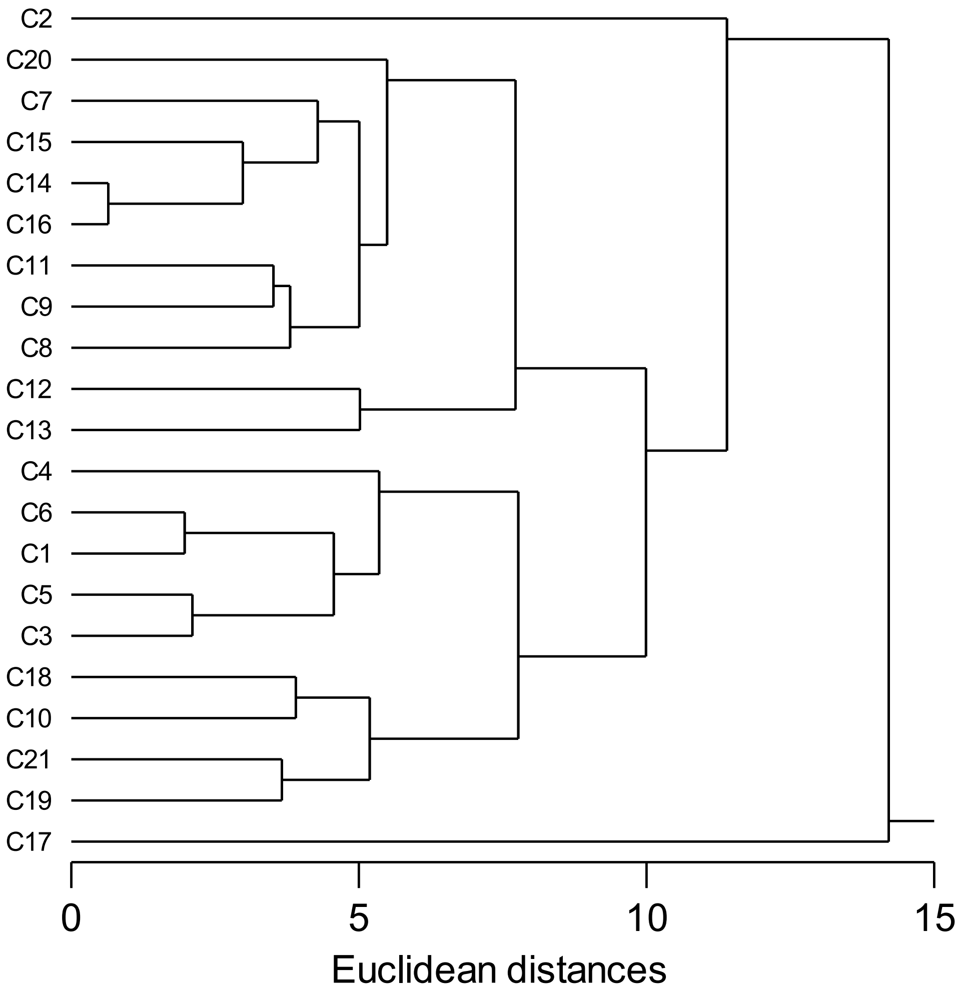


Figure 3: Benthic macroinvertebrate communities' simmilarity on Timiş River, based on taxonomic groups' relative abundance (Euclidean distance grouping for C1-C21 sampling river stations).

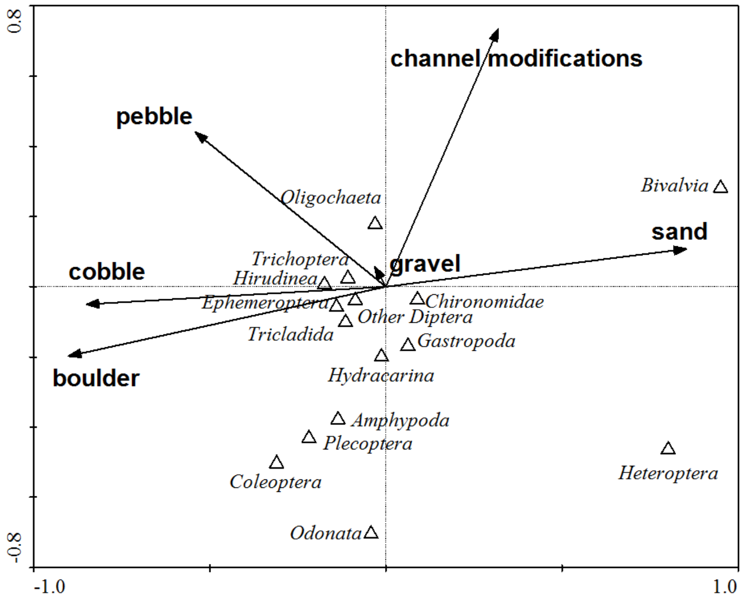


Figure 4: CCA relating macroinvertebrate groups density to substrate channel modification, in the case of the Timiş River (eigenvalues: λ1 - 0.141, λ2 - 0.085; variance explained - 64.7%)

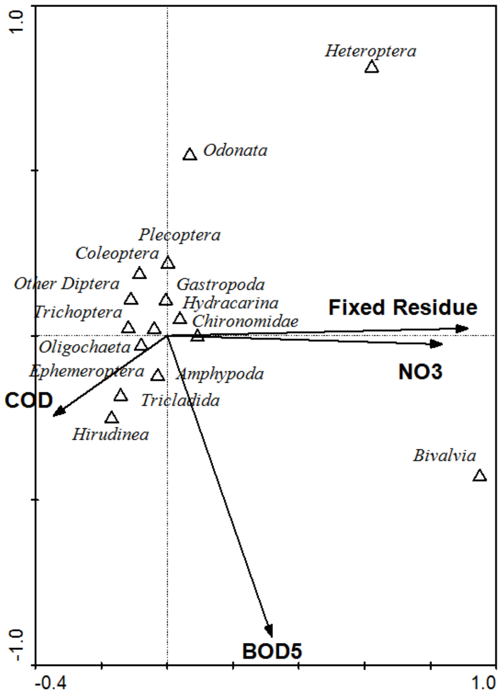


Figure 5. CCA relating macroinvertebrate groups density to fixed residue, NO_3^-, COD-Cr and BOD_5, in Timiş River (eigenvalues: λ1 - 0.151, λ2 - 0.067; variance explained - 71.9%).

The CCA relating macroinvertebrate groups density to substrate and to the channel modification (Fig. 4) indicating that: a high density of plecopters, choleopters, odonats, and amphipods is associated with lithological substrates, a high density of bivalves is associated with sandy substrates, and a large majority of macroinvertebrate groups' density residing in the Timiş River is negatively correlated with channel modifications.

The CCA relating macroinvertebrate groups density to fixed residue, NO_3, COD-Cr and BOD_5 (Fig. 5) showed that: the majority of macroinvertebrate groups' density is negatively correlated with the high values of the COD-Cr and BOD_5, except the Chironomidae, Amphypoda, Tricladida and Hirudinea; benthic macroinevertebrates density is not correlated with water salinity (fixed residue and NO_3^-).

Table 1: Benthic macroinvertebrates communities' structure in Timiş River (Ds - mean density, A% - relative abundance).

Sampling station/ position, altitude	Benthic macroinvertebrate community structure		
	Taxonomic group	Ds (ind./m^2)	A%
C1	Oligochaeta	7.44	0.50
	Hirudinea	3.72	0.25
	Amphypoda	29.99	2.01
	Ephemeroptera	424.58	28.39
	Plecoptera	112.74	7.54
	Trichoptera	101.47	6.79
	Coleoptera	131.45	8.79
	Chironomidae	672.6	44.98
	other Diptera	11.27	0.75
C2	Tricladida	7.44	0.51
	Oligochaeta	7.44	0.51
	Hydracarina	3.72	0.26
	Amphypoda	402.03	27.73
	Ephemeroptera	304.40	20.99
	Odonata	3.72	0.26
	Plecoptera	248.03	17.10
	Trichoptera	37.54	2.59
	Heteroptera	3.72	0.26
	Coleoptera	82.64	5.70
	Chironomidae	289.29	19.95
	other Diptera	60.09	4.14
C3 N 45°12'290" E 22°08'007" 870 m	Oligochaeta	56.37	6.15
	Hydracarina	7.44	0.81
	Amphypoda	3.72	0.41
	Ephemeroptera	157.84	17.22
	Plecoptera	142.73	15.57
	Trichoptera	22.55	2.46
	Coleoptera	14.99	1.64
	Chironomidae	503.49	54.93
	other Diptera	7.44	0.81
C4 N 45°13'163" E 22°07'426" 846 m	Oligochaeta	214.21	8.12
	Hydracarina	3,72	0.14
	Amphypoda	29,99	1.28
	Ephemeroptera	608,79	23.08

	Plecoptera	552,42	20.94
	Trichoptera	154.00	5.84
	Heteroptera	3.72	0.14
	Coleoptera	14,99	0.57
	Chironomidae	890.64	33.76
	other Diptera	161.56	6.12
C5 N 45°12'875" E 22°08'847" 802 m	Oligochaeta	29.99	3.33
	Hirudinea	33.82	3.75
	Ephemeroptera	210.37	23.33
	Plecoptera	105.19	11.67
	Trichoptera	14.99	1.66
	Chironomidae	503.49	55.85
	other Diptera	3.72	0.41
C6 N 45°09'299" E 22°16'838" 420 m	Tricladida	15.78	0.51
	Gastropoda	4.51	0.15
	Oligochaeta	184.89	6.01
	Hydracarina	69.9	2.27
	Amphypoda	6.76	0.22
	Ephemeroptera	863.59	28.06
	Plecoptera	175.87	5.71
	Trichoptera	259.3	8.42
	Coleoptera	171.36	5.57
	Chironomidae	1271.7	41.32
	other Diptera	54.11	1.76
C7 N 45°11'264" E 22°18'308" 354 m	Tricladida	18.04	0.99
	Gastropoda	9.02	0.49
	Oligochaeta	376.55	20.64
	Hydracarina	2.25	0.12
	Ephemeroptera	329.2	18.05
	Plecoptera	22.55	1.24
	Trichoptera	590.76	32.39
	Coleoptera	2.25	0.12
	Chironomidae	439.68	24.10
	other Diptera	33.82	1.85
C8 N 45°14'768" E 22°17'745" 296 m	Tricladida	4.51	0.20
	Gastropoda	4.51	0.20
	Oligochaeta	63.13	2.75
	Hydracarina	2.25	0.10
	Amphypoda	4.51	0.20
	Ephemeroptera	581.74	25.29
	Plecoptera	243.52	10.59
	Trichoptera	608.79	26.47
	Coleoptera	27.06	1.18
	Chironomidae	694.48	30.20
	other Diptera	65.39	2.84
C9 N 45°18'220" E 22°16'516" 265 m	Gastropoda	105.98	6.14
	Oligochaeta	112.74	6.53
	Hydracarina	99.21	5.74
	Amphypoda	2.25	0.13

	Ephemeroptera	288.61	16.71
	Odonata	2.25	0.13
	Plecoptera	45.1	2.61
	Trichoptera	514.09	29.77
	Coleoptera	4.51	0.26
	Chironomidae	469	27.15
	other Diptera	83.43	4.83
C10 N 45°19'770" E 22°15'610" 250 m	Tricladida	41.26	1.70
	Oligochaeta	45.10	1.86
	Hirudinea	11.27	0.47
	Hydracarina	18.71	0.77
	Amphypoda	7.44	0.31
	Ephemeroptera	236.75	9.77
	Plecoptera	11.27	0.47
	Trichoptera	266.74	11.01
	Coleoptera	3.72	0.15
	Chironomidae	1766.18	72.88
	other Diptera	14.99	0.62
C11 N 45°22'255" E 22°13'553" 219 m	Tricladida	4.51	0.11
	Oligochaeta	33.89	0.84
	Hydracarina	187.15	4.65
	Amphypoda	11.27	0.28
	Ephemeroptera	795.94	19.79
	Plecoptera	20.29	0.50
	Trichoptera	1400.23	34.81
	Coleoptera	6.76	0.17
	Chironomidae	1497.18	37.22
	other Diptera	65.39	1.63
C12 N 45°26'569" E 22°12'111" 175 m	Tricladida	37.54	0.72
	Gastropoda	131.45	2.52
	Oligochaeta	604.96	11.61
	Hirudinea	71.36	1.37
	Hydracarina	7.44	0.14
	Amphypoda	3.72	0.07
	Ephemeroptera	1770.01	33.96
	Plecoptera	3.72	0.07
	Trichoptera	1416.69	27.18
	Chironomidae	1086.0	20.84
	other Diptera	78.92	1.52
C13 N 45°31'456" E 22°10'413" 174 m	Oligochaeta	435.85	15.44
	Hydracarina	45.1	1.60
	Ephemeroptera	1217.59	45.68
	Plecoptera	7.44	0.26
	Trichoptera	398.31	14.11
	Coleoptera	3.72	0.13
	Chironomidae	620.07	21.97
	other Diptera	22.55	0.80
C14 N 45°32'939" E 22°09'401"	Tricladida	2.25	0.02
	Gastropoda	18.04	0.17
	Oligochaeta	1573.84	14.45

158 m	Hirudinea	9.02	0.08
	Hydracarina	9.02	0.08
	Ephemeroptera	1456.6	13.39
	Plecoptera	42.84	0.39
	Trichoptera	2901.92	26.65
	Heteroptera	2.25	0.02
	Coleoptera	6.76	0.06
	Chironomidae	4581.74	42.07
	other Diptera	284.1	2.61
C15 N 45°36’476” E 22°04’608” 142 m	Tricladida	20.29	0.18
	Gastropoda	22.55	0.20
	Oligochaeta	2550.17	22.62
	Hydracarina	38.33	0.34
	Amphypoda	2.25	0.02
	Ephemeroptera	1855.69	16.46
	Trichoptera	2786.92	24.72
	Heteroptera	2.25	0.02
	Coleoptera	27.06	0.24
	Chironomidae	3848.93	34.15
	other Diptera	117.25	1.04
C16 N 45°40’182” E 21°57’885” 117 m	Tricladida	13.53	0.29
	Oligochaeta	629.09	13.36
	Hydracarina	49.61	1.05
	Ephemeroptera	649.38	13.79
	Plecoptera	2.25	0.05
	Trichoptera	1303.27	27.67
	Coleoptera	15.78	0.34
	Chironomidae	2011.27	42.70
	other Diptera	36.08	0.77
C17 N 45°44’181” E 21°51’222” 116 m	Tricladida	15.78	1.06
	Oligochaeta	913.19	61.36
	Hydracarina	20.29	1.36
	Ephemeroptera	20.29	1.36
	Trichoptera	58.62	3.94
	Chironomidae	457.72	30.76
	other Diptera	2.25	0.16
C18 N 45°43’590” E 21°34’262” 83 m	Oligochaeta	49.61	4.33
	Ephemeroptera	261.56	22.83
	Plecoptera	15.78	1.38
	Trichoptera	67.64	5.91
	Heteroptera	9.02	0.79
	Chironomidae	741.83	64.76
C19 N 45°38’734” E 21°10’696” 83 m	Gastropoda	31.57	1.56
	Oligochaeta	311.16	15.40
	Hydracarina	20.29	1.01
	Ephemeroptera	15.78	0.78
	Trichoptera	2.25	0.12
	Heteroptera	103.72	5.13
	Chironomidae	1535.51	76.00

C20 N 45°33'000" E 21°03'033" 75 m	Tricladida	11.27	0.50
	Oligochaeta	266.74	11.77
	Hydracarina	112.74	4.98
	Ephemeroptera	63.81	2.82
	Plecoptera	14.99	0.66
	Trichoptera	939.46	41.46
	Heteroptera	14.99	0.66
	Coleoptera	14.99	0.66
	Chironomidae	823.0	36.32
	other Diptera	3.72	0.16
C21 N 45°26'859" E 20°53'309" 74 m	Gastropoda	11.27	0.21
	Bivalvia	529.08	10.01
	Oligochaeta	657.61	12.43
	Hydracarina	37.54	0.71
	Ephemeroptera	409.58	7.74
	Trichoptera	3.72	0.07
	Chironomidae	3641.49	68.82

CONCLUSIONS

The results show that structural spatial variability of benthic macroinvertebrate communities' is conditioned by the substrate type, by the degree of minor riverbed's structural change from the natural conditions, and by the oxydable matter quantity diluted in water.

REFERENCES

1. Abdul-Aziz O. I., Wilson B. N. and Gulliver J. S., 2010 – Two-zone model for stream and river ecosystems, *Hydrobiologia*, 638, 85-107.
2. Allan D. J., 1995 – Stream Ecology. Structure and function of running waters, Chapman and Hall.
3. Aura C. M., Raburu P. O., Herrmann J., 2011 – Macroinvertebrates' community structure in Rivers Kipkaren and Sosiani, Kenya, *Journal of Ecology and the Natural Environment*. 3, 2, 39-46.
4 Badea L., (coord.), 1983 – Geografia României, I, Geografia Fizică, Edit. Academiei (in Romanian).
5. ter Braak C. J. E, 1986 – Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis, *Ecology*, 67, 1167-1179.
6 Curtean-Bănăduc A., 2008 – Vişeu River and some tributaries ecological assessment based on macroinvertebrate communities (Maramureş, Romania), *Transylvanian Review of Systematical and Ecological Research,* 5, The Maramureş Mountains Nature Park, 165-182.
7. Diggins T. P. and Newman A. M., 2009 – Environmental and spatial influences on benthic community composition in Zoar Valley headwater streams, New York, *Hydrobiologia*, 630, 313-32.
8. Dudgeon D., 2010 – Prospects for sustaining freshwater biodiversity in the 21st Century: linking ecosystem structure and function, *Current Opinion in Environmental Sustainability*, 2, 422-430.
9 Infante D. M., Allan D. J., Linke S. and Norris R. H., 2009 – Relationship of fish and macroinvertebrate assemblages to environmental factors, *Hydrobiologia*, 623, 87-103.
10. Jiang X., Xiong J., Xie Z. and Chen Y., 2011 – Longitudinal patterns of macroinvertebrate functional feeding groups in a Chinese river system, *Quaternary International*, 244, 2, 289-295.
11. Kreatzweiser D. P., Capell S. S. and Good K. P., 2005 – Macroinvertebrate community response to selection logging, *Journal of the North American Benthological Society*, 24, 208-222.
12. Leunda P. M., Oscoz J., Miranda R., Arino A. H., 2009 – Longitudinal and seasonal variation of the benthic macroinvertebrate and biotic indices in an Pyrenean river, *Ecological indicators*, 9, 52-63.
13. Posea G., (coord.), 1982 – Enciclopedia Geografică a României, Bucureşti (in Romanian).
14. Rawer-Jost C., Bohmer J., Blank J., Rahmann H., 2000 – Macroinvertebrate functional feeding group methods in ecological assessment, Hydrobiologia 422/423, 225-232.
15. Roşu A., 1980 – Geografia Fizică a României, Ed. Didactică şi Pedagogică, Bucureşti (in Romanian).
16. Theiling C. H. and Nestler J. M., 2010 – River stage response to alteration of Upper Mississippi River channels, floodplains, and watersheds, *Hydrobiologia*, 640, 17-47.

THE DIVERSITY OF CADDISFLIES (INSECTA, TRICHOPTERA) SPECIES IN TIMIȘ RIVER CATCHMENT AREA (WESTERN ROMANIA)

Mălina PÂRVU * and *Lucian PÂRVULESCU* **

* West University of Timişoara, Faculty of Chemistry, Biology, Geography, Department of Biology - Chemistry, 16A Pestalozzi Street, 300115, Timişoara, Romania, malina.pirvu@cbg.uvt.ro
** West University of Timişoara, Faculty of Chemistry, Biology, Geography, Department of Biology - Chemistry, 16A Pestalozzi Street, 300115, Timişoara Romania, lucian.parvulescu@cbg.uvt.ro

DOI: 10.2478/trser-2013-0039.

KEYWORDS: Trichoptera, water quality, bioindicators, western Romania.

ABSTRACT

In order to determine the benthic macro invertebrates communities role as bioindicators, researchers worldwide carried out analyses into the structure, dynamics and diversity of the different groups as well as into the physical-chemical factors. A total of twenty one species of caddisfly larvae were identified in the study. Numerical abundance, frequency and diversity values recorded for the caddisfly species varied according to the physical-chemical conditions specific to each sample collecting station. The physical and chemical parameters monitored in Timiș River water catchment basin have corresponded with the limits of the Ministry of Environment and Water Management (MEWA) Order 161/2006, which states the ecological status of surface bodies of water with, few exceptions being identified.

RĖSUMĖ: La diversité des trichoptères dans le bassin hydrographique de la rivière de Timiș.

Dans le but d'établir le rôle de bioindicateur des communautés de macro-invertébrés benthiques, les chercheurs du monde entier ont effectué des études d'analyse de la structure, de la dynamique et de la diversité des différents groupes, en relation avec l'étude des agents physico-chimiques. Dans la présente étude, 21 espéces de trichoptères au stade larvaire ont été identifiés. Les valeurs d'abondance en pourcentage, de la fréquence et de la diversité biologique relative aux larves de trichoptéres identifiées, ont varié par rapport aux modifications des paramétres physico-chimiques spécifiques à chaque station de collecte d'échantillons. Les valeurs des paramètres physico-chimiques relevées dans le bassin hydrographique de Timiș sont conforment aux normes établies par le Ministère des Eaux et de la Protection de l'Environnement 161/2006, qui prévoit un bon état écologique des cours d'eau; quelques exceptions sont tout de même à noter.

REZUMAT: Diversitatea speciilor de trichoptere în zona bazinului hidrografic al râului Timiş.

În vederea determinării rolului de bioindicatori al comunităților de macronevertebrate bentonice, cercetători din întreaga lume au desfăşurat studii de analiză a structurii, dinamicii și diversității diferitelor grupe, alături de cele privind factorii fizico-chimici. În prezentul studiu, au fost identificate 21 specii de trichoptere în stadiul larvar. Valorile abundenței numerice procentuale, ale frecvenței și diversității biologice privind larvele de trichoptere identificate au variat în raport cu modificările parametrilor fizico-chimici specifici fiecărei stații de colectare a probelor. Valorile parametrilor fizico-chimici monitorizați în bazinul hidrografic al Timișului au corespuns limitelor Ordinului Ministrului Apelor și Protecției Mediului 161/2006, care prevede starea ecologică a corpurilor de apă, fiind identificate câteva excepții.

INTRODUCTION

The ecological monitoring of the quality of the water supposes the use of multiple methods of chemical, physical and biological analysis, its importance being given by the specific adaptations to the specific habitat conditions (Ouyang, 2005; Guilpart et al., 2012). The higher the interest, the more the anthropic influences become stronger with direct influence upon the natural ecosystems of aquatic types (Böhmer et al., 2004; Van Hoey et al., 2010). The monitoring programs for water quality has become a major concern in most of European countries, and each country using their own or borrowed system. The joint element being represented by the macro fauna that are frequently used as an indicator (Böhmer et al., 2004; Borja et al., 2007).

The studies carried out presently place caddisflies as an instrumental group of biological indicators, due to their sensitive to alteration of water quality (Azrina et al., 2006; Li et al., 2010; Wesolek et al., 2010). The spread of the different species of caddisflies through the aquatic systems is given by a series of key factors, one of which is the critical role played by the anthropic impact (Englund et al., 1997; Fernández-Aláez et al., 2002; Roy et al., 2003; Kail et al., 2012; Almeida et al., 2013) and ecologic and habitat preferences of each and every species (Hildrew and Edington, 1979; Boyero and Barnard, 2004; Hughes, 1978).

Timiş drainage area (TDA) (5.673 km^2) represents, together with Bega drainage area, (BDA) (2.362 km^2) approximately 43% of the surface of Banat hydrographic space located in the western part of the country (Ilie, 2007).

The main purpose of this study is to analyse the diversity and the structure of the Trichoptera community in the target area for the purpose of establishing a natural and/or anthropic impact, either present or potential.

MATERIAL AND METHODS

Benthos samples collection

In the summer of 2009 a field investigation was conducted in Timiş River water catchment area, western Romania. A total of 19 semi-quantitative samples (1 sample/station) were processed using a hand net (meshes of 250 µm), each of the sites investigated were approximately 200 m in length. In the laboratory, the identification of the organisms was conducted on a species level (Waringer and Graf, 1997; Wallace et al., 2003). Organisms were not identified in the first stages of existence at a species level, they did not feature fully developed morphological traits to allow a proper analysis. 349 individuals were processed.

Localizing the sampling stations and processing the data

The localization of sampling stations according to the code number is as follows:

S1, Moraviţa (45°21'25" N, 21°45'51" E, altitude - alt. 240 m); S2, Străjeşti (45°23'08" N, 22°02'43" E, alt. 280 m); S3, Valea Runc (45°22'46" N, 22°07'47" E, alt. 320 m); S4, Grădişte (45°13'13" N, 22°06'42" E, alt. 820); S5, Brebu (45°14'03" N, 22°08'47" E, alt. 860 m); S6, Cernei (45°12'39" N, 22°15'53" E, 270 m); S7, Armeniş (45°14'21" N, 22°21'25" E, alt. 440 m); S8, Valea Petroşniţei (45°19'14" N, 22°14'14" E, alt. 300 m); S9, Bolnişoara (45°19'07" N, 22°21'31" E, alt. 400 m); S10, Slătinioara (45°21'38" N, 22°22'01" E, alt. 395 m); S11, Valea Vidra (45°25'05" N, 22°31'25" E, alt. 620 m); S12, Mânzul (45°29'56" N, 22°31'14" E, alt. 490 m); S13, Stârna Mare (45°31'33" N, 22°31'10" E, 390 m); S14, Valea Micota (45°32'16" N, 22°33'28" E, alt. 460 m); S15, Loznişoara (45°34'28" N, 22°29'35" E, 415 m alt.); S16, Glimboca (45°31'19" N, 22°19'16" E, alt. 295 m); S17, Macioava (45°31'59" N, 22°11'53" E, alt. 235 m); S18, Padeşu (45°39'30" N, 22°11'59" E, alt. 300 m); S19, Hăuzeasca (45°42'24" N, 22°09'40" E, alt. 260 m).

In each of the sampling sectors, the water temperature (°C), average river width, depth (m) and percentage of riparian tree coverage (%) were estimated. Along with several physico-chemical parameters: pH, dissolved oxygen (mg l^{-1}), conductivity (µS cm^{-1}), water hardness (°dH), dissolved calcium and magnesium ions (mg l^{-1}), dissolved inorganic nitrogen forms (N-nitrate, N-nitrite and N-ammonia) (mg l^{-1}) and soluble reactive phosphorus (SRP) (mg l^{-1}). These indicators were recorded with HACH-Lange (Düsseldorf, Germany) multi-parameter and spectrophotometer field equipment following the standard procedure for each parameter. Each parameter was analysed using one subsample in each sampling sector.

The abundance $A = (n_i\ N^{-1})*100$ and frequency $F = (N_i*100)\ N_p^{-1}$ were further calculated, where n_i represents the total number of individuals for the i species, S_p the total researched area, N the total number of individuals belonging to all species (from the sample or samples studied), N_i the number of stations where i species were identifies, N_p total number of stations (Stan, 1995). The Shannon-Wiener (SW-DI) diversity index, $H' = -\Sigma p_i \log_2 p_i$ and the Pielou equitability index (PEI) $E = H'/H_{max}$, where p_i represents species abundance calculated according to $p_i = n_i\ N^{-1}$, $H_{max} = \log S$, S the total number of species (Sîrbu and Benedek, 2004) were also determined.

RESULTS

The mean values of the maximum river bed stretch and water depth for the 19 stations were 2.71±0.49 m and 0.43±0.10 m. The mean values of the minimum river bed stretch and water depth for the 19 stations were 1.04±0.32 m and 0.08±0.02 m. The mean values of the coverage degree of the river bed was 57.95±13.62% and the sub-layer analyzed was mostly made up of stones, boulders and gravel.

After processing the samples, 21 species included in 12 genera and 7 families were identified as follows: Fam. Glossosomatidae: genus *Glossosoma* (*G. conformis* Neboiss, 1963), Fam. Hydropsychidae: genus *Hydropsyche* (*H. angustipennis* Curtis, 1834; *H. fulvipes* Curtis, 1834; *H. incognita* Pitsch, 1993; *H. instabilis* Curtis, 1834; *H. pellucidula* Curtis, 1834), Fam. Limnephilidae: genus *Chaetopterygopsis* (*C. maclachlani* Stein, 1874), genus *Halesus* (*H. digitatus* von Paula Schrank, 1781; *H. rubricollis* Pictet, 1834), genus *Micropterna* (*M. lateralis* Stephens, 1837), genus *Potamophylax* (*P. latipennis* Curtis, 1834; *P. nigricornis* Pictet, 1834; *P. luctuosus* Piller and Mitterpacher, 1783), Fam. Philopotamidae: genus *Philopotamus* (*P. montanus* Donovan, 1813), Fam. Psychomyiidae: genus *Lype* (*L. phaeopa* Stephens, 1836), genus *Psychomyia* (*P. pusilla* Fabricius, 1781), Fam. Rhyacophilidae: genus *Rhyacophila* (*R. dorsalis* Curtis, 1834; *R. obliterata* McLachlan, 1863; *R. tristis* Pictet, 1834), Fam. Sericostomatidae: genus *Sericostoma* (*S. personatum* Kirby and Spence, 1826), genus *Oecismus* (*O. monedula* Hagen, 1859).

The *Hydropsyche* genus featured the highest number of species (5), followed by the rest, with three species for *Potamophylax* sp. and *Rhyacophila* sp. respectively, and with one species for each of the rest. Their distribution according to the sample collection stations is shown in table 1.

The analysis of the percentage numerical abundance showed a high value for the *H. incognita* species (94.74%), followed by the other two species, but at a great distance from the point of view of value identified, with 31.58% each (Fig. 1). The lowest values were established for 7 of the 21 species of caddisflies identified in total, with values of 5.26% each. In terms of frequency, the highest values were established for two species of the genus *Hydropsyche*, *H. pellucidula* and *H. incognita* with 23.21% and respectively 22.64% (Fig. 2). The lowest frequency was set for *H. digitatus* (0.29%).

After calculating the SW-DI index, a maximum value of diversity for S14 (0.76) and S1 (0.70) were established, the lowest value of 0.15 being set for 5 sampling stations (S2, S5, S13, S15, S17) (Fig. 3). These low values were also established by calculating the PEI index for the same sampling stations, the maximum being identified for S8 and S16 with 1.04 and respectively 1.03 (Fig. 4).

Table 1: Caddisflies species distribution in Timiș River water catchment area, 2009.

	H. angustipennis	*H. fulvipes*	*H. instabilis*	*H. incognita*	*H. pellucidula*	*Pt. latipennis*	*Pt. nigricornis*	*Pt. luctuosus*	*R. dorsalis*	*R. obliterata*	*R. tristis*	*H. digitatus*	*H. rubricolis*	*S. personatum*	*O. monedula*	*L. phaeopa*	*P. montanus*	*M. lateralis*	*P. pusilla*	*G. conformis*	*C. maclachlani*
S1		x	x	x						x	x	x									
S2				x																	
S3				x	x		x				x										
S4	x			x																	
S5				x															x		
S6				x																	
S7				x	x	x	x		x		x			x	x		x	x			
S8				x		x		x	x						x		x	x			
S9	x			x						x				x							
S10			x	x	x					x	x		x								x
S11				x		x		x	x												
S12				x	x																
S13				x		x			x												
S14			x	x		x			x					x	x	x				x	
S15				x																	
S16				x																	
S17				x	x																
S18				x	x																
S19				x		x			x					x							

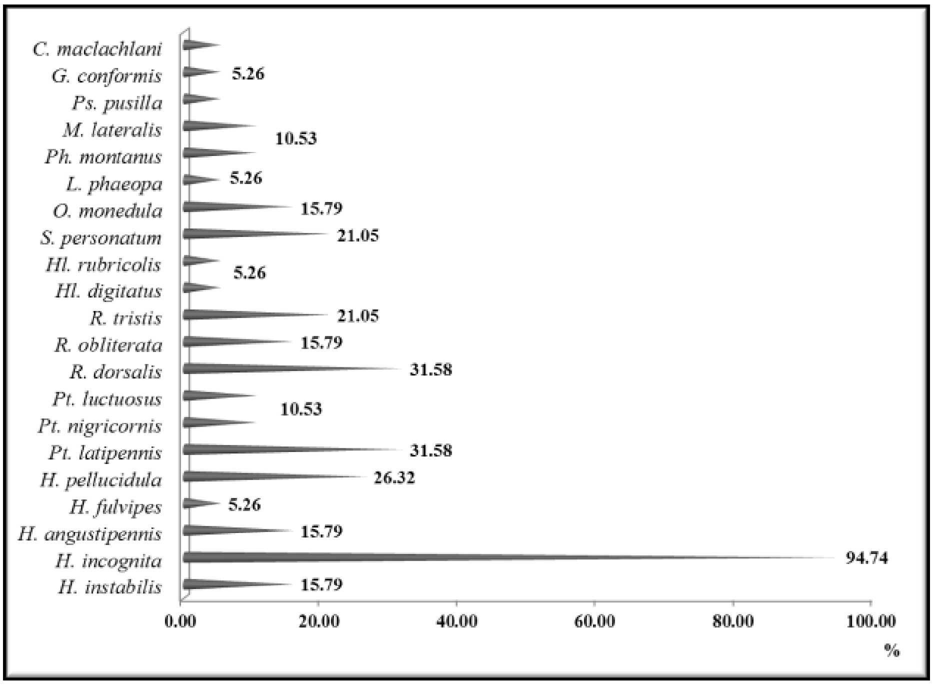
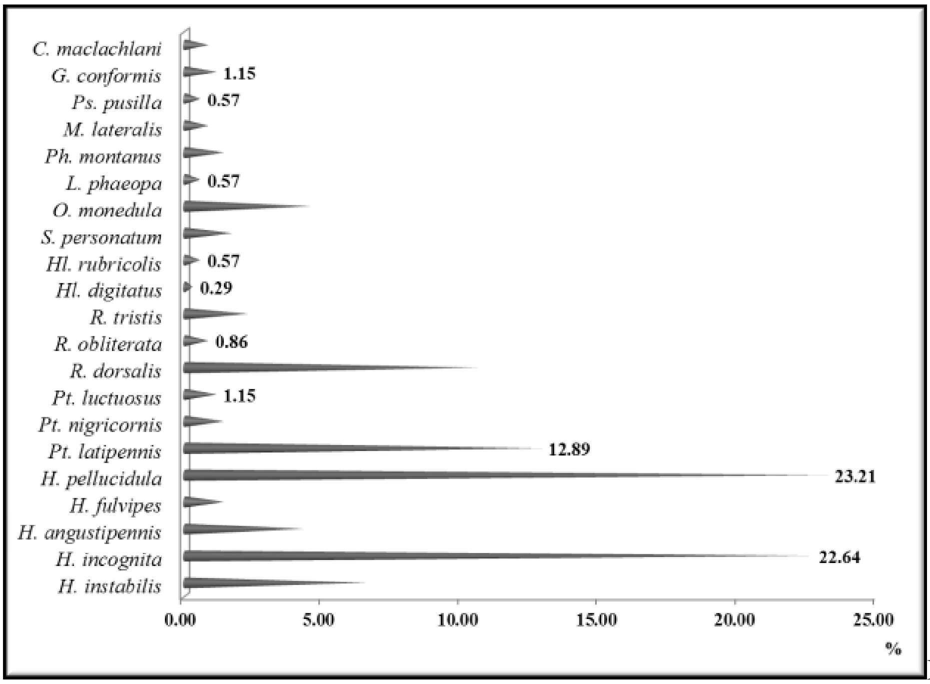


Figure 1: Percentage numerical abundance (%) of caddisflies species in Timiş River water catchment area, 2009.



B

Figure 2: Frequency (%) of caddisflies species in Timiş River water catchment area, 2009.

The SW index and PEI values corresponding to the 19 sampling stations for the summer of 2009 in Timiș River water catchment basin were presented in figure 3.

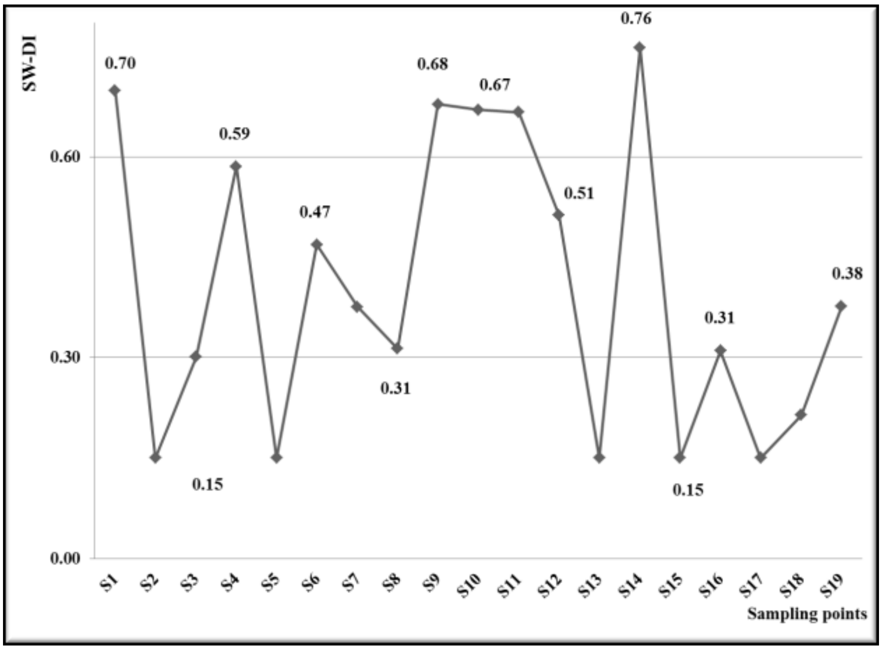


Figure 3: SW-DI values in Timiș River water catchment area, 2009.

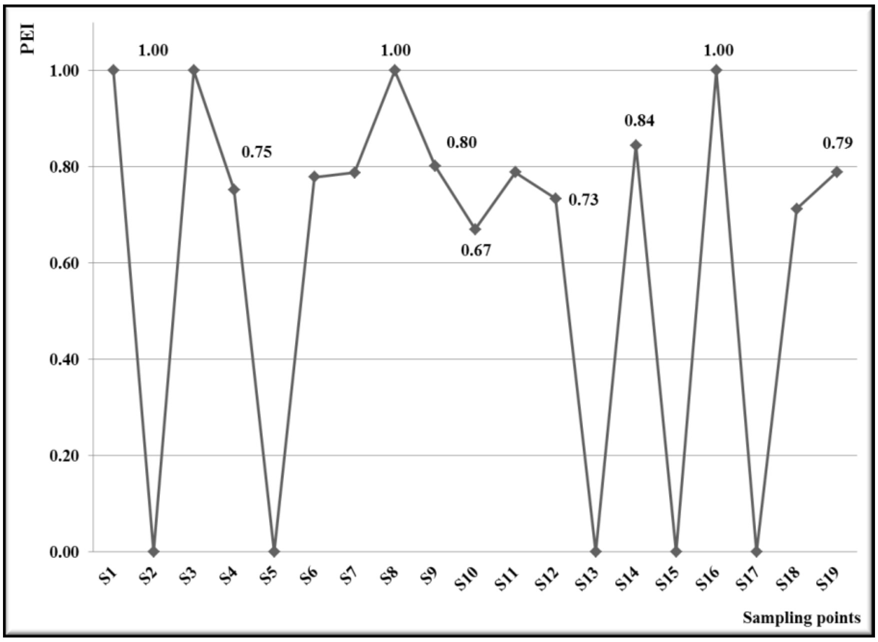


Figure 4: PEI values in Timiș River water catchment area, 2009.

In table 2, the water quality of the monitored stations in this study is presented based on the values of chemical parameters measured in accordance with the Ministry of Environment and Water Management (MEWA) Order 161/2006, reflecting not only the quality of the water, but also the structure of benthic fauna in the area. For table 2, the following abbreviations have been used in determining the appropriate water quality class: field marked white - class I, field marked light gray - class II, field marked dark gray - class III, field marked dark gray and bold values - class IV and field marked white and bold values - class V. pH values were not marked in the table, its values being in accordance with the required normal limits.

Table 2: Assigning the appropriate water quality classes for the sampling stations and the study interval in accordance with Order 161/2006.

Sampling stations	**Dissolved oxygen**	**Ca**	**Mg**	**N-nitrate**	**N-nitrite**	**SRP**	**N-ammonia**	**pH**
S1	8.78	22.50	9.650	0.30	0.06	0.07	0.04	7.08
S2	8.69	11.90	7.610	0.40	0.03	0.14	0.04	7.01
S3	9.00	11.10	3.740	0.20	0.001	0.11	0.08	7.44
S4	9.22	23.50	0.860	0.80	0.002	**1.07**	0.03	7.87
S5	9.01	4.42	16.300	1.10	0.01	**0.78**	0.04	7.74
S6	8.75	6.53	2.240	0.90	0.01	0.17	0.03	8.26
S7	8.73	9.86	4.870	0.40	0.01	0.17	0.04	7.18
S8	8.65	98.50	4.300	1.10	0.002	**0.94**	0.02	7.58
S9	8.93	23.10	2.500	0.70	0.003	0.07	0.02	8.02
S10	9.59	25.70	4.570	0.40	0.003	**0.42**	0.21	7.82
S11	9.03	12.40	7.300	0.10	0.01	0.27	0.07	7.55
S12	9.63	23.60	2.830	0.50	0.01	0.21	0.02	8.15
S13	8.16	18.30	2.000	0.70	0.01	0.21	0.02	6.89
S14	8.88	18.50	2.900	0.40	0.002	**0.80**	0.01	7.90
S15	8.30	19.90	1.540	0.40	0.002	**0.61**	0.01	7.52
S16	8.99	27.10	0.262	0.20	0.002	**0.61**	0.06	8.13
S17	8.20	23.70	1.680	0.30	0.003	**0.49**	0.03	7.60
S18	8.20	61.90	4.430	0.10	0.003	0.05	0.03	8.12
S19	9.04	72.40	26.500	0.20	0.01	0.30	0.01	8.22

Table 3: The values of the physical-chemical parameters calculated at the 19 sites in Timiş River water catchment area, 2009.

Sampling stations	**Water temperatur**	**pH**	**Dissolved oxygen**	**Conductivity**	**Water hardness**	**Dissolved calcium and magnesium ions**		**Dissolved inorganic nitrogen forms**			**SRP**
						Ca	Mg	N-nitr	N-nitr	N-am	
S1	15.90	7.08	8.78	32.20	3.16	22.50	9.65	0.30	0.06	0.04	0.07
S2	15.90	7.01	8.69	26.70	1.67	11.90	7.61	0.40	0.03	0.04	0.14
S3	19.10	7.44	9.00	66.00	1.55	11.10	3.74	0.20	0.001	0.08	0.11
S4	18.00	7.87	9.22	161.70	3.29	23.50	0.86	0.80	0.001	0.03	1.07
S5	18.70	7.74	9.01	141.10	3.76	4.42	16.30	1.10	0.01	0.04	0.78
S6	24.20	8.26	8.75	151.30	0.92	6.53	2.24	0.90	0.01	0.03	0.17
S7	19.00	7.18	8.73	60.40	1.38	9.86	4.87	0.40	0.01	0.04	0.17
S8	19.50	7.58	8.65	70.70	1.38	98.50	4.30	1.10	0.001	0.02	0.94
S9	17.30	8.02	8.93	131.70	3.24	23.10	2.50	0.70	0.002	0.02	0.07
S10	14.50	7.82	9.59	79.60	3.61	25.70	4.57	0.40	0.002	0.21	0.42
S11	17.00	7.55	9.03	55.40	1.73	12.40	7.30	0.10	0.01	0.07	0.27
S12	16.30	8.15	9.63	125.20	3.32	23.60	2.83	0.50	0.01	0.02	0.21
S13	17.00	6.89	8.16	141.50	2.57	18.30	2.00	0.70	0.01	0.02	0.21
S14	18.20	7.90	8.88	98.40	2.59	18.50	2.90	0.40	0.002	0.01	0.80
S15	19.50	7.52	8.30	116.60	2.79	19.90	1.54	0.40	0.002	0.01	0.61
S16	27.40	8.13	8.99	178.10	3.86	27.10	0.26	0.20	0.002	0.06	0.61
S17	21.10	7.60	8.20	136.40	3.33	23.70	1.68	0.30	0.001	0.03	0.49
S18	20.80	8.12	8.20	342.00	9.71	61.90	4.43	0.10	0.001	0.03	0.05
S19	15.80	8.22	9.04	601.00	16.30	72.40	26.50	0.20	0.01	0.01	0.30

DISCUSSIONS

The interest in studying caddisfly larvae is sustained by their contribution to turning the allochtone material into biomass, which is then spread across upper trophic levels (Burd et al., 2008). Scientific literature sustains the role caddisflies occupy in evaluating water quality also, as well as the various degrees of tolerance to changes in qualitative parameters of water bodies (Solà and Prat, 2006; Arimoro and Ikomi, 2009; Rizo-Patrón et al., 2013).

Based on the Order 161/2006, it was established that the majority of the physico-chemical parameters studied indicated a high quality of the water, belonging to class I. There were exceptions such as the concentration of the dissolved oxygen (S1, S2, S6-S9, S13-S19 - class II), dissolved calcium (S8, S18, S19 - class II), dissolved magnesium (S5, S19 - class II), nitrate (S5, S8 - class II), nitrite (S1 - class III; S2 - class II) and SRP (S2, S3, S6, S7 - class II; S11-S13, S19 - class III; S5, S10, S13-S17 - class IV; S4, S8 - class V) (Tabs. 2 and 3).

However, these exceptions have not changed the diversity of caddisflies in monitored sampling stations, SW-DI index values and those of the PEI index still being relatively high compared with other stations (Figs. 3 and 4). We believe that this is due to large numbers of individuals belonging to the tolerant species such as the representatives of the *Hydropsyche*, *Rhyacophila* and the *Potamophylax* genus (Tab. 1) (Graf et al., 2008).

Potamophlylax genus preference for altitudes of 150-3100 m and below 150 m, with substrate composed of stones, gravel and boulders and also its tolerance to organic material was demonstrated in the literature (Graf et al., 2008). Lukáš and Krno (2003) for example, the species identified at the altitude of 200-450 m and over 450 m. In this study, three species belonging to this genus were identified at an altitude between 240 and 490 m (Tab. 1). A similar pattern was set for *Rhyacophila* species. The literature has associated the species with pH values ranging from acid to alkaline and considered them tolerant (Fjellheim and Raddum, 1990; Bonada et al., 2005). High altitude dependence of these species was also demonstrated (Urbanič and Toman, 2007) signaling the presence of this species at an altitude over 500 m. In our study, the three species were reported between 270 and 820 m (Tab. 1).

Also, the presence of species tolerant to changing water quality parameters as those belonging to the *Hydropsyche* genus may suggest that an imbalance exists, these species being generally considered to be less sensitive than other species of the order (Bonada et al., 2005; Philipson and Moorhouse, 2006). Given the presence in certain areas of some sensitive caddisfly species and that the species of the *Hydropsyche* genus are predatory by building a special net-spinning trap (Fuller and Mackay, 1980; Poepperl, 2000), we consider that their high number compared to the rest of the species is due to their preference for fast flowing waters such as those analyzed in the present study and by being more tolerant. Moreover, these results are suggested by low values of SW-DI and PEI diversity in 5 of the 19 stations surveyed, in all five locations only one species was identified, *H. incognita* (Tab. 1; Figs. 3 and B). In fact, the highest values of numerical abundance were identified for *H. incognita* with 94.74%, this situation being similar for frequency in which case the maximum values were set for two species of the genus, *H. incognita* and *H. pellucidula* (Figs. 1 and 2). In general the two species replace one other in terms of altitude, but there were noted situations of coexistence (Hildrew and Edington, 1979; Miklós and Ujvárosi, 2009).

Taking into account the results of this study and those reported by the literature, we believe that the caddisfly larvae can be successfully used as biological indicators in determining the water quality. However, future detailed studies are needed.

CONCLUSIONS

Were identified 21 species included in 12 genera. The *Hydropsyche* genus featured the highest number of species (5), followed by the rest of the types, with three (*Potamophylax* sp. and *Rhyacophila* sp. respectively) and the rest of the species with one each. *H. incognita* and *H. pellucidula* have been identified with maximum values in terms of percentage numerical abundance and frequency.

As regarding the diversity indices SW-DI and PEI a maximum value was established for the two sampling stations (S14 - 0.76; S1 - 0.70), the lowest value of 0.15 being set for five sampling stations (S2, S5, S13, S15, S17). These low values were established by calculating the PEI index also for the same sampling stations, the maximum being identified for S8 and S16 with 1.04 and 1.03 respectively.

The physical and chemical parameters monitored in Timiș River water catchment basin have corresponded with the limits of the MEWA Order 161/2006, which states the ecological status of surface water bodies, with a few exceptions.

ACKNOWLEDGMENTS

The main part of this study is a result of investigations in the project “The stone crayfish (*Austropotamobius torrentium*), distribution in Romanian habitats, ecology and genetics of populations” funded by the National Research Council (CNCS) of Romania, project code PCE-1458/2008.

REFERENCES

1. Almeida D., Merino-Aguirre R. and Angeler D.G., 2013 – Benthic invertebrate communities in regulated Mediterranean streams and least-impacted tributaries, *Limnologica*, 43, 34-42.
2. Arimoro F.O. and Ikomi R.B., 2009 – Ecological integrity of upper Warri River, Niger Delta using aquatic insects as bioindicators, *Ecological Indicators*, 9, 3, 455-461.
3. Azrina M. Z., Yap C. K., Ismail A. R., Ismail A. and Tan S. G., 2006 – Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of the Langat River Peninsular Malaysia, *Ecotoxicology and Environmental Safety*, 64, 337-347.
4. Böhmer J., Rawer-Jost C., Zenker A., Meier C., Feld C. K., Biss R. and Hering D., 2004 – Assessing streams in Germany with benthic invertebrates: Development of a multimetric invertebrate based assessment system, *Limnologica - Ecology and Management of Inland Waters*, 34, 4, 416-432.
5. Bonada N., Vives S., Rieradevall M. and Prat N., 2005 – Relationship between pollution and fluctuating asymmetry in the pollution-tolerant caddisfly Hydropsyche exocellata (Trichoptera, Insecta), *Archiv für Hydrobiologie*, 162, 167-185.
6. Borja A., Josefson A. B., Miles A., Muxika I., Olsgard F., Phillips G., Rodríguez J. G. and Rygg B., 2007 – An approach to the intercalibration of benthic ecological status assessment in the North Atlantic ecoregion, according to the European Water Framework Directive, *Marine Pollution Bulletin*, 55, 1-6, 42-52.
7. Boyero L. and Barnard P. C., 2004 – A *Potamophylax* larva (Trichoptera: Limnephilidae) using other caddisfly cases to construct its own case, *Journal of Natural History*, 38, 1297-1301.
8. Burd B. J., Barnes P. A. G., Wright C. A. and Thomson R. E., 2008 – A review of subtidal benthic habitats and invertebrate biota of the Strait of Georgia, British Columbia, *Marine Environmental Research*, 66, 3-38.
9. Englund G., Malmqvist B. and Zhang Y., 1997 – Using predictive models to estimate effects of flow regulation on net-spinning caddis larvae in North Swedish rivers, *Freshwater Biology*, 37, 687-697.
10. Fernández-Aláez C., de Soto J., Fernández-Aláez M. and García-Criado F., 2002 – Spatial structure of the caddisfly (Insecta, Trichoptera) communities in a river basin in NW Spain affected by coal mining, *Hydrobiologia*, 487, 193-205.
11. Fuller R. L. and Mackay R.J., 1980 – Field and laboratory studies of net-spinning activity by Hydropsyche larvae (Trichoptera: Hydropsychidae), *Canadian Journal of Zoology*, 58, 11, 2006-2014.
12. Graf W., Murphy J., Dahl J., Zamora-Muñoz C. and López-Rodríguez M. J., 2008 – Distribution and ecological preferences of European freshwater organisms, I, Pensoft Publishing House, Sofia-Moscow, 389.
13. Guilpart A., Roussel J. M., Aubin J., Caquet T., Marle M. and Le Bris H., 2012 – The use of benthic invertebrate community and water quality analyses to assess ecological consequences of fish farm effluents in rivers, *Ecological Indicators*, 23, 356-365.
14. Hildrew A.G. and Edington J.M., 1979 – Factors facilitating the coexistence of hydropsychid caddis larvae (Trichoptera) in the same river system, *Journal of Animal Ecology*, 48, 557-576.
15. Hughes S. J., 2006 – Temporal and spatial distribution patterns of larval trichoptera in Madeiran streams, *Hydrobiologia*, 553, 27-41.
16. Ilie A. C., 2007 – Complexul spaţial al bazinelor râurilor, Edit. Fundaţiei România de Mâine, Bucureşti, 212. (in Romanian)
17. Kail J., Arle J. and Jähnig S.C., 2012 – Limiting factors and thresholds for macroinvertebrate assemblages in European rivers: Empirical evidence from three datasets on water quality, catchment urbanization, and river restoration, *Ecological Indicators*, 18, 63-72.
18. Li L., Zheng B. and Liu L., 2010 – Biomonitoring and Bioindicators Used for River Ecosystems: Definitions, Approaches and Trends, *Procedia Environmental Sciences*, 2, 1510-1524.

19. Lukáš J. and Krno J., 2003 – Caddisflies (Trichoptera) of the Gidra River basin, *Acta Zoologica Universitatis*, 45, 69-75.
20. Miklós B. and Ujvárosi L., 2009 − Distribution patterns of *Hydropsyche incognita* (Pitsch, 1993) and *H. pellucidula* (Curtis, 1834) in Transylvania (Romania), with special reference to their ecological requirements (Trichoptera: Hydropsychidae), *Bulletin De La Société Des Naturalistes Luxembourgeois*, 110, 167-172.
21. Order 161/16.02.2006 approving the (Norms concerning the classification of surface water quality in order to determine the ecological status of water bodies), 122. (in Romanian)
22. Ouyang Y., 2005 – Evaluation of river water quality monitoring stations by principal component analysis, *Water Research*, 39, 12, 2621-2635.
23. Philipson G. N. and Moorhouse B. H. S., 2006 – Observations on ventilatory and net-spinning activities of larvae of the genus Hydropsyche Pictet (Trichoptera, Hydropsychidae) under experimental conditions, *Freshwater Biology*, 4, 525-533.
24. Poepperl R., 2000 – The Filter Feeders Hydropsyche angustipennis and *H. pellucidula* (Trichoptera: Hydropsychidae) in a Northern German Lowland Stream: Microdistribution, Larval Development, Emergence Pattern, and Secondary Production, *Limnologica,* 30, 65-72.
25. Rizo-Patrón F. V., Kumar A., McCoy Colton M. B., Springer M., Florencia A. and Trama F. A., 2013 – Macroinvertebrate communities as bioindicators of water quality in conventional and organic irrigated rice fields in Guanacaste, Costa Rica, *Ecological Indicators*, 29, 68-78.
26. Roy A. H., Rosemond A. D., Paul M. J., Leigh D. S. and Wallace J. B., 2003 – Stream macroinvertebrate response to catchment urbanisation (Georgia, U.S.A.), *Freshwater Biology*, 48, 329-346.
27. Sîrbu I. and Benedek A. M., 2004 – Ecologie practică, Edit. „Lucian Blaga" University of Sibiu, 254. (in Romanian)
28. Solà C. and Prat N., 2006 – Monitoring metal and metalloid bioaccumulation in Hydropsyche (Trichoptera, Hydropsychidae) to evaluate metal pollution in a mining river. Whole body versus tissue content, *Science of The Total Environment*, 359, 1-3, 221-231.
29. Stan G., 1995 – Metode statistice cu aplicații în entomologie, *Buletinul informativ al Societății Lepideptorologice Române*, 6, 67-96. (in Romanian)
30. Urbanič G. and Toman M. J., 2007 − Environmental Variables on Stream Caddis Larvae in Three Slovenian Ecoregions: Alps, Dinaric Western Balkans and Pannonian Lowland, *International Review of Hydrobiology*, 92, 582-602.
31. Van Hoey G., Borja A., Birchenough S., Buhl-Mortensen L., Degraer S., Fleischer D., Kerckhof F., Magni P., Muxika I., Reiss H., Schröder A. and Zettler M. L., 2010 – The use of benthic indicators in Europe: From the Water Framework Directive to the Marine Strategy Framework Directive, *Marine Pollution Bulletin*, 60, 12, 2187-2196.
32. Wallace I. D., Wallace B. and Philipson G. N., 2003 – Case-bearing caddis larvae of Britain and Ireland, Edit. Freshwater Biological Association, UK, 1-156.
33. Waringer J. and Graf W., 1997 – Atlas der Österreichischen Köcherfliegenlarven, Edit. Facultas Universitätsverlag, Wien, 19-219. (in German).
34. Wesolek B. E., Genrich E. K., Gunn J. M. and Somers K. M., 2010 – Use of littoral benthic invertebrates to assess factors affecting biological recovery of acid- and metal-damaged lakes, *Journal of the North American Benthological Society*, 29, 2, 572-585.

THE FISH FAUNA OF THE TIMIŞ RIVER (BANAT, ROMANIA)

Doru BĂNĂDUC *, *Victor STROILĂ* *
and *Angela CURTEAN-BĂNĂDUC* *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Ioan Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, ad.banaduc@yahoo.com, stroilavictor@yahoo.com, angela.banaduc@ulbs.ro

DOI: 10.2478/trser-2013-0040

KEYWORDS: lotic system, fish communities, spatial dynamic, habitats, human impact, trends, assessment.

ABSTRACT

This study assessed the fish communities' diversity and structure spatial dynamic in the Timiş River, in correlation with the biotope characteristics to establish management measures.

The results are based on quantitative fish samples from 21 stations of the Timiş River, situated between its sources and the Romanian-Serbian border (241 km). The sampling campaign was conducted during 2011-2012.

In the reference zone 32 fish species were identified, belonging to 27 genera and nine families. The fish associations present a high diversity along the entire Romanian sector of the Timiş River.

The fish communities' diversity distribution patterns reflect the biotope conditions diversity and the human impact factors presence and degree on the Timiş River sectors.

The fish communities' diversity assessment in correlation to biotope characteristics allows the establishment of priorities, objectives and measures for the sustainable management of the studied river biodiversity.

ZUSAMMENFASSUNG: Die Fischfauna des Timiș-Flusses (Banat, Rumänien).

Die Studie befasst sich mit der Untersuchung der Diversität, räumlichen Struktur und Dynamik der Fischgemeinschaften im Timiș-Fluss in Verbindung mit den Merkmalen des Lebensraums im Hinblick auf zu ergreifenden Maßnahmen für ein entsprechendes Management.

Die Ergebnisse beruhen auf qualitativen Erfassungen an 21 von den Quellen bis zur serbischen Grenze im Timiș-Fluss entlang einer Strecke von 241 km verteilten Probestellen. Die Probeentnahme erfolgte während des Jahres 2011-2012.

In der Referenzzone wurden 32 Fischarten identifiziert, die zu 27 Gattungen und neun Familien gehören. Die Fischgemeinschaften weisen eine hohe Diversität entlang der gesamten rumänischen Strecke des Timiș auf.

Die Verteilungsmuster der Fischgemeinschaften widerspiegeln die Kennzeichen der Diversität der Lebensraumbedingungen und das Vorhandensein und Maß menschlicher Eingriffsfaktoren an den untersuchten Strecken des Timiș-Flusses.

Die Erfassung der Diversität der Fischgemeinschaften in Verbindung mit den Biotopcharakteristika erlaubt die Festlegung von Prioritäten, Objektiven und Messungen für ein nachhaltiges Management der Biodiversität des untersuchten Flusses.

REZUMAT: Ihtiofauna râului Timiş (Banat, România).

Acest studiu a evaluat diversitatea şi dinamica spațială a comunităților de pești din râul Timiş, în corelație cu caracteristicile de biotop pentru stabilirea măsurilor de management.

Rezultatele se bazează pe probe cantitative de pești din 21 de stații situate de-a lungul râului Timiş, între izvoare şi granița româno-sîrbă (241 km). Campania de prelevare a probelor a fost realizată în 2011-2012.

În zona de referință, au fost identificate 32 specii de pești, aparținând la 27 genuri şi nouă familii. Asociațiile de pești prezintă o diversitate ridicată de-a lungul întregului sector românesc al râului Timiş.

Modelele de distribuție a diversității comunităților de pești reflectă diversitatea condițiilor de biotop, prezența şi gradul factorilor de impact antropic asupra sectoarelor râului Timiş.

Evaluarea diversității comunităților de pești în corelație cu caracteristicile de biotop, permite stabilirea priorităților, obiectivelor şi măsurilor pentru un management sustenabil a râului studiat.

INTRODUCTION

The Timiş River is the main lotic system of the south-west region of Romania, being the largest river of the Banat area, with a total basin surface of 5,795 km^2 and 241 km length in the Romanian national territory and its lowest part in Serbia.

From the ichtiological point of view it was studied only in the 60's of the last century (Bănărescu, 1964).

The Timiş River springs area is located in the eastern part of the Semenic Mountains, in the proximity of Piatra Goznei Peak (1,145 m altitude), flowing and passing through mountainous, hilly and lowland areas. This river is actually formed by the confluence of four upper streams Semenic, Grădiştei, Brebu Nou and Pârâul Lung.

The upper part of the Timiş River basin includes the eastern slopes of the Banat Mountains, the western slopes of Ţarcu Mountains - Muntele Mic and Poiana Ruscă mountains and Timiş-Cerna corridors (Oancea and Velcea, 1987).

The middle-lower basin includes lower altitudes relief units like Lugojului Hills, the Pogănişului Hills, Lugoj Plain and Timiş Plain (Badea and Bugă, 1992).

The Timiş River lower basin is contained in the Serbian territory. (INMH, 1971; Udo et al., 2011; Arba et al., 2013; Ujvari, 1972; Linc, 2002; Ştef and Costea, 2006).

Usually such large lotic systems should be ecologically assessed/monitored as often as it is possible, for their biodiversity conservation and lotic associated services management, and for the riverine human communities' welfare.

With significant human negative impact effects since the XVII Century, this river varies a lot from almost pristine sectors/habitats to heavily impacted ones. The only exhaustive information regarding the ichthyofauna of Timiş River originates before 1960 (Bănărescu, 1964). An update of this information is absolutely necessary in order to be able to achieve an actual river-wide management plan with regard to the fish population.

This study aims to inventory and assess the fish fauna status of the Timiş River in Romania, from its headwaters to the national Romanian-Serbian border, to identify the human activities with significant impact on this important conservative and economic taxonomic group and to suggest management measures.

MATERIAL AND METHODS

This ichthyological study was conducted along the whole Romanian length of the Timiş River (Fig. 1), from its mountainous springs area to the Romanian-Serbian border, during 2011-2012. The fish samples were taken in every season, the paper presenting the total average aboundances of quantitative captures of every sampling section.

Quantitative and qualitative (q) seasonal repeated samples made possible the provision of an updated list of fish species with populations considered permanent, structural balanced and therefore stable, to the extent to which human activities conducted in the future will not change their certain parameters.

In the present fish assemblage survey, through time (one hour) on effort unit, quantitative samples were taken in 21 sampling stations (Fig. 2), with an Aquatech IG 600, 30 A, 0.65/1.2 kw, electrofishing device in the upper sectors and with an IG 1300, 60 A, 2.6 kw, electrofishing device in the middle-lower river course. The fishing team consisted of the same number of members in all the sampling stations to assure a similar effort of sampling during each time period, and comparable results among the stations.

The studied sampling stations were chosen according to: the valley morphology, the type of river substratum and the human impact presence bias (riverine land use, hydro-technical works, substrate mineral exploitation, urban and industrial pollution sources).

The fish were identified, counted and released at once back in their habitat for conservation reasons.

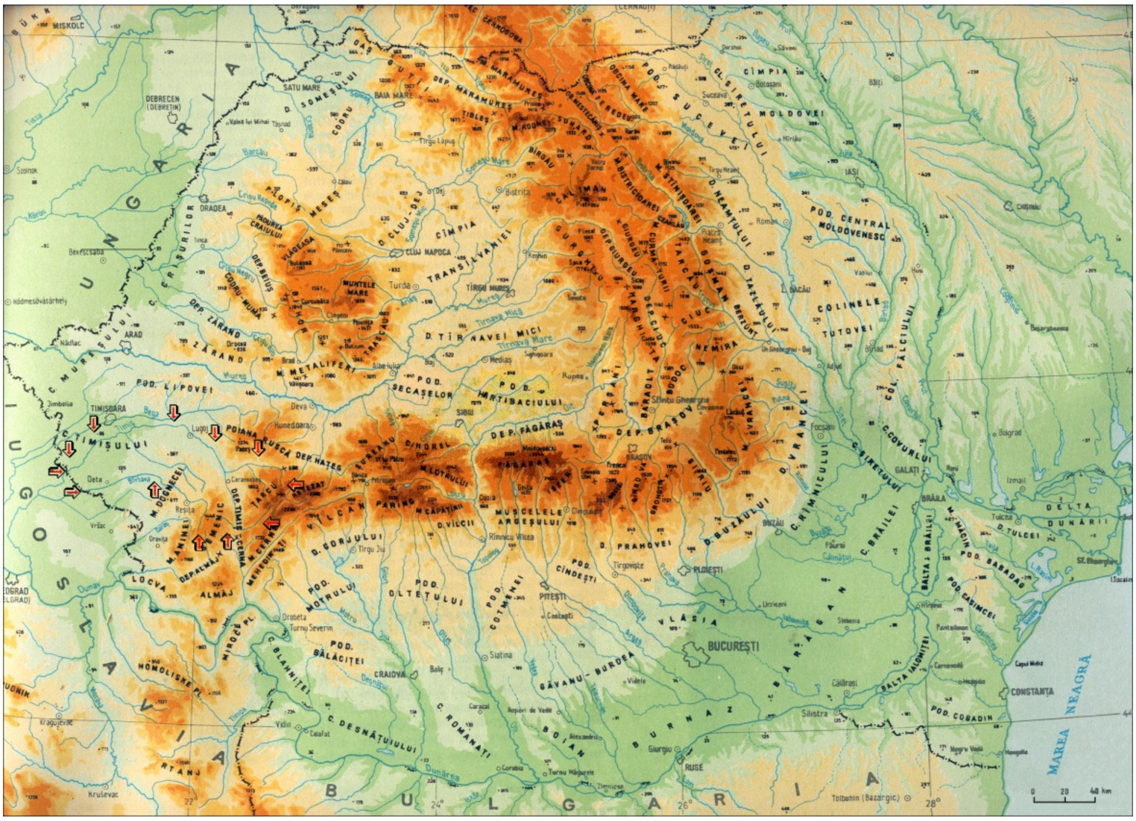


Figure 1: Timiş River basin localization (Romanian sector).

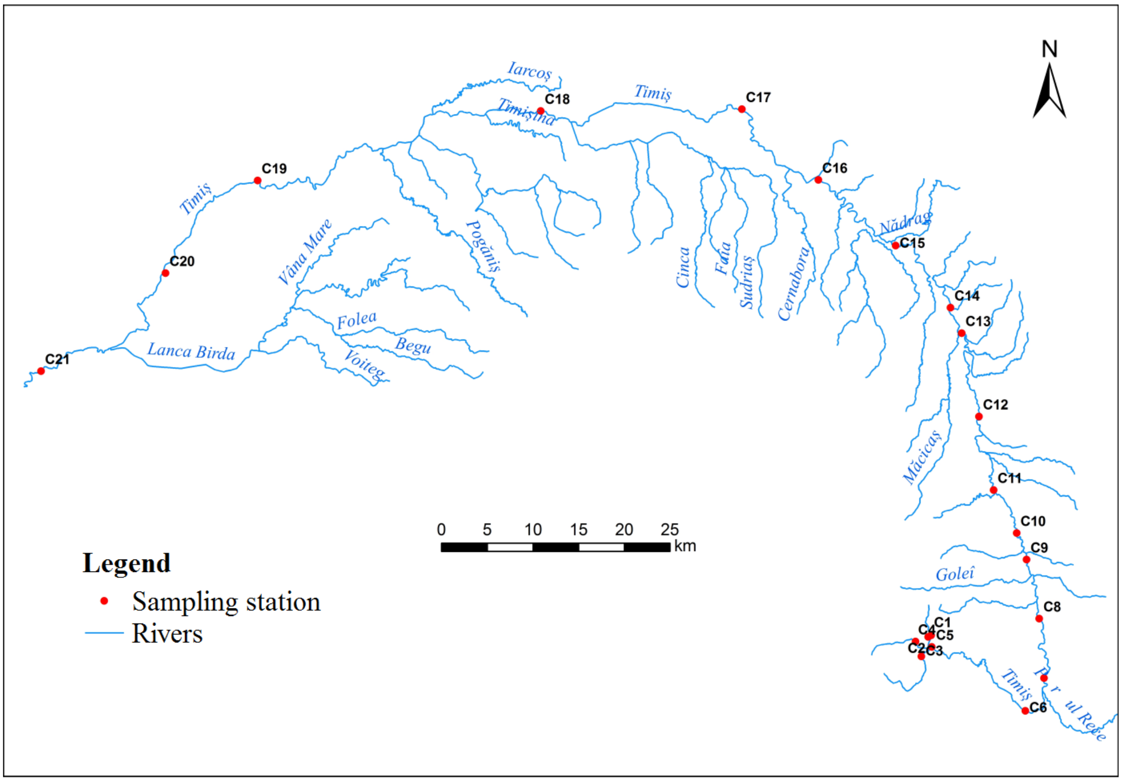


Figure 2: Fish sampling stations (C1-21) on Timiş River.

RESULTS

The studied biological material consists of the following Cyclostomata and Osteichthyes species: *Eudontomyzon danfordy* Regan, 1991; *Eudontomyzon vladykovi* Oliva and Zanandrea, 1959 (q - qualitative sample); *Salmo trutta* Linnaeus, 1758; *Salvelinus fontinalis* (Mitchill, 1814); *Thymallus thymallus* (Linnaeus, 1758); *Esox lucius* Linnaeus, 1758 (q); *Rutilus rutilus* (Linnaeus, 1758) (q); *Squalius cephalus* (Linnaeus, 1758) ; *Phoxinus phoxinus* (Linnaeus) 1758; *Tinca tinca* (Linnaeus, 1758) (q); *Scardinius erythrophthalmus* (Linnaeus, 1758); *Leuciscus aspius* (Linnaeus, 1758) (q); *Alburnus alburnus* (Linnaeus, 1758); *Alburnoides bipunctatus* (Bloch, 1782); *Vimba vimba* (Linnaeus, 1758); *Chondrostoma nasus* (Linnaeus, 1758); *Rhodeus sericeus* (Pallas, 1776); *Gobio gobio* (Linnaeus, 1758); *Romanogobio uranoscopus* (Agassiz, 1828); *Romanogobio albipinnatus* (Lukasch, 1933); *Romanogobio banaticus* (Bănărescu 1960); *Pseudorasbora parva* (Temminck and Schlegel, 1846); *Barbus barbus* (Linnaeus, 1753); *Barbus meridionalis* Risso, 1827; *Cyprinus carpio* Linnaeus 1758; *Carasius auratus* (Linnaeus, 1758); *Barbatula barbatula* (Linnaeus, 1758); *Cobitis taenia* Linnaeus 1758; *Sabanejewia balcanica* (Karaman, 1922); *Silurus glanis* Linnaeus 1758 (q); *Ameiurus nebulosus* (Lesueur, 1819) (q); *Lota lota* (Linnaeus, 1758); *Lepomis gibbosus* (Linnaeus, 1758); *Perca fluviatilis* Linnaeus, 1758; *Gymnocephalus cernua* (Linnaeus, 1758); *Gymnocephalus schraetzer* (Linnaeus, 1758); *Zingel streber* (Siebold, 1863); *Zingel zingel* (Linnaeus, 1766) and *Cottus gobio* Linnaeus 1758.

The four streams (Brebu Nou, Lung, Semenic and Grădişte) form the man-made Trei Ape/Three Waters Lake. The downstream sector of the rock-fill dam forms the Timiş River. These have a different ichtyofauna because they have different characteristic of habitats and because they suffered different effects caused by the human presence along time.

The **Semenic Stream** (**C1** sampling station) with typical mountain habitats (Fig. 3) has a typical mountain dominant fish fauna: *Salmo trutta* (45%), *Phoxinus phoxinus* (25%) and *Eudontomyzon danfordy* (10%), fish species that show a good quality of this stream; and secondary fish species coming from the near Trei Ape Lake: *Squalius cephalus* (15%) and *Perca fluviatilis* (5%). The values represent the average of total abundances obtained in each trip of ichtyofauna sampling in this section.

The relatively difficult car access in this stream area and the inclusion in the Semenic-Cheile Caraşului National Park of this lotic system, respectively the subsequent inclusion of this area also in the Natura 2000 European network by designating here a Natura 2000 site also with the name Semenic-Cheile Caraşului, currently offers very good protection (mainly due to its relative geographic isolation) to mountain ichthyofauna of this stream.

Figure 3: Characteristic Semenic Stream habitat
with 500 m upstream its flow into Trei Ape/Three Waters Lake.

However, an exception with negative effects is the practice of drawing/transporting the cut trees/logs directly in riverbed.

The future increasing accessibility on the local roads can be a threat for this river fish fauna too.

The **Brebu Nou Stream** (C2) (Fig. 4) and **Lung Stream** (C3) (Fig. 5), both flowing into the Trei Ape/Three Waters man-made lake, at a distance of few tens of meters, in the proximity of Brebu Village, with less mountainous geomorphological characteristics and a long lasting anthropogenic impact on banks and terraces (deforestation, grazing and colmatation) have strongly influenced the local lotic habitats and ichthyofauna by species that have proliferated in the downstream lake after the lake formation. Thus, although *Salmo truta* is still there (5.56% in Brebu Nou Stream and 6.98% in Lung Stream), as in the period before the formation of the lake, it is in the minority in favor of *Phoxinus phoxinus* (13.89% in Brebu Nou Stream and 62.79% in Lung Stream), *Squalius cephalus* (77.78% in Brebu Nou Stream) and *Perca fluviatilis* (2.78% in Brebu Nou Stream and 30.23% in Lung Stream). *Eudontomyzon danfordy* disappeared here.

Figure 4: Brebu Nou stream characteristic habitat 500 m upstream the Trei Ape Lake.

Especially the population of *Salmo truta fario*, a species of economic interest, it may grow again, and that of *Eudontomyzon danfordy*, a species of conservation interest, can be reintroduced and can recovers if these rivers management would consider creating physical barriers (small dams of wood) to stop the upstream constant movement of species of fish characteristic for the Trei Ape lake (minnow, chub and perch) and the increase of permanent shading of banks by planting coniferous trees to decrease the water average temperature.

Also, the water quality must be protected by the local (Brebu locality) households and on adjacent lands waste waters which flows in these two small streams and to reduce the sediment deposition in the riverbed based on some riverine vegetation protection. The lack of the antierosional measures on the banks (Fig. 5) and slopes and the presence of small water pools for cows water supply (Fig. 6) affected the river habitats and salmonids.

Figure 5: Loose slopes, on the roadside of Brebu-Slatina Timiş near the Lung Stream, increase sedimentation and habitats degradation impact on salmonids.

Figure 6: Lenitic sector transformed from lotic sector, for cattle water reservoires use.

In terms of habitat conditions and ichthyofauna, the last analyzed of the four tributaries that form the Trei Ape Lake, **Grădişte Stream** (**C4**) (Fig. 7) has intermediate characteristics for the first three tributaries analyzed so far. Here are present the species: *Squalius cephalus* (62.5%), *Eudontomyzon danfordi* (12.5%), *Phoxinus phoxinus* (12.5%) and *Perca fluviatilis* (12.5).

Figure 7: Characteristic habitat for the Grădişte Stream.

For the preservation of the natural habitats and ichthyocenoses, here, as in Lung and Brebu Nou streams cases, would be of interest to build a small wooden dam at the river confluence with the Trei Ape Lake, to prevent the upstream advancement of the lenitic fish species (the minnow, the chub and the perch) and pressure on typical mountain/lotic species (the sucker fish), important under conservative aspects.

There are also required to implement management measures for the Gărâna Village waste waters and poaching control.

The numerical increasing with 66% of the alien cyprinids in this lotic systems area, situation induced by the Trei Ape Lake (Fig. 8) lotic discontinuum (Fig. 9), makes that the four tributaries which form the lake, where the river springs now, need a proper management of mountain fish species of conservative or economically interest, because we cannot count on the inputs of fresh genetic material from downstream.

Figure 8: The lotic discontinuum due to Trei Ape/Three Waters Lake, view from the dam.

Figure 9: The lotic discontinuum due to Three Waters Dam - the overflow spilway of the dam.

In the sampling sector located at **500 m downstream the rockfill dam of the Trei Ape Lake** (**C5**) were registered the following total abundances: *Squalius cephalus* (37.78%), *Salmo trutta* (35.56%), *Perca fluviatilis* (13.33), *Phoxinus phoxinus* (8.89%) and *Eudontomyzon danfordy* (4.44%).

Salmo trutta fario, *Eudontomyzon danfordy* and *Phoxinus phoxinus* reveal the natural mountain habitat and the Timiş River ichthyofauna here; *Leuciscus cephalus* and *Perca fluviatilis* show the direct influence of the habitat and ichthyofauna of Trei Ape Lake (Fig. 8).

The low water flow regime (Fig. 10), especially in periods of drought, still allow the existence of populations of *Salmo trutta fario* and *Eudontomyzon danfordyi* under former natural potential of this sector of the river, the individuals sampled from the holes in the substrate of the riverbed, where they retreat after periods of floods, by overflow outlets of the lake or they may come from downstream during their migration towards the upstream.

The water passage under the dam is made by iron pipes, the iron deposits causing an impact (Fe sedimentation) covering the invertebrate microhabitats, the fish trophic base.

Figure 10: River habitat downstream the Trei Ape/Three Waters Dam.

For the remote area of Timiş between Trei Ape Dam and Teregova, it is worth mentioning the presence of an individual of *Eudontomyzon vladikovy* (q), a species of high conservative importance, the Timiş River basin being the only watershed where this fish have been lately still found in Romania. Together with this very rare species were also found *Eudontomyzon danfordyi, Salmo trutta fario* and *Phoxinus phoxinus*, revealing good local habitat conditions.

One km upstream the **Teregova** locality in sub-mountain habitats (**C6**) (Fig. 11) were collected the following species: *Phoxinus phoxinus* (38.57%), *Cottus gobio* (30%), *Barbatula barbatula* (24.29%), *Edontomyzon danfordy* (1.43%), *Salmo trutta* (1.43%), *Alburnoides bipunctatus* (1.43%), *Barbus meridionalis* (1.43%) and *Squalius cephalus* (1.43%). The presence of fish species characteristic for the downstream sector (*Alburnoides bipunctatus*, *Leuciscus cephalus* and *Barbus meridionalis*) is determined by the modified lotic habitats in semi-lenitic areas, habitats altered (Fig. 12) for water supply of a local mill.

Figure 11: Characteristic habitat for the Timiş River at 2 km upstream Teregova locality.

Figure 12: Anthropogenically altered habitat at 1 km upstream of the Teregova locality.

In the sampling station located in the **Teregova Gorges** (**C7**), at 2 km upstream from the Armeniş locality were obtained the following total abundances: *Barbatula barbatula* (26.98%), *Eudontomyzon danfordy* (22.22%), *Barbus meridionalis* (22.22%), *Phoxinus phoxinus* (11.11%), *Pseudorasbora parva* (4.76%), *Romanogobio uranoscopus* (3.17), *Alburnoides bipunctatus* (1.59%), *Squalius cephalus* (1.59%), *Salvelinus fontinalis* (1.59%), *Thymallus thymallus* (1.59%), *Cottus gobio* (1.59%) and *Chondrostoma nasus* (1.59%).

Eudontomyzon danfordi (very frequent and active in this river sector - Fig. 13), *Salmo trutta fario, Salvelinus fontinalis, Thymallus thymallus, Cottus gobio, Phoxinus phoxinus, Orthrias barbatulus*, reveal the sub-mountainous character of this sector of the Timiş River and the following (*Barbus meridionalis*, *Gobio uranoscopus*, *Alburnoides bipunctatus*, *Leuciscus cephalus* and *Chondrostoma nasus*) reveal the continuity and natural influence of downstream ichthyological sectors.

Although with a specific very complex structure and a balanced age structure of the ichthyofauna, which shows a very good condition of this lotic sector, the presence of the invasive fish species *Pseudorasbora parva* can show that the biocenosis condition is not optimal, since this foreign species was able to create an ecological niche and remain viable in this area.

Figure 13: The traces of the place where was set a sucker flish on a Mediterranean barbell.

In the sampling sector (Fig. 14) located 0.5 km upstream of the **Sadova Veche** Village (**C8**) were collected and identified the following species: *Barbus meridionalis* (37.5%), *Alburnus alburnus* (16.67%), *Cottus gobio* (13.89%), *Phoxinus phoxinus* (8.33%), *Squalius cephalus* (6.94%), *Alburnoides bipunctatus* (6.94%), *Barbatula barbatula* (4.17%), *Eudontomyzon danfordi* (1.39%), *Romanogobio uranoscopus* (1.39%), *Chondrostoma nasus* (1.39%) and *Sabanejewia balcanica* (1.39%). The quantitative aspects of ichthyological samples can reveal a liquid flow mismanagement due to hidrotechnical works in the proximity eastern main tributaries basins (Râul Rece and Feneş). Also there are information about ongoing poaching.

Figure 14: Timiş River characteristic lotic habitat near Sadova Veche locality.

In the sampling area located upstream of **Bucoşniţa** Village (Fig. 15) (**C9**) were collected and identified the following species: *Eudontomyzon danfordy* (1.45%), *Squalius cephalus* (1.45%), *Alburnus alburnus* (13.04%), *Alburnoides bipunctatus* (5.8%), *Gobio gobio* (5.8%), *Romanogobio uranoscopus* (1.45%), *Barbus meridionalis* (44.93%), *Barbatula barbatula* (5.8%), *Sabanejewia balcanica* (8.7%), *Cottus gobio* (8.7%), *Phoxinus phoxinus* (1.45%) and *Chondrostoma nasus* (1.45%). Poaching is practiced in the area.

Figure 15: Characteristic habitat for Timiş River, in the proximity of Bucoşniţa locality.

In the sampling area located near the village **Petroşniţa** (**C10**) (Fig. 16) were collected and identified the following species: *Sabanejewia balcanica* (27.87%), *Alburnus alburnus* (18.03%), *Romanogobio uranoscopus* (14.75%), *Barbus meridionalis* (14.75%), *Barbatula barbatula* (11.48%), *Squalius cephalus* (4.92%), *Eudontomyzon danfordy* (1.64%), *Alburnoides bipunctatus* (1.64%), *Gobio gobio* (1.64%), *Chondrostoma nasus* (1.64%) and *Cottus gobio* (1.64%). There is information about intensive poaching, including with electricity.

Figure 16: Characteristic habitat for Timiş River, in the proximity of Petroşniţa locality.

In the sampling area located in the locality **Buchin** (Fig. 17) (**C11**) were collected and identified the following species: *Barbus meridionalis* (79.59%), *Alburnus alburnus* (4.08%), *Romanogobio uranoscopus* (4.08), *Barbatula barbatula* (4.08%) *Squalius cephalus* (2.04%), *Alburnoides bipunctatus* (2.04%), *Chondrostoma nasus* (2.04%) and *Sabanejewia balcanica* (2.04%). The over 50% numerical reduction of fish species in comparison with older data (Bănărescu, 1964), although the vast majority of species are missing in this sector, it is in the areas located immediately upstream and immediately downstream is due to mismanagement of the mining of minerals from this river sector. It should be noted that scientific knowledge is necessary for these operations to grow aquatic biodiversity, but not to decrease it. But the investors or local administrations should contact the proper biodiversity specialists to achieve this goal required of the coexistence of financial gain with protection of natural resources including biodiversity.

Figure 17: Lotic habitat adversely affected by a poor management of minerals exploitations.

In the sampling station located at **Caransebeş** locality (Figs. 16, 17 and 18), upstream of **Jupa** Village (**C12**) were obtained the following total abundances: *Barbus meridionalis* (48.28%), *Barbatula barbatula* (18.97%), *Romanogobio uranoscopus* (12.07%), *Squalius cephalus* (6.9%), *Sabanejewia balcanica* (5.17%), *Rhodeus sericeus* (1.72%), *Romanogobio banaticus* (1.72%), *Alburnus alburnus* (1.72%), *Alburnoides bipunctatus* (1.72%), *Chondrostoma nasus* (1.72%), *Esox lucius* (q).

Figure 16: Typical habitat for Timiş River, downstream from the town Caransebeş.

The total abundances of captured and identified species in this sector has shown the existence in the area of *Barbus meridionalis*, species penetrated here only in recent decades that has replaced the *Barbus barbus*, which now appears only downstream (P. M. Bănărescu, in verbis). Also from the values of total abundances transpires the negative impact of the locality Caransebeş, organic pollution (Fig. 17) and not only, and habitat modification due to minerals exploitation (Fig. 18) poorly designed embankments of the banks, largely damage of the corridors of tree vegetation on the banks of Timiş River, which induce changes in some main physico-chemical parameters of water, such as temperature, oxygenation, light penetration in the water, etc., the liquid and solid flow regime change due to inlet of other flows with different characteristics from other river basins (upper Bistra Mărului River water is passed in the Timiş River tributary, the Sebeş River, which confluence in Caransebeş); for example, this can be the reason of *Barbus barbus* replacement with *Barbus meridionalis*.

Figure 17: Organic load deposited on the substrate of the riverbed - detail.

Figure 18: Anthropogenic lentic environments in the proximity of the Timiş riverbed.

In the sampling area located near the locality **Peştere** (**C13**) (Fig. 19) were collected and identified the following species: *Barbus meridionalis* (23.16%), *Barbatula barbatula* (22.11%), *Alburnus alburnus* (12.63%), *Alburnoides bipunctatus* (8.42%), *Romanogobio uranoscopus* (8.42%), *Squalius cephalus* (6.32%), *Romanogobio banaticus* (5.26%), *Sabanejewia balcanica* (5.26%), *Phoxinus phoxinus* (5.26%), *Chondrostoma nasus* (1.05%), *Rhodeus sericeus* (1.05%), *Gobio gobio* (1.05%), *Squalius aspius* (q) and *Esox lucius* (q). The sector is relative far from human impact, being proposed by the authors in the Biogeographic seminars for Romania and Bulgaria (helded in "Lucian Blaga" University of Sibiu, Sibiu/Romania, 2008) to be part of the Natura 2000 site of the upstream Timiş.

Figure 19: Characteristic habitat for Timiş River, in the sector of Peştere locality.

In the sampling area located in the proximity of the locality **Constatin Daicoviciu** (the former Căvăran locality) (**C14**) (Figs. 20 and 21), were collected and identified the following species: *Barbatula barbatula* (27.4%), *Alburnus alburnus* (15.07%), *Romanogobio uranoscopus* (9.59%), *Gobio gobio* (9.59%), *Alburnoides bipunctatus* (9.59%), *Squalius cephalus* (6.85%), *Romanogobio banaticus* (5.48%), *Phoxinus phoxinus* (5.48%), *Sabanejewia balcanica* (5.48%), *Rhodeus sericeus* (4.11%), *Chondrostoma nasus* (1.37%), *Squalius aspius* (q) and *Esox lucius* (q).

Figure 20: Characteristic habitat for Timiş River at Constantin Daicoviciu locality.

Figure 21: Habitat affected by mining ballast at Constantin Daicoviciu locality.

In the sampling area located in the proximity of the locality **Jena** (**C15**) were collected and identified the following species: *Alburnus alburnus* (40%), *Gobio gobio* (20%), *Alburnoides bipunctatus* (20%) and *Squalius cephalus* (20%). The decreasing of the number of species is due to aggressive (intensive and extensive) exploitation of the substrate of the riverbed (Figs. 22 and 23), which actually led even to lowering the groundwater levels in this sector till downstream Lugoj locality.

Figure 22: Aggressive exploitation of the substrate with lotic habitat damage.

Figure 23: Aggressive exploitation of the substrate with lotic habitat damage.

In the sampling area located in the proximity of the **Lugojel** locality (**C16**) (Fig. 24), the mud became dominant as a substrate (Fig. 25) were collected and identified the following species: *Barbus barbus* (41.67%), *Perca fluviatilis* (13.1%), *Squalius cephalus* (13.1%), *Alburnoides bipunctatus* (10.71%), *Barbus meridionalis* (5.95%), *Alburnus alburnus* (3.57%), *Gobio gobio* (2.38%), *Carasius gibelio* (2.38%), *Sabanejewia balcanica* (1.19%), *Romanogobio banaticus* (1.19%), *Pseudorasbora parva* (1.19%), *Rhodeus sericeus* (1.19%), *Chondrostoma nasus* (1.19%), *Scardinius erythrophthalmus* (1.19%), *Esox lucius* (q), *Squalius aspius* (q). The increasing number of fish species is determined by the decline of the ballast mining impact in the upstream and passage of the river in a high ichthyological diversity river sector.

Figure 24: Characteristic habitat for Timiş River, near Lugojel locality.

Figure 25: River sector with dominant mudy substrate near Lugojel locality.

In the sampling station located at **Coştei (C17)**, downstream from the Lugoj town were obtained the following total abundances: *Barbus barbus* (41.91%), *Squalius cephalus* 16.18%, *Perca fluviatilis* (12.5%), *Alburnoides bipunctatus* (12.5%), *Alburnus alburnus* (3.68%), *Gobio gobio* (3.68%), *Carasius auratus* (2.94%), *Chondrostoma nasus* (1.47%), *Barbus meridionalis* (0.74%), *Sabanejewia balcanica* (0.74%), *Pseudorasbora parva* (0.74%), *Rhodeus sericeus* (0.74%), *Scardinius erythrophthalmus* (0.74%), *Cobitis taenia* (0.74%), *Lepomis gibbosus* (0.74%). The specific diversity is affected by the oversized (in the last 10 years) dam towards the hydraulic node Coştei (Fig. 26), who is here since 1758. The near Timiş-Bega channel, collect the majority, and sometimes all the water of Timiş River to deviate it through Bega River (Fig. 27).

Figure 26. Major lotic discontinuity at Coşteiu Dam; view from the dam to downstream.

Figure 27: The Timiş-Bega deviation/channel.

In the sampling area located between **Topolovăţu Mare** and **Hitiaş** localities (**C18**) (Fig. 28) were identified the following species: *Barbus barbus* (23.2%), *Romanogobio banaticus* (17.01%), *Squalius cephalus* (13.4%), *Sabanejewia balcanica* (11.86%), *Alburnoides bipunctatus* (8.25%), *Perca fluviatilis* (8.25%), *Alburnus alburnus* (4.64%), *Scardinius erythrophthalmus* (2.58%), *Lota lota* (2.58%), *Gobio gobio* (2.06%), *Romanogobio albipinnatus* (1.55%), *Carassius gibelio* (1.55%), *Cobitis taenia* (1.03%), *Rhodeus sericeus* (1.03%), *Pseudorasbora parva* (0.52%), *Vimba vimba* (0.52%), *Silurus glanis* (q), *Ictalurus nebulosus* (q), *Cyprinus carpio* (q), *Lepomis gibbosus* (q), *Acerina cernua* (q), *Aspro streber* (q), *Gymnocephalus schraetzer* (q), *Abramis brama* (q), *Esox lucius* (q), *Rutilus rutilus* (q) and *Aspius aspius* (q). The diversity of fish species shows a good lotic ecosystem status.

Figure 28: Characteristic habitat for Timiş River betweenTopolovăţu Mare and Hitiaş.

In the sampling station located at **Şag** (**C19**), were obtained the following total abundances (the values represent the average of total abundances obtained in each trip of ichtyofauna sampling in this section): *Sabanejewia balcanica* (21.3%), *Romanogobio banaticus* (16.96%), *Barbus barbus* (14.35%), *Squalius cephalus* (12.61%), *Perca fluviatilis* (7.39), *Alburnoides bipunctatus* (6.09%), *Alburnus alburnus* (5.22%), *Scardinius erythrophthalmus* (3.04%), *Lota lota* (3.04%), *Romanogobio albipinnatus* (2.17%), *Gobio gobio* (1.74%), *Pseudorasbora parva* (1.3%), *Rhodeus sericeus* (1.3%), *Cobitis taenia* (1.3%), *Lepomis gibbosus* (0.87%), *Vimba vimba* (0.43%), *Cyprinius carpio* (0.43%), *Carassius auratus* (0.43%), *Acerina cernua* (q), *Silurus glanis* (q), *Ictalurus nebulosus* (q), *Gymnocephalus schraetzer* (q), *Aspro streber* (q), *Chondrostoma nasus* (q), *Abramis brama* (q), *Streber lucioperca* (q), *Esox lucius* (q), *Aspius aspius* (q), *Rutilus rutilus* (q); the diversity of fish species showing a good lotic ecosystem both with long natural sectors (Fig. 29) and anthropogenicaly modified short sectos (Fig. 30).

Figure 29. Characteristic habitat for Timiş River at Şag.

Figure 30: Affected river sector following hydrotechnical works related to a bridge.

Near the locality **Cebza (C20)** (Fig. 31) were identified: *Romanogobio banaticus* (22.22%), *Barbus barbus* (15.28%), *Squalius cephalus* (14.58%), *Alburnus alburnus* (11.11%), *Perca fluviatilis* (10.42%), *Lepomis gibbosus* (5.56%), *Gobio gobio* (4.17%), *Scardinius erythrophthalmus* (4.17%), *Romanogobio albipinnatus* (2.78%), *Pseudorasbora parva* (2.08%), *Zingel zingel* (1.39%), *Sabanejewia aurata balcanica* (0.69%), *Cyprinus carpio* (0.69%), *Carassius auratus* (0.69%), *Sabanejewia balcanica* (0.69%), *Rhodeus sericeus* (0.69%), *Cobitis taenia* (0.69%), *Alburnoides bipunctatus* (0.69%), *Vimba vimba* (0.69%), *Gymnocephalus cernuus* (0.69%), *Zingel streber* (0.69%), *Chondrostoma nasus* (q), *Silurus glanis* (q), *Ictalurus nebulosus* (q), *Lota lota* (q) (Fig. 32), *Blicca bjoerkna* (q), *Abramis brama* (q), *Silurus glanis* (q), *Ictalurus nebulosus* (q), *Streber lucioperca* (q), *Esox lucius* (q), *Aspius aspius* (q); the diversity of fish species show a good lotic ecosystem.

Figure 31: Characteristic habitat for Timiş River, in the proximity of the locality Cebza.

Figure 32. *Lota lota*.

In the sampling station located at **Cruceni (C21)** (Fig. 33), were obtained the following total abundances: *Alburnus alburnus* (17.54%), *Squalius cephalus* (15.79%), *Lepomis gibbosus* (13.16%), *Perca fluviatilis* (12.28%), *Barbus barbus* (9.65%), *Zingel zingel* (7.02%), *Gobio gobio* (6.14%), *Scardinius erythrophthalmus* (5.26%), *Gymnocephalus cernua* (5.26%), *Zingel streber* (4.39%), *Pseudorasbora parva* (2.63%), *Gymnocephalus schraetzer* (0.88%) (Fig. 34); the lower ichthyological diversity can be attributed to increased anthropogenic uniformity of habitat.

Figure 33: Timiş River anthropogenic modified habitat, at Cruceni.

Figure 34: *Zingel streber*.

DISCUSSIONS

The identified fish communities similarity (Fig. 35) reveal the fact that almost the whole river course is more or less (with few exceptions) negatively damaged by the human impact, situation which disturb in different degrees the natural lotic longitudinal connectivity induced by the regional and local relief (Fig. 36), in respect of habitats and the associated ichtiocenosis. The fish communities similarities were obtained only basing on the quantitative (electrofishing) samples results and not on the qualitative samples results (q) too, based on other qualitative methods (angling and/or net traps fishing).

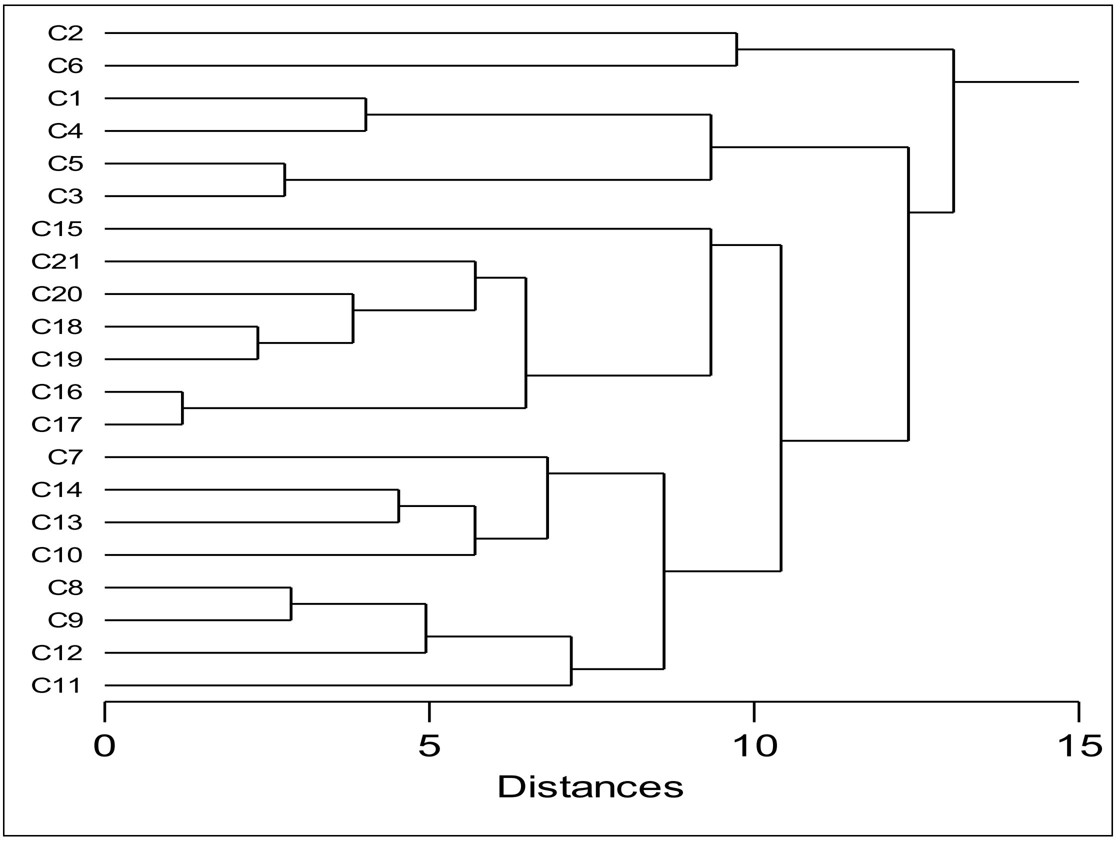


Figure 35: Timiș River fish communities similarity.

C1-C6 sector (Fig. 35) the mountain and sub-mountain (mainly schsists geological substratum) (Fig. 36) related rivers sectors of Timiş River, with different/variable ichtiological characteristics among them related with different types of human impact presence.

C1 (Semenic Stream) and C4 (Grădiște Stream) sectors (Fig. 35) are similar in respect of the fish communities mainly due to the fact that their sources and upper sectors are protected by natural conservation areas (Semenic-Cheile Caraşului National Park).

C2 (Brebu Nou Stream section) and C6 (upstream Teregova locality sector) sectors (Fig. 35) seem to be similar from the ichthyofauna point of view because these sectors are influenced in similar ways by the presence of anthropogenicaly pools in the riverbed.

C3 (Lung Stream section) and C5 (downstream Trei Ape Dam) sectors (Fig. 35) are similar apparently based on their natural (in the first case) and antropogenical (in the second case) variability and scarcity of water flow especially in the drought seasons.

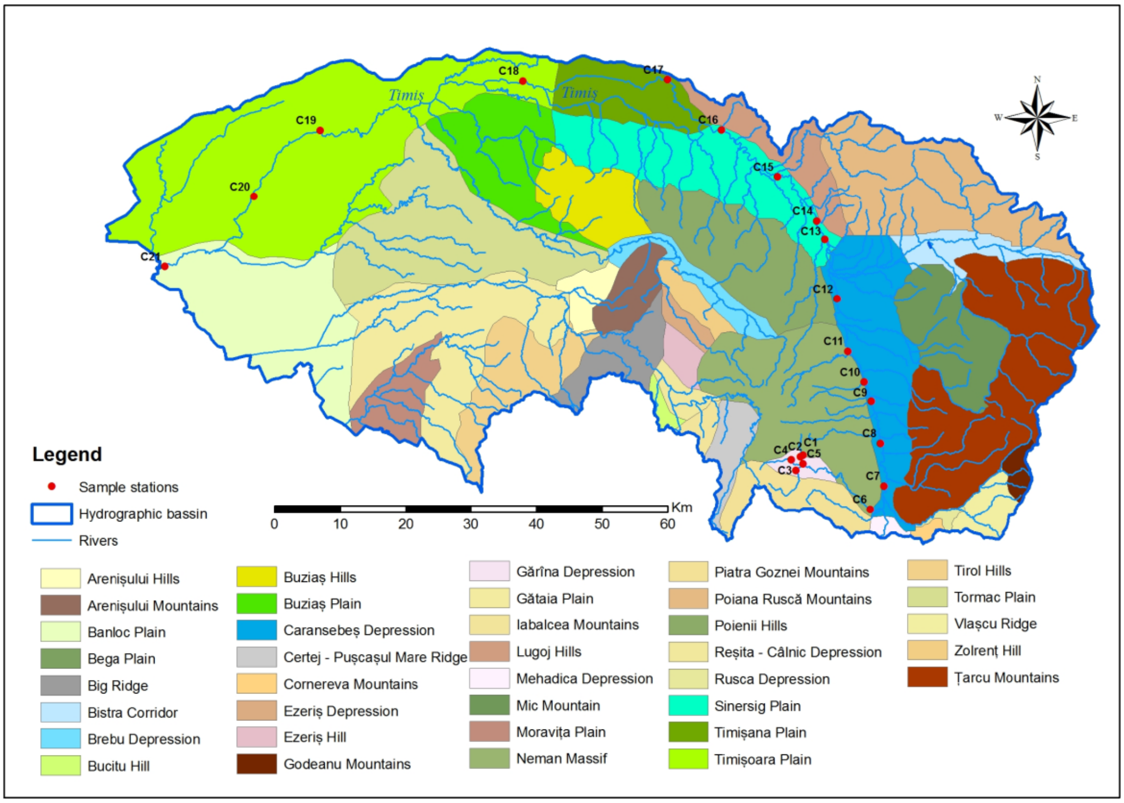


Figure 36: Timiş River main geographical units and samplig stations

C7-C12 sector obviously highlight the entering of Timiş River in the Caransebeş Depression area (Fig. 36), habitats reflected in the ichthyofauna structure. This sector is prolonged till **C14** (Fig. 35) from the fish fauna point of view because of Bistra River tributary, received here, bringing a good quality water and also upper river characteristic fish species, prolonging/keeping this Timiş River sector in an upper fish fauna characteristic diversity structure. The very low human impact here helps this situation too.

C7 (Teregova Gorges section) was individualized (Fig. 35) because of the best natural habitats and associated related fish community structure, due to its relative geographic isolation and may be because is proper protected by an upper Timiş River Natura 2000 site.

C8 (Sadova section) and C9 (Petroşniţa section) represent a similar river sector because the river gets out of the Teregova Gorges geographical relative isolation and enter in a sector where the river is influenced by the local riverine human impact (the villages are localised on the river course) and ecologically inadequate water flow management due to some hydrotechnical works present on the upper eastern main tributaries.

C11-12 sector (Fig. 35) is obviously and significantly negatively affected by the human activities (riverbed mineral exploitations, pollution, embankments, riverine vegetation destruction, etc.) of the Caransebeş locality.

C13-14 fish fauna similarity (Fig. 35) is determined by the enter of the Timiş River in the Sinersig Plain (Fig. 36) and moustly to the effect of the Bistra River confluence, in terms of water quality and fish species (Bănăduc, unpublished data).

C15 sector is obviously individualised (Fig. 35) due to the decrease of the number of fish species, due to aggressive (intensive and extensive) exploitation of the river substrate.

C16-17 fish associations similarity (Fig. 35) can be based on their common position in Timişana Plain (Fig. 36.), can be aspected that this similarity to decrease in the future due to the local dam (Coştei hydraulic node) oversized in the last few years.

C18-21 sector have a relative fish species diversity similarity (Fig. 35) due to these sections localisation in the lowest Romanian geographical units of the Timiş River (Timişoara Plain) (Fig. 36.). The quality of the habitats still separate them in two, C18-C19 with better habitats and C20-C21 with habitats more affected mainly by human hidrotechnical works, especially in the lowest sampling station.

CONCLUSIONS

The length and direction of flow of the Timiş River, its position and the surface of its hydrographic basin, the multitude of anthropogenic impacts make one of the most complex medium size river in Romanian Carpathian Basin regarding the fish fauna.

The identified fish communities structure variation can be explained based on the geographic units characteristics and human activities impact. The actual fish fauna of this river suffered significant modifications in the last half of the century, and its dynamic it is still not in an equilibrium state mainly due to the human impact dynamic.

This fish fauna assessment should be continued through monitoring in subsequent years in order to grasp the dynamic elements, both of fish structurally stable populations and associations, and of those structurally unstable.

In this river basin management plan must be implemented a fish monitoring system with at least 12 permanent seasonal monitoring stations (one for every identified similarity fish species groups) so that the conclusions can have the degree of accuracy required to the optimal management at the level of the entire river and subsequently at the level of the entire basin.

ACKNOWLEDGMENTS

This paper results are based on the scientific field campaigns of the project "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS project, no. 411 - 90964/30.12.2010/07, of "Lucian Blaga" University, Faculty of Sceinces, financed by the European Community. The authors thank to the GIS expert Gheorghe L. for figure number 36 and the following students for their help in some of the the field campaignes: Stroilă V., Mărginean M. and Răchită R.. A good thought to my childhood and teenage best friend Adam H. with which we discovered together the wonderful Timiş River.

REFERENCES

1. Arba A., 2013 – Extreme Hydro-Meteorological phenomena on the hydrographical basin of Timiş (1965-2009), *Riscuri şi Catastrofe*, XII, 12, 1, 99-112.
2. Badea L. and Bugă D. (coord.), 1992 – Geografia României IV, Regiunile pericarpatice, Edit. Academiei Române, București, 580. (in Romanian)
3. Bănărescu P. M., 1964 – Fauna R.P.R., Pisces-Osteichthyes, (Peşti ganoizi şi osoşi), XIII, Edit. Academiei Române, București, 959. (in Romanian)
4. Costea M., 2006 – Riscul la inundaţii. Impactul în peisaj, în Hidrologie aplicată, Ştef, V. and Costea M. (eds.), Edit. Universităţii „Lucian Blaga" din Sibiu, 205-240. (in Romanian)
5. Diaconu C., 1971 – Râurile României. Monografie, Edit. INMH, București, 494. (in Romanian)
6. Linc R., 2002 – Culoarul Timiş - Cerna, Edit. Universităţii din Oradea. (in Romanian)
7. Oancea D. and Velcea V. (coord.), 1987 – Geografia României, III, Carpaţii şi Depresiunea Transilvaniei, Edit. Academiei, București, 647. (in Romanian).
8. Udo J., Aldescu C., Dumitrache R. and Luca L., 2011 – INHGA, 109-122. (in Romanian)
9. Ujvari I., 1972 – Geografia apelor României, Edit. Științifică, București, 577. (in Romanian)

THE TIMIŞ RIVER BASIN (BANAT, ROMANIA) NATURAL AND ANTHROPOGENIC ELEMENTS. A STUDY CASE - MANAGEMENT CHALENGES

Bianca BURGHELEA * *Doru BĂNĂDUC* * and *Angela CURTEAN-BĂNĂDUC* *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, Dr. Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, burghelea.bianca@yahoo.com, ad.banaduc@yahoo.com, angela.banaduc@ulbsibiu.ro

DOI: 10.2478/trser-2013-0041

KEYWORDS: Timiş River, natural background, anthropogenic impacts, management needs.

ABSTRACT

This study presents a summary of the human impact activity analysis that has influenced the ecological state of the Timiş River.

The results show that because of human activity the Timiş riverbed has been significantly changed due to serious degradation of water quality and extinction of aquatic biota.

In the context of the European Water Framework Directive, in order to achieve water quality standards, the present work aims to take stock of the main human intervention and its effects within the basin to find adequate management solutions to achieve "good ecologically status".

RĖSUMĖ: Les éléments naturels et anthropogéniques du bassin de la rivière Timiş (Banat, Roumanie). Une étude de cas - La mise à l'épreuve d'une gestion.

Cet article présente une synthèse de l'analyse des activités humaines d'impact ont influencé l'état écologique de la rivière Timiş.

Les résultats montrent que le lit de la rivière Timiş, car de nombreuses activités humaines réalisées, il ya eu des changements mineurs dans le lit de la rivière, une grave dégradation de la qualité de l'eau et l'élimination des organismes aquatiques.

Afin d'atteindre les normes de qualité de l'eau dans le contexte de la directive cadre européenne sur l'eau, ce document vise à faire le point de la principale intervention humaine dans le bassin et les changements qu'ils amenés à des solutions de gestion appropriées pour atteindre un "bon état de vue écologique".

REZUMAT: Elemente naturale şi antropice ale bazinul râului Timiş (Banat, România). Studiu de caz - provocări de management.

Lucrarea de față prezintă o sinteză a analizei privind impactul activităților umane ce au influențat starea ecologică a râului Timiș.

Rezultatele arată că la nivelul albiei râului Timiş, datorită numeroaselor activităţi umane desfăsurate, s-au produs modificări ale albiei minore a râului, degradarea gravă a calității apei și eliminarea elementelor de biota acvatică.

În vederea atingerii standardelor de calitate a apei în contextul Directivei Europene Cadru pentru Apă, lucrarea de față își propune realizarea unui bilanț a principalelor intervenții antropice din cadrul bazinului și a modificărilor induse de acestea pentru a găsi soluții de management adecvate pentru atingerea unei „stări bune din punct de vedere ecologic".

INTRODUCTION

Since water is indispensable to human life, the human history cannot be understood if its relation to the rivers, lakes and underground water is not understood. The humans lived along the rivers and near the lakes or wetlands since the beginning of their history. Great ancient civilizations (Egypt, Mesopotamia, China, etc.) relied obviously on important water sources (Nile, Tigris, Euphrates, Yellow, Yangzi, etc.). The river waters have been and will be a direct source of food for humans, facilitate explorations, transport and agricultural use of the riverine lands, satisfy the communities' hygiene needs, provide an energy source or space for relaxation. (Goubert, 1989; Fagan, 2011; Solomon, 2010; Diamond, 2011; Laenen and Dunnette, 1997; Alcamo et al., 2007; Postel, 2000) Tiny villages or the world's great cities usually need the proximity of rivers or lakes. Different studies revealed the economic value of river basins in the billions of dollars (Schuyt, 2005). In the man-river relation, many types of coexistence can be seen, based on the humans' attitude and actions. At one end, the improvement efforts for water supply and waste management in France, in the 19th century, exemplify humanity's desire for using water to increase the life standards. At another end the efforts of Russia to create canals and dams in the 1930s show the follies humans can do in their illusions to control water. In general people once thought that the associated natural resources and services offered by rivers were endless but now we understand the opposite bitter truth at a global scale. (Pandi, 2002; Henrichs and Alcamo, 2001; Hughes, 1978; Van Dijk et al., 1994; Malmqvist and Rundle, 2002; Allan, 2004; Lacoste, 2003; Turner et al., 2007)

The Europeans need and love their rivers but they also abuse them. Even the large ones such asVolga, Danube, Rhine and Rhône can no longer be assured of reaching the sea unhindered. In Europe this situation is more complex due to the presence of over 150 transborder rivers. Danube is a complex river itself due to the fact that this 29th largest river in the world passes through 19 countries and 10 ecoregions. (Tockner et al., 2009; Müller, 1995; Litvinov et al., 2009).

As far as aquatic and semiaquatic species goes, Danube is the richest basin in Europe. About 20% of European freshwater fish fauna, representing 115 native species, occur in this basin. Danube's ecological status and fishing activity are influenced by regularization schemes which began in the 19th century and early 20th century. In total, approximately 600 major hydraulic plant structures (dams and weirs greater than 15 m), including hydroelectric dams (over 160) were built along the Danube and its main tributaries; this does not include many smaller dams. Over the main course of the Danube River, 69 dams have been built and 30% of its total length is occupied. Upstream of Bratislava City, only about 15% of the 1000 km remain free. Furthermore, there are 34 dams along the river Lech, Austria/Germany. Instead, the river Isar is one of the last natural alpine rivers in Europe. Construction of damsystems on river Gabcikovo near Bratislava, opened in 1992, led to a decline in annual fish catch by more than 80% in 1993, compared to the pre-dam period (1961-1979). Construction of the hydroelectric plant Iron Gates (1972, 1984) had a major impact on the sturgeon populations in the middle of the Danube. The major consequences of the regularization of the Danube River, including its tributaries, are flood reduction (Inn - 210 ha of the 1600 ha existing in 1855, Moravia and Siret), loss of fish and invertebrate stocks (Drava), increased soil salinity (Tisza/Tisa), clogging the downstream hydraulic works (clogging of lake Brăteşti due to hydropower plant Stânca-Costeşti situated on the river Prut) (Sommerwerk et al., 2009).

Agriculture and forestry were the first human activities which determined major changes in management discharge and sediment transport. After the XI century, river actions were elementary and relied moustly on dam construction for flood control and ground recovery

(Tockner et al., 2009). In the last century mechanization has highly increased productivity. This high increase determined environmental problems such as the desertification, erosion, salinisation, compaction and pollution of the soil. The use of chemical fertilizers has led to an accumulation of nitrates and phosphates in soils and their leakage into rivers and lakes. If the leakage occurred, some processes such as eutrophication and the death of ichthyofauna appeared (O'Connor, 2005). Despite their undeniable advantages (rich crops, the eradication or the supervision of some diseases transmitted by some insects - malaria, trypanosomiasis, filariasis, etc.) the widespread use of these compounds has led to unexpected and very serious side effects such as mass mortality of organisms, mutations and cancer diseases in humans and animals, reduction of primary production process and, not the least, the appearance of induced tolerance (Barbu, 2010).

Agricultural development in floodplains along with the river regularization for navigation and land protection led to the loss of wetlands (about 50%) and floodplains (above 95%). In 45 European countries, over 80% of floodplain forests have disappeared. From the former floodplain area of 26,000 km^2 along the Danube and its major tributaries, approximately 20,000 km^2 were lost. Switzerland lost about 95% of the original floodplain over the last two centuries (Tockner et al., 2009).

At present, European rivers have problems with the substances derived from agriculture. The damming of banks and the conversion of wetlands into agricultural lands in the Danube Basin affect reproduction areas for some species of migratory fish and birds. For example, the quantity of sturgeon and carp decreased by 98% and 90% (Vădineanu et al., 2001). In the Romanian part of the Danube the major changes began between 1960-1989, when 1000 km^2 of polders were used for agriculture and fish breeding (Sommerwerk et al., 2009).

The cities are permanent sources of water pollution and the wastewater is continuously produced by diverse human activities. In industrialized areas in Europe wastewater discharge in rivers and lakes led to serious degradation of water quality and extinction of aquatic biota. Past dumping practices led to soil and stream and groundwater pollution by a variety of chemical and biological contaminants, including organic compounds and pathogens (O'Connor, 2005).

Currently, over 70% of the European population lives in urban areas; the number of cities with a population greater than 100000 inhabitants is about 350 (Tockner et al., 2009). According to the EU Water Framework Directive, 60% of European cities exploit their groundwater resources irrationally and three quarters of Europeans are supplying with water from underground sources in the depths of the Earth.

Danube River drains 19 countries with a total of 83 million people. Approximately 6% of the total population in the basin is living in areas below the flood level. From 1950 to 1970 water quality has been affected primarily in urban and industrial areas in the upper Danube. In addition, the ability of self-purification of the inputs suffered because of toxic industrial wastewaters.

In the early 1980s construction of wastewater treatment plants has led to a major reduction of biodegradable organic matter and improved water quality in the upper Danube River. Today, the main course of the Danube has a relatively good water quality (class II, II-III). Excessive organic pollution can still be observed on some tributaries in Romania and Bulgaria, the Iskar River, Prut River and Olt River (Sommerwerk et al., 2009).

Industrial development puts more exploitative pressures on rivers, which presents a risk to human health. Rapid industrial development and inadequate pollution control, between 1950-1970, were the causes for the water quality deterioration in the Danube Basin. Today, the main course of the river Danube has relatively good water quality (Class II, II-III) (Sommerwerk et al., 2009).

The pressure from diverse human activities induced important changes in numerous lotic habitats, biocoenosis and ecosystems structure in the Romanian national territory too. The majority of the taxonomic groups were negatively affected by this human impact. (Sîrbu et al., 1999; Angela Curtean-Bănăduc, 2005; Angela Curtean-Bănăduc et al., 2005, 2009, 2011)

Facing the common pressures and threats (deforestation, riverine lands cultivation, river works and regulation, dredging, draining, fragmentation, pollution, etc.) ten Danubian countries and the European Union ratified the Danube River Protection Convention to found the International Commission for the Protection of the Danube River (ICPDR, 2006). The Danube River Protection Convention decided to apply the European Union Water Framework Directive. However much progress is still to be done in this respect. In 2004 the European Commission's General Director for Environment took charge of the International Commission for the Protection of the Danube River to bring forth a Danube Basin study, to provide a basin overview of lotic systems environmental state (ICPDR, 2004). This overview clearly emphasised the need to concentrate efforts with regard to riparian areas restoration, water quality improvement, flood management improvement, biodiversity conservation, sustainable livelihoods development for riverine human communities, etc., at least in the large and medium sized Danube Watershed component basins. This objective's implementation was rather slow, due to the fact that on many Danube tributaries basins the level of environmental knowledge still needs to be improved.

Usually the Romanians believe that their country is a rich country rather than a poor one with regard to lotic systems related products and services, and the ecological state of the rivers is rather a good one, but the late climate changes evidence and mostly the wrong/insufficient watersheds management should raise interest in studies with results that should reflect the reality and to offer solutions for the improving of the actual situation. These studies should target also the identification of the major environmental problems due to human activities at basins level, the effects prognosis and the proposal of management solutions. The necessity of this study came also from the European Water Framework Directive obligations which should be fulfilled by Romania.

This study intends to offer such needed specific data for the Timiş River basin and to propose some general and specific management topics.

RESULTS AND DISCUSSION

Natural elements in Timiş River basin

The Timiş River basin belong to the Danube River watershed and drains 7319 km^2, of which 5795 km^2 on the Romanian national territory as part of the Banat basin (Fig. 1), is a large and complex basin, its catchment area overlapping on distinct and variable relief units: mountains, hills and plains. (NIMH, 1971; Antonescu et al., 1981)

In the relief units, the Timiş River catchment area crosses in the upper flow the Semenic Mountains and the Timiş-Cerna tectonic corridor until downstream of Caransebeş locality, while in the middle flow it crosses the hills of Northeast Lugoj locality, the hills of Pogăniş South of Lugoj, and finally the Plain of Banat, forming subdivisions of it (Ujvári, 1972). This river lower sector crosses the Serbian territory.

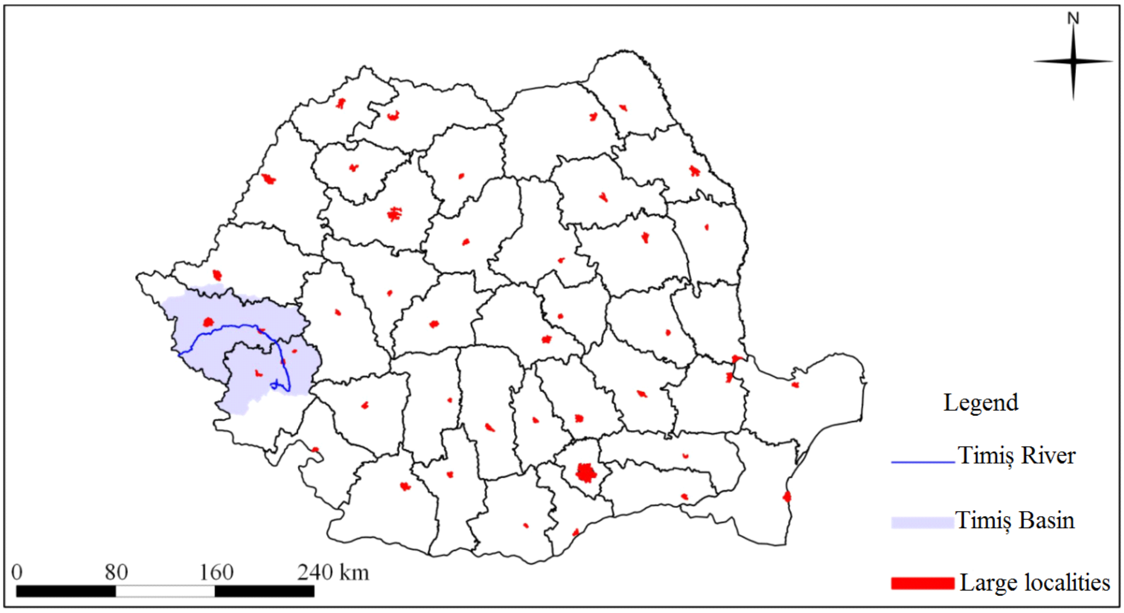


Figure 1: The Timiş River catchment area.

The current physiognomy of the region is the result of long geological (Fig. 2) processes. The area of the Banat Mountains has a relatively common evolution with the Southern Carpathians, but resulted from the collision of Moesian microplate (its Western front) with the Pannonian microplate. In their case, the compression was much smaller than in South and, consequently, the area is less elevated than the Southern Carpathians (Posea, 2002). The Banat Mountains are composed of two main geotectonic units: the indigenous Danube, as one of the oldest nucleus of the Carpathian crystalline, and the Gaetic crystalline consisting of two crystalline series: the Mesocatazonal Semenic suite and the Epizonal suite of Locva-Poiana Ruscă (Antonescu et al., 1981).

The piedmont and the lowland areas were formed at the same time as the Pannonian basin. The Pannonian basin was formed by sinking (starting with Tortonian), at different depths, of an area of the Carpathian crystalline. Over these crystalline blocks were laid sedimentary formations during Tortonian (sand, clay, limestone, sandstone), Sarmatian (marl, sand, sandy marl, lignite intercalations), Pannonian (marl, clay, sand, gravel), and Quaternary deposits (gravel, sand, clay, red clay, loess) covered the field (Munteanu and Munteanu, 1998).

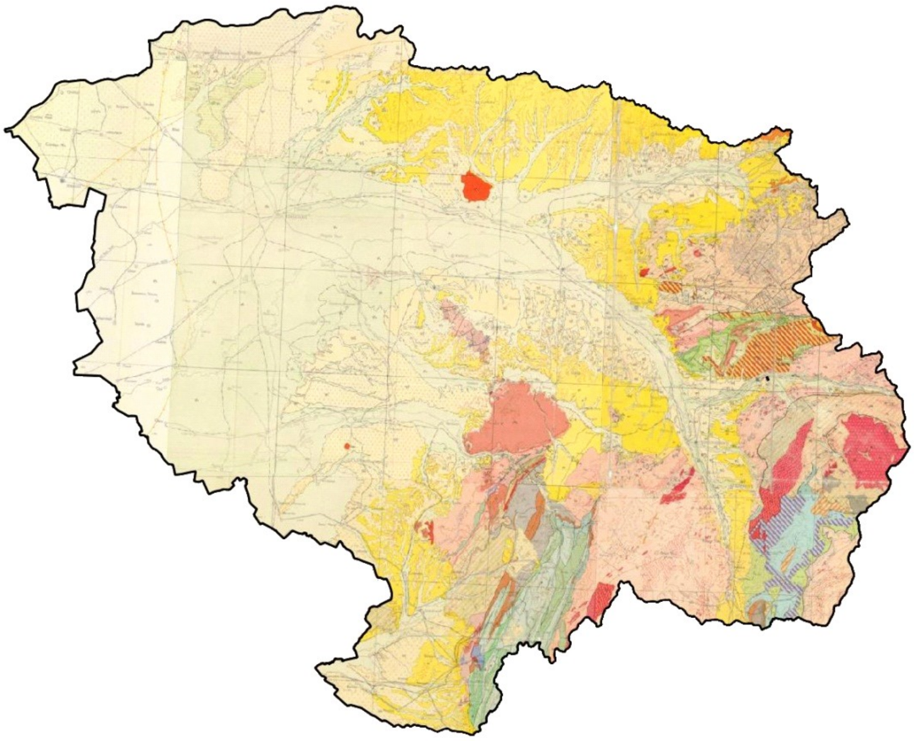


Figure 2: The Timiş River catchment area geology. (geo-spatial.org, 1: 200000 - modified).

Legend - sedimentary rocks:

Gravels, sands, clays	Marls, gravels
Gravels and sands	Clays, sands, tuff, sandy limestones
Loess deposit	Gravels
Gravels, sands and clays (red clay)	Conglomerates, sandstones , clays
Gravels and sands	Marls
Gravels and sands	Conglomerates, sandstones , red clay shale, agglomerated porphyry
Gravels, sands, clays	Conglomerates, sandstones and red clay
Marls, sands and gravels	Conglomerate sandstones
Sands, clay sands, sandstones, conglomerates	Limestones
Hexacorals limestones	Limestones with silicious accidents, marly limestones, sandstones
Marly limestones and schists	Conglomerates, sandstones, clay schists, coals

Limestones, sandstones, conglomerates

Lythographic limestones, nodular, dolomitic limestones, marl lens limestones and marls

Limestones with siliceous accidents, marly limestones, sandstones

Conglomerates, sandstones, clay schists, coals

Hexacorals limestones

Marls, limestones and schists

Limestones, sandstones, conglomerates

Lithographic limestones, nodular limestones, dolomitic limestones, limestones with silex and marl lenses

magmatic rocks:

Basalt β (qp_1)

Diorite δ (Pq_1), Granogabbro ω (Pg_1)

Granite γ (Pg_1), $\gamma\,\delta$ Granodiorite (Pg_1), $\gamma\,\delta\pi$ Porphyric Granodiorite (Pg_1)

β Basalts and associated rocks (J)

r Granitoide (Pz) , b- Granite γ (Pz),
e – Gneiss facies (fg)

Sedimentary volcanogenous formation (J) (sandstones and black clays associated with spilites, keratophyres, alkaline tuffs)

metamorphic rocks:

Phyllites, sericitous-chloritous Schists

Micaschists and Paragneiss

Metaserpentines

Crystalline Limestones

Quartzites

Graphitous Schists

Conglomerates, sandstones with coal clays, bituminous clays with sphaerosiderites and marls

Conglomerates with gabbro elements

Ardesian argillites, diabases

Conglomerates, sandstones, clays

Conglomerates, sandstones, clays with coal interlayers

Phyllites, tuffogenous green sediments

Micaschists, paragneiss

Tulisa series

Amphibolites, a- Metagabbros

Tuffogenous green sediments

Pegmatites

Metablastic Migmatites

Metatectic Migmatites

Diaphtoresis areas

Magmatic metamorphism

Contact halos: Corneans (co), Contact Marbles (c)

Skarns

Autometamorphic rocks

Genetic types of Quaternary deposits

Fluvial deposits

Deluvial deposits

Proluvial-Deluvial Deposits

From a geomorphologic point of view, the Timiş River catchment area is characterized by four relief forms: the mountain area, the Timiş-Cerna tectonic depression, the western hills (the hills of Pogăniş and Lugoj) and the Western Plain (the Lugoj plain and the Timiş plain).

The mountain region. The Timiş River originates in the Semenic Mountains area, part of Central formation of Munceii Bănăţeni, north of the Nera Corridor, and forms a distinct unit in the Banat Mountains, being separated on three sides by depressionary units and tectonic corridors: Ezeriş-Brebu Depression and Pogăniş Hills (North), Timiş Corridor and partially Cerna (East) and Almăj Depression in the South. These mountains are mainly made of crystalline rocks formed over geological times. The crystalline schists were metamorphosed in the Baikalian and Hercynic mountains genesis, during the Neosoic functioning as land, when the action of subaerial factors resulted in a rather intense shaping and forming of the erosion surfaces. Downward movements from Badenian and prolonged erosion led to the formation of heavy ridges, sometimes rounded, with heights below 1450 m (1447 m in Piatra Goznei), this situation giving them ample habitation opportunities (Pop, 2002).

Depression region. Timiş-Cerna Corridor. Is an inflectional lower unit between the Southern Carpathians and Western Carpathians, with one of the most favourable positions regarding humanization as demonstrated by the material traces of habitation from Neolithic (Caransebeş), and by the Dacian and Roman localities (Caransebeş, Mehadia, Teregova, etc.) as well as some of the oldest mining traces. It was formed by immersion, during the Helvetian and the Badenian, representing an elongated elbow that was related to Almăj and Haţeg depressions where there were deposited limestone, sandstone, gravel, sandy clays, the waters receding only in the early Quaternary (Pop, 2002). By deepening the rivers formed in this tectonic corridor (Cerna, Bela Reca, Mehadica, Bistra) in the lower erosion surface, today appearing as a marginal area, a well developed system of terraces was created (Roşu, 1973).

The hills region. West hills enter in the Western Carpathians following the Timiş corridor, of the former coastal plain of accumulation during the Pliocene, continued on land with continental accumulations of piedmont type. With the elevation of the Western Carpathians and the Pannonian Sea sedimentation, sediments formed high plateaux at first and “hills” afterwards. In some places, under the blanket of loose rocks (especially sand, clay, marl, piedmont accumulations) appear tougher rocks with the appearance of “knobs” that can be from either crystalline or volcanic schists (Mândruţ, 1993). They have altitudes between 200 and 300 m, and altitudes higher than 300 m occur frequently in Lugoj Hills.

The hydrographical network widened slightly in the soft molasses strata, forming real bays that penetrate deep into the hills. Among rivers the most important is Timiş, along which the Banat Plain advances more toward east and forms the Lugoj Plain, with a wide opening to Caransebeş Depression, marking the largest geographical discontinuity between the Banat hills (Badea et al., 1992).

The plain region. The Plain of Banat is part of the Western Plain which, in its turn, is a subdivision of the Tisa Plain. It runs from the southern part of the Mureș Plain to the southern border of the country (Roşu, 1973) and represents nearly half of the western plain. The elevation is between 75 and 180 m, and has a slight incline from East to the West, while the lower altitudes are located in areas of subsidence (Badea et al., 1992).

It was formed from the sedimentation of Pannonian Sea with sediments brought by rivers during the Neogene until recent time periods. It dried gradually since Pleistocene (the high plains) and Holocene (the low plains, the meadows). Lithologically speaking, it consists of sands, gravels, loess (high plains) and silt - more recent (in lower plains) (Mândruț, 1993).

Given the genesis, the constituent formations and physical-geographical particularities, three field types are differentiated: low type, subsidential (the Plains of Timiş and Aranca), high type, on foothills (the Plains of Vinga, Lugoj and Bârzava) and intermediate type (the Plain of Jimbolia) (Munteanu and Munteanu, 1998).

From a **climate** perspective, the studied area belongs to temperate-continental climate, with Mediterranean and Oceanic type influences (Bradea et al., 1981). Because of its location in the south-west, the sector up to Caransebeş falls into Banat's subtype, with submediterranean type shades (Antonescu et al., 1981). Regarding the plains, there is a difference from the East (near the hills) to the West, besides the latitude difference from the South to the North. There is also a large variety of topo-climates and micro-climates as diverse landforms lead to a variety of climates. The topo-climate and micro-climate of natural subunits of Banat's plain are both complex and elementary (Soroceac, 2005).

The main climatic subtypes here are Western ocean-tinted subtype, Banat's Mediterranean-tinted subtype, Western Hills oceanic-tinted subtype and Medium mountain - climate subtype.

In general, the average temperature ranges between 10-11°C. Thermal regime in the coldest month varies between 0° and -3°C. The entire area of Banat Hills and Timiş corridor is contained by 0 and -1° isotherms, -1° and -2° isotherms can be found throughout the western part of the Tisza Plain and the -2° and -3° isotherms include Western Hills and Banat Mountains. The thermal regime of the hottest month is contained inside the 18-22° isotherms. Regarding rainfall, these are quite frequent, approximately 600 mm per year in Tisza Plains, and 700-800 mm per year in the Western Hills (Roşu, 1973).

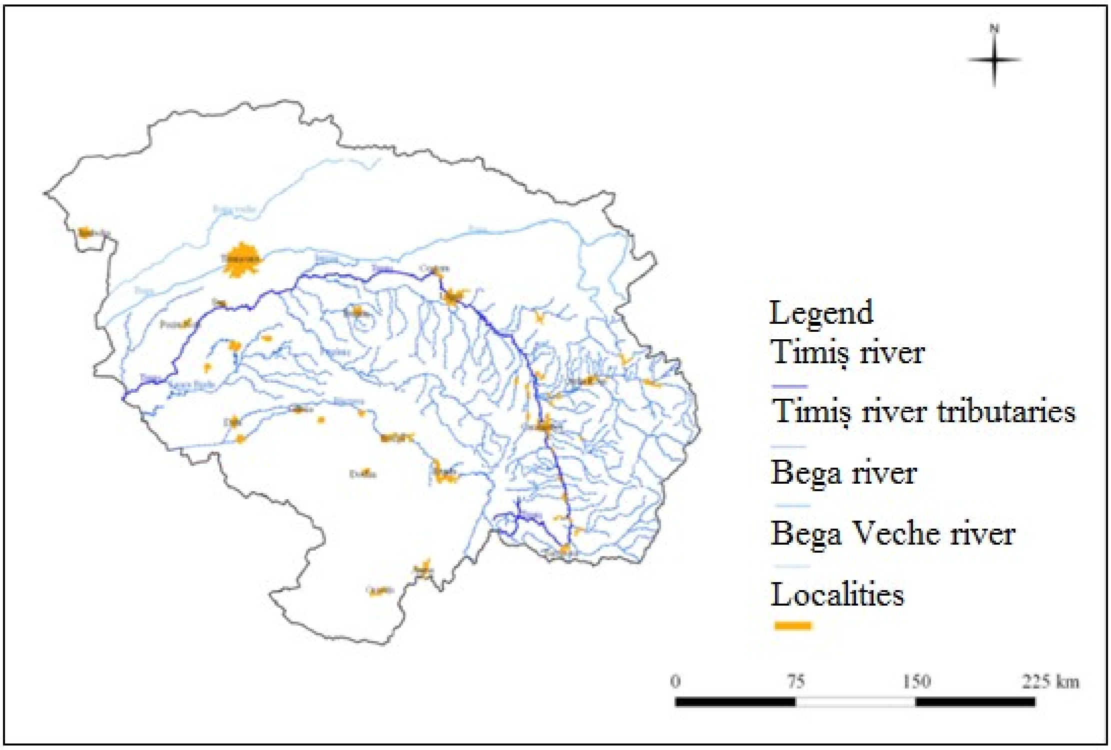


Figure 3: The Hydrographic basin of Timiş River, Romania.

Timiş River (Fig. 3) is the main **hydrographical** artery in Banat, having the greatest expansion of all rivers. It springs from the eastern slope of the Semenic Mountains, from under the Piatra - Goznei Peak, at an altitude of 1135 m and flows into the Danube in Serbia, downstream of Belgrade at Pančevo. Timiş River basin has a total area of 7319 km^2 of which 5248 km^2 is located on the territory of Romania (Antonescu et al., 1981). Its total length is 358 km, of which 241.2 km in Romania and 123 km in Serbia (Ujvári, 1972).

Its course is divided into three parts: the first part in the mountainous area, where it gathers small rivers, the second part is the Timiş-Cerna Gorge, a tectonic shell that separates the Banat Mountains among the Southern Carpathians (the Meridionals Carpathians). Here it receives tributaries from mountain chains like Ţarcu Godeanu and Semenic Mountains, showing a relatively constant and consistent flow. Finally, the last part - after receiving the most important tributary - Bistra (S = 919 km^2, L = 60 km) (Teodorescu, 2008).

Its upper course has a typical mountainous aspect, with average falls of over 20 m/km (max. 37 m/km). In the mountain regions, Timiş River receives two relatively small but important streams Brebu (S = 15 km^2, L = 5 km) and Semenic (S = 29 km^2, L = 10 km), and after 25 km from the source it enters the Timiş-Cerna corridor. At its spring its waters and that of its tributaries are captured by the Semenic Channel. The minor depression at Teregova is a real market for water gatherings.

Here, Teregova River (S = 51 km^2, L = 15 km) also arrived from the Semenic massive, a small creek - Criva in the valley of which the road to the Eastern Gate (Pasul Domaşnea) winds its way and finally Hideg or Râul Rece River (S = 171 km^2, L = 34 km) that springs below the peaks of Ţarcului Mountains (Căleanu - 2190 m), all flow in Timiş River. Râul Rece River has its origin near the springs of Seş River, from the cirque, with the late melting of snow, which imprints on the Timiş River the first characteristics of a Carpathian regime type, which will increase downstream especially after receiving Bistra River.

Downstream of the confluence with river Hideg, Timiş River enters the Armeniş Gorge, and then the valley widens gradually acquiring a more pronounced ramble character with relatively high slopes (4-8 m/km). The corridor ends downstream of Caransebeş where in the piedmont plain the ramble is emphasized even more in terms of an average slope of 1.6 m/km between Caransebeş and Lugoj.

Along the corridor sector, Timiş River receives in a symmetrically manner tributaries from the Semenic and from Ţarcu Mountains, but the right tributaries are more developed. The first tributary, Feneş River (S = 137 km^2, L = 24 km) with its tributary Pârâul Alb (S = 64 km^2, L = 24 km) have their origin near the Hideg springs, but from the western slopes. Like the Hideg River, their average slopes are higher, ranging around 45-56 m/km, representing good areas for hydraulic structures. Downstream, until Caransebeş, Timiş receives only small tributaries, which spring from Sarmatian deposits such as Armeniş, Ilova, Groaşa, Bolvaşniţa and Zlagna.

From Semenic Mountains, Timiş River collects from its corridor sector the rivers Slatina (S = 27 km^2; L = 11 km), Goleţul (S = 43 km^2; L = 15 km), Bucoşniţa, Cerneţul and Valea Mare (S = 51 km^2; L = 13 km).

At Caransebeş the final tributary of the western flank of the Ţarcu massif flows into Timiş River, Sebeş River (S = 142 km^2, L = 23 km), spring from the glacial cirques, and then Timişul receives its largest tributary Bistra River.

After the confluence with Bistra, the fan-shaped alluvial cone of Timiş starts close to the border with Serbia. In the area of the cone there is a gradual deviation of the Timiş to the right, largely because of its tributaries developed mostly on the left, but probably due to neotectonic movements, as the phenomenon was noticed in the case of Bega River. The abandoned courses that are parallel to the Timiş River and who eventually flow into it are Măcicaşul (S = 77 km^2; L = 20 km), Vâna Secănească (S = 72 km^2; L = 13 km), Ştiuca and Timişina (S = 434 km^2, L = 47 km) all on the left. The last collects also from the left the rivers Sudriaşul, Faţa, Cinca, Dicşanul and Cherăstrău, acting as a subpiemontan river collector. The tendency to deviate to the right of the Timiş is betrayed by its abandoned left arm, Timişul Mort, which was once the main course of the river. The conclusion of this process was hastened by the Timiş River embankments and other improvement works that have adapted to the natural process trend.

The left hills are largely drained by river Pogăniş (S = 696 km^2; L = 100.2 km), which has an average gradient of 6.6 m/km, a relatively poor drainage and ample digression on Valeapai - Ersig and Duboz - Otveşti sectors. Finally, in the plain sector where it receives the waters of Pogăniş River, Timiş River has much lower slopes of 2.43 m/km, and slightly downstream they already fall below 1.0 m / km, so that at the border they get at 0.24‰. This last tributary with a typical character of plain is river Lanka - Birda, a channelled river (S = 485 km^2, L = 45 km), which has longitudinal slopes less than 0.18 m/km.

Out of the tributaries of the right of Timiş River in the piedmont sector we mention the rivers Calova, Macioviţa, Vălişoru and Nădragul (S = 164 km^2; L = 33.6 km) which penetrates to the core of the Poiana Ruscă massif. At the confluence of Cornetului with Nădragul the metallurgical plants of Nădrag can be found.

At Coşteiu, from Timiş River, the flow supply channel of Bega River is derived, at Hitiaş it flows into the discharge channel of Bega channel and near Drăgşina it receives his last right tributary - Iarcoş River.

In the piedmont plain of Timiş River, extensive hydro facilities have been made, given the large floodplain area (about 1000 km^2) and the existence of groundwater near the surface. (Ujvári, 1972)

Historical significant changes in Timiş River basin

Timiş River, previously called Themesius: ad Themesium amnem (form used by Cantemir and Bonfinius) or Titius: ad ripas Amnisos titi/Tibiscus (form used by Michael Riccio Neapolitanus) or Tibisis (form used over 2000 years back by the Romans), (Florentina and Olteanu, 2004) is the main river of the southwest part of Romania. It springs from the Semenic Mountains plateau and after passing the “Trei Ape/Three Waters” dam it digs deep and narrow valley on the NW-SE direction in the crystalline schists of Semenic its course having a strong torrential, with large slope drains(20-25 m/km). Downstream, Timiş’s bed begins to expand across the depression corridor of Caransebeş (Antonescu et al., 1981). At Coşteni, Timiş River enters its lower course, which mostly overlaps the digression plain. In this area the river valley is wide, meandering and digress with a very low slope. The river has a pronounced tendency to deviate to the right, a process betrayed by its abandoned arms (Timişul Mort, Oldâcău and Vâna Opâru) (Munteanu and Munteanu, 1998).

Timiş River, together with Bega and Bârzava rivers, has always had deviations that ramble throughout the Timiş Plain and a part of the Lugoj fields. After damming and channelling, some traces of relatively recent courses still remained: Small Bega, Timişatul and Dead Timiş Bega Mică, Timişatul and Timişul Mort.

Old Timiş always digressed a series of cones that each follow from Lugoj Bay to the border and often mix their waters with Bega, to or in Timișoara’s area. To the west, the ramble extends to Old Bega, and to the south to Delibat and Alibunar’s swamps (Serbia) (Posea, 2002). In the past all the surrounding area of Timişoara city and lower Timiş was mostly swampy and muddy (Aldescu, 2010). The writings of Francesco Griselini in the eighteenth century support the words of Aldescu: "Numerous swamps and stagnant waters made in those times the air very unhealthy" or "The largest swamp begins at Mureș's disbursement into Tisza. (...) The other drained side, extends inside Timișoara's district, from Clarii, Crnja and Checea to Itbej and Pardan. Begheiul (Bega) goes through this part of the swamp with its sinuosity". (Griselini and Feneşan, 1984)

Mehmed Raşid's chronicles written in the XVII'th century relating the 1695 fight of Lugoj city, describe the area between Caransebeș city as a marshy place "except that Timiș river surroundings (…) were full of swamps. In the battle's description, is also described the surroundings of Lugoj city: "The place chosen by Veterani was situated at 2,750 m south-east from Lugoj city, in a place called "At city's tsarina" a muddy land situated on the left side of Timiş River, at an altitude of 124 m, crossed from south-east to north-east by the Ştiuca creek". A description of the area appears in Silahdar Fîndliklîli Mehmed Aga fight chronicles, "Veterani's forces were placed about an hour before the city of Lugoj, on Sebeş's road, with its right side resting on the heads of two large swamps and its left side on a flowing river (Groza, 1995).

Currently wetlands have disappeared due to hydro technical works carried out with different economic purposes. The first hydraulic works began after 1716. After the reconquest of Banat by the Habsburg Empire (1716), there were allocated considerable sums to "drain the swamps and marshy waters in rivers, and from here to the Tisza and Danube, with the help of bigger canals, ditches aqueducts and artificial. "Maximilian Fremaut, an eminent hydraulic engineer conducted a series of works" (Griselini and Feneşan, 1984). Many of these works were made for drainage and flood protection, to improve navigation, to supply the city with drinking water and for industry. Another series of hydraulic structures were built in the 70s, consisting of reservoirs and polders to retain water during floods (Aldescu, 2010).

To demonstrate changes in the Timiş river's course in Caransebeş-Cruceni sector, we can consider the four map representations from the area:

- The first Josephine rising of Banat (1769-1772) Josephinische Landesaufnahme-detail;
- The third Josephine rising of Banat (1868-1880) Franzisco-Josephinische Landesaufnahmen - detail;
- A topographic map showing the situation in year 1996 – detail;
- A satellite map showing the situation in 2012 - detail;

From figures 4-38 it can be noted that in the years 1769 to 1772 until the present day, Timiş river has undergone many changes, mostly due to the regularization. The main changes occurred are the loss of its arms, cutting meanders and straightening course, embankments and the disappearance of wetlands. Compared to the years 1769-1772, the biggest changes occurred in Caransebeş city (Figs. 4-7), at the confluence with Bistra (Figs. 8, 9 and 11) and on the Găvojdia - Măguri (Figs. 16-19), Bazoş - Moşniţa Nouă (Figs. 24-27), Şag - Uliuc (Figs. 28-31), Cebza - Petroman (Figs. 32, 33 and 35) and the Gad - Cruceni (Figs. 36, 37 and 38) sectors.

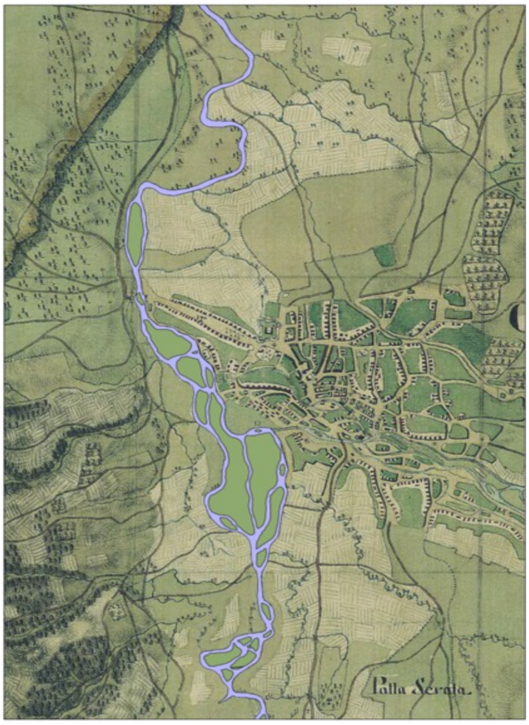


Figure 4: The first Josephine map rising - Caransebeş detail.

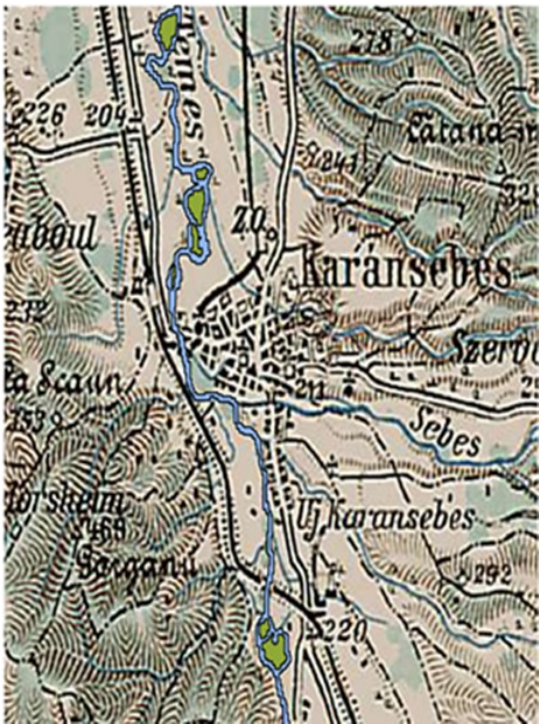


Figure 5: The third Josephine map rising - Caransebeş detail.

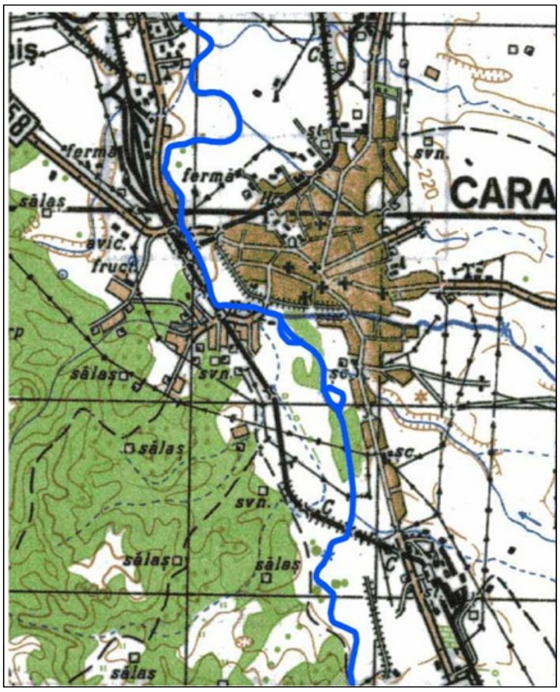


Figure 6: Kind topographic – Caransebeş detail 1996.

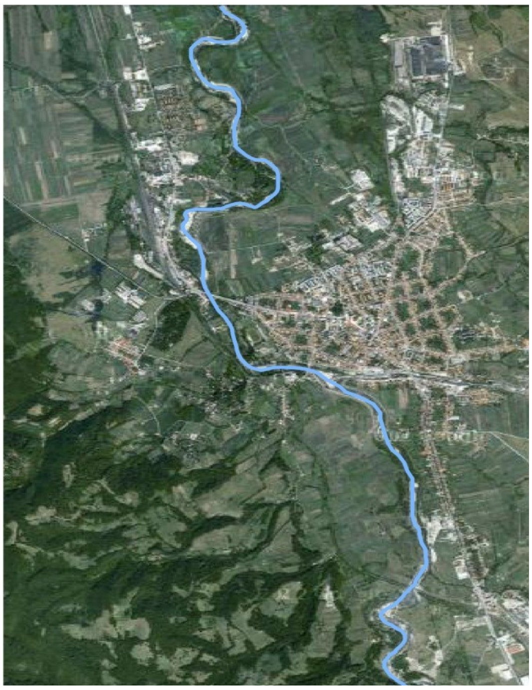


Figure 7: Satellite maps - Caransebeş detail – 2012.

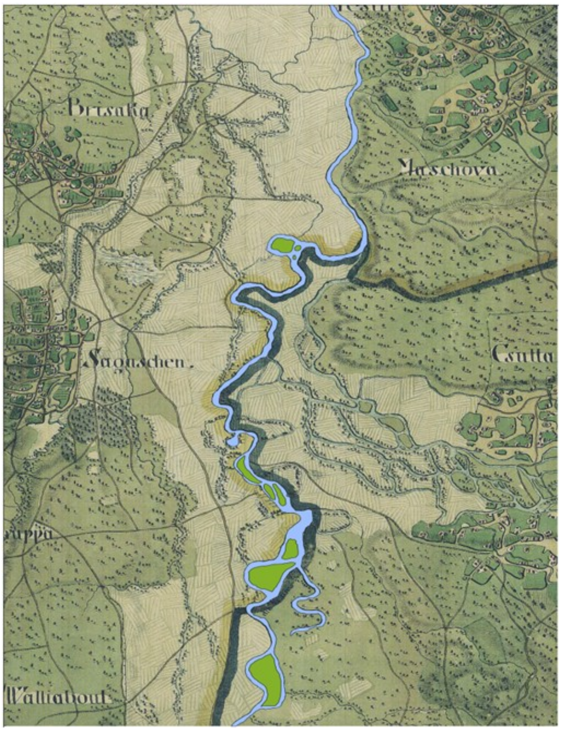


Figure 8: The first Josephine map rising: Confluence with Bistra - detail.

Figure 9: The third Josephine map rising: Confluence with Bistra - detail.

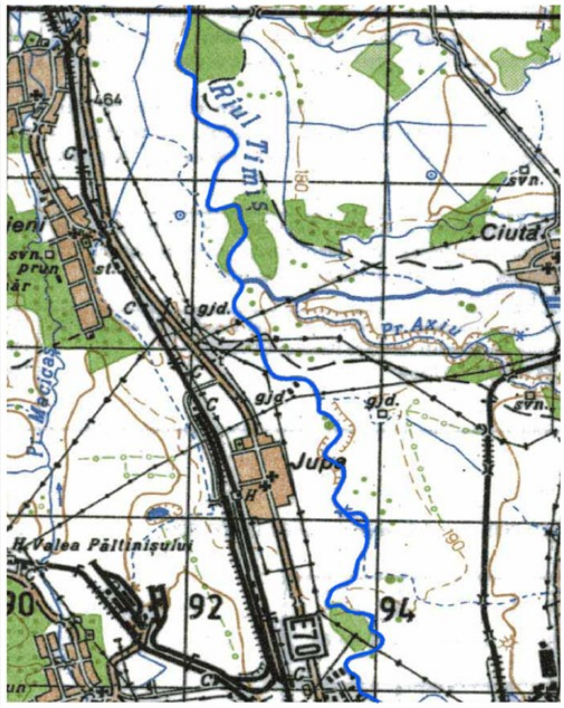


Figure 10: Kind topographic - Confluence with Bistra- detail 1996.

Figure 11: Satellite maps - Confluence with Bistra- detail - 2012.

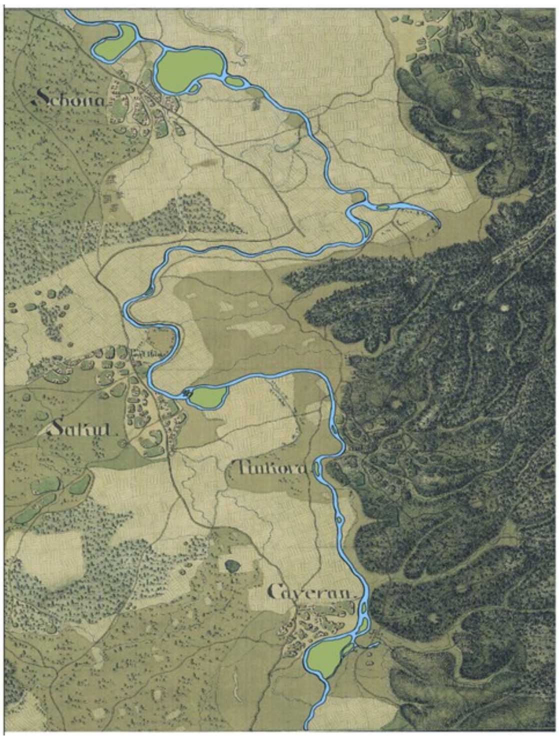


Figure 12: The first Josephine rising: Constantin Daicoviciu - Jena - detail.

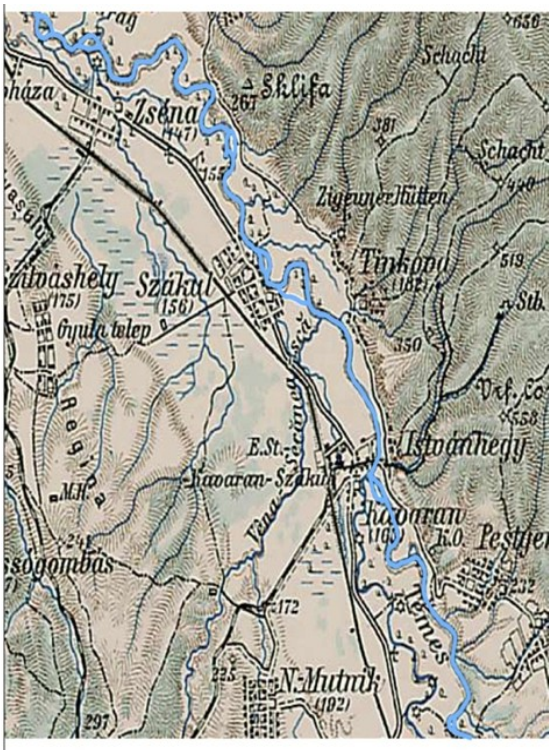


Figure 13: The third Josephine rising: Constantin Daicoviciu - Jena - detail.

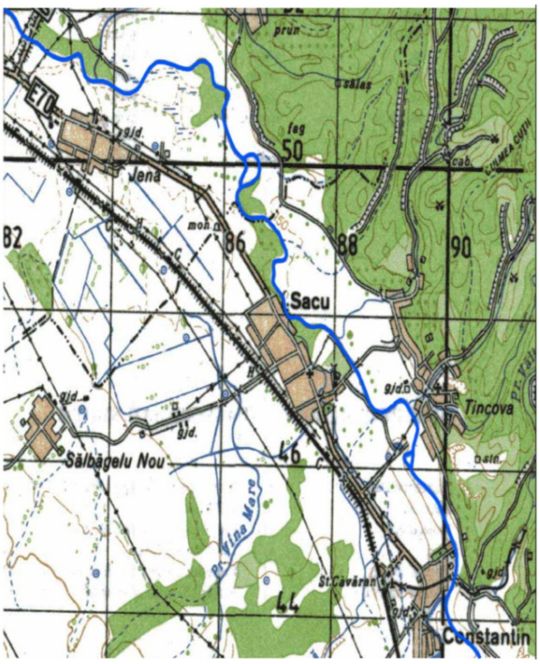


Figure 14: Kind topographic - Constantin Daicoviciu - Jena- detail 1996.

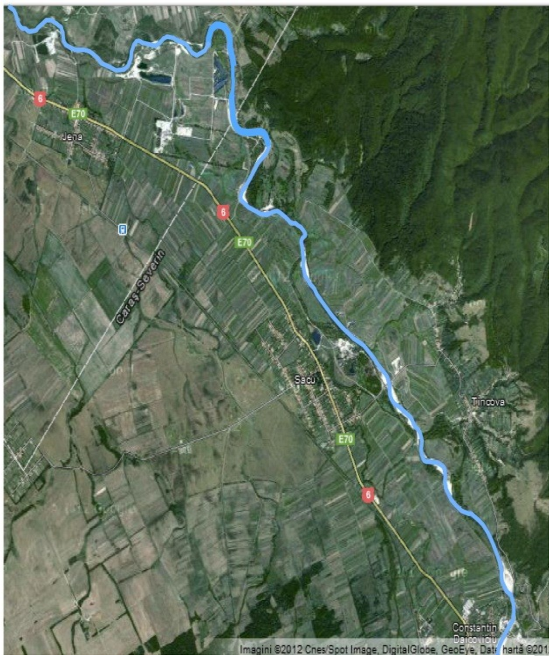


Figure 15: Satellite maps – Constantin Daicoviciu - Jena - detail - 2012.

Figure 16: The first Josephine rising: Găvojdia - Măguri - detail.

Figure 17: The third Josephine rising: Găvojdia - Măguri - detail.

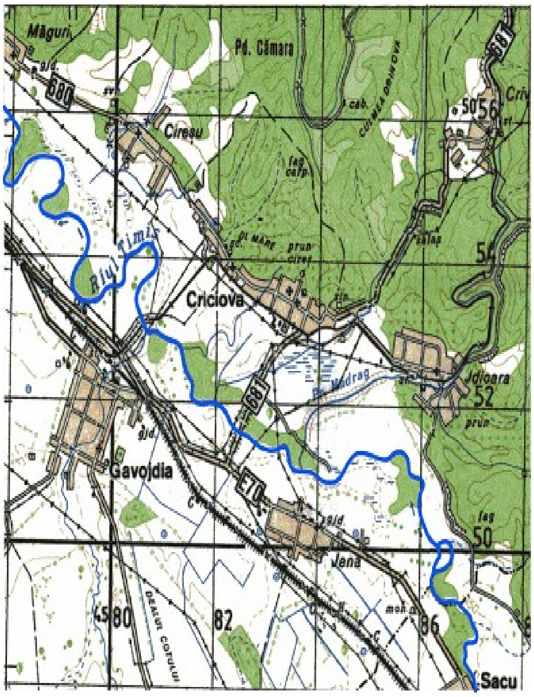


Figure 18: Kind topographic - Găvojdia - Măguri - detail - 1996.

Figure 19: Satellite maps - Găvojdia - Măguri - detail - 2012.

Figure 20: The first Josephine rising: Lugoj - Coştei - detail.

Figure 21. The third Josephine rising: Lugoj - Coştei- detail.

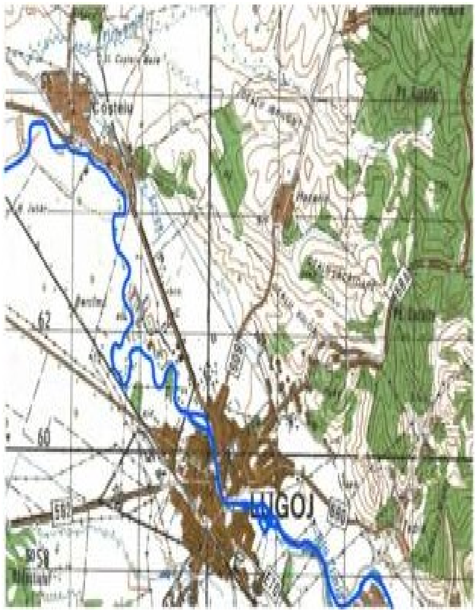


Figure 22: Kind topographic - Lugoj - Coştei - detail 1996.

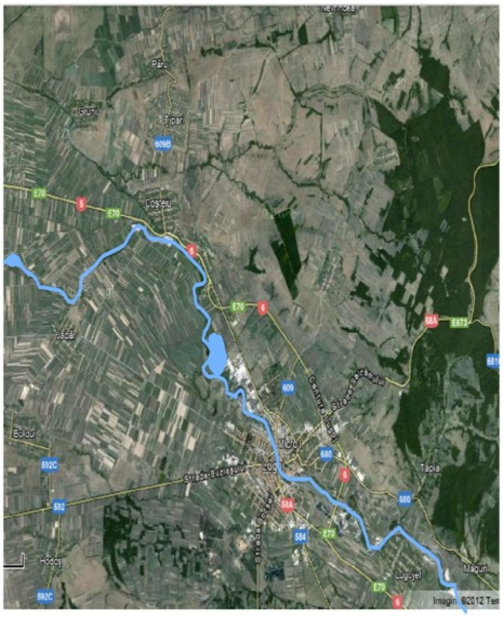


Figure 23. Satellite maps - Lugoj - Coştei - detail 2012.

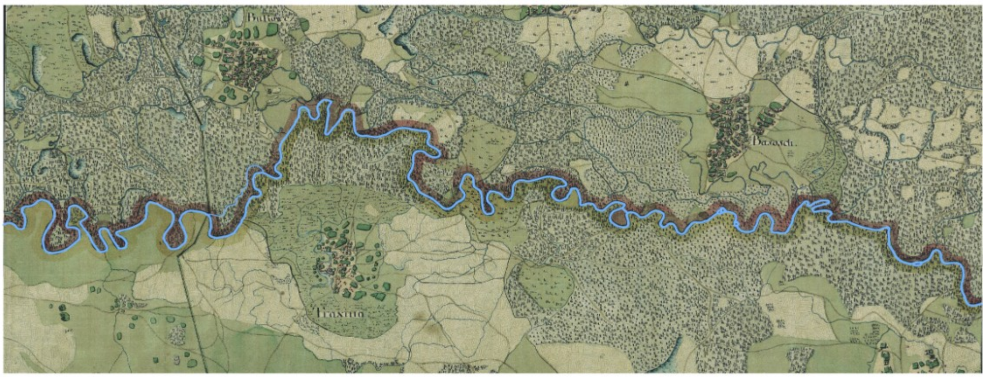


Figure 24: The first Josephine rising: Bazoş - Moşniţa Nouă - detail.

Figure 25: The third Josephine rising: Bazoş - Moşniţa Nouă - detail.

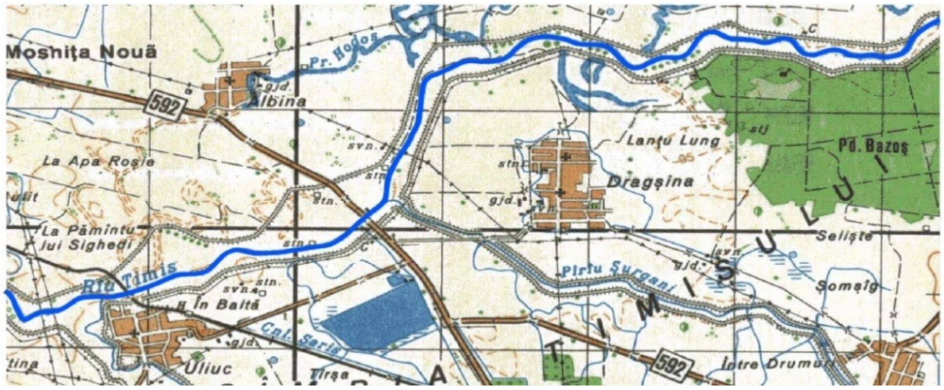


Figure 26: Kind topographic - Bazoş - Moşniţa Nouă - detail 1996.

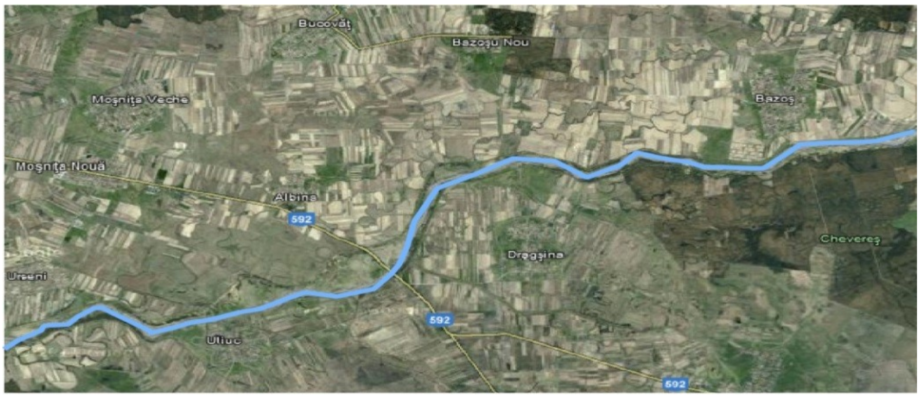


Figure 27: Satellite maps - Bazoș - Moșnița Nouă detail - 2012.

Figure 28: The first Josephine rising: Uliuc - Șag - detail.

Figure 29: The third Josephine rising: Uliuc - Șag - detail.

Figure 30: Kind topographic - Uliuc - Șag - detail - 1996.

Figure 31: Satellite maps - Uliuc - Șag- detail - 2012.

Figure 32: The first Josephine rising: Cebza - Petroman - detail.

Figure 33: The third Josephine rising: Cebza - Petroman - detail.

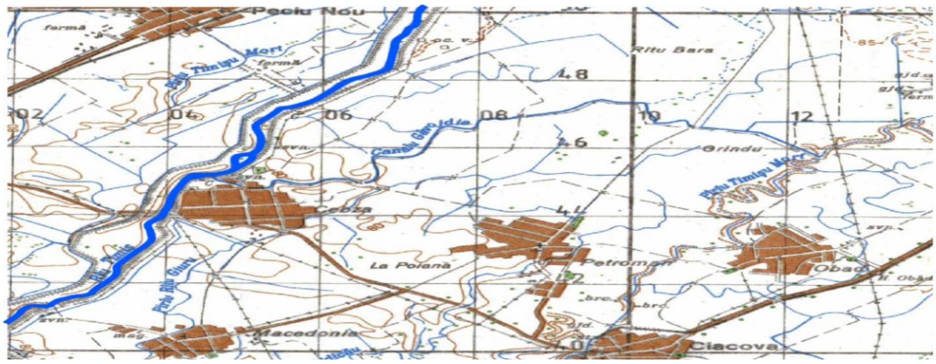


Figure 34: Kind topographic - Cebza - Petroman - detail 1996.

Figure 35: Satellite maps - Cebza - Petroman - detail 2012.

Figure 36: The first Josephine rising: Gad - Cruceni - detail.

Figure 37: Kind topographic - Gad - Cruceni - detail 1996.

Figure 38: Satellite maps - Gad - Cruceni - detail 2012.

At the level of the Timiş River basin there have been identified a number of anthropogenic intervention as well as **hydro-technical structures, industry, intensive agriculture and human settlements** which have contributed over time to alteration of morphological and ecological conditions of the water body review.

Hydrotechnical structures

The main anthropogenic interventions which have been highlighted in the Timiş River basin are **hydrotechnical structures** (Fig. 39), some of them old, making the hydrologic risk relatively high as a result of the low slope of the relief in these areas, high waters and floods and the surplus of water located close to surface (*, 2010-2011) but also for the improvement of navigation, water demand of the towns and industrial activities and energy production.

Within the catchment area of the river Timiş there have been identified, in sectors where the risk of water is accentuated, several classes of hydro-technical works - for example special hydro-technical works, water accumulations, settlement works and construction of dikes and bank defences

Special hydro-technical works have been made in order to solve problems such as excess moisture, flood control, water supply of human settlement, and not in the least to ensure optimal flows for navigation.

This category includes a number of technical works, some historical, such as double interconnection Timiş - Bega River, Italian Channel (1860) and Semenic Channel (1911) on the body of Bârzava.

The most important hydrotechnic work is the double interconnection Timiș-Bega which was started in 1757 by building a dam on the Bega canal at Coștei town and a large ditch to Timiş River under the supervision of engineer Maximilian Fremaut. The double interconnection Timiș-Bega involved the creation of several types of channelling and water course regulations on the Timiș-Bega canal - Serbian border sector, the derivation of the Timiș River in Bega canal and vice versa, embankment, hydraulic components of derivation - Coştei (Timiș River) and Topolovăţ (Bega Canal), hydraulic components of biefare - U.H.E. Timişoara (www.rowater.ro).

Accumulation of water built for energy, water supply system and flood avoidance are located mainly on the Timiș River (Trei Ape water accumulation with a total volume of 143 * 103 m^3, Hitiaș accumulation and Pădureni accumulation with a volume of 35 mil.m^3) and some tributaries like the Lanca Birda River (Liebling accumulation with an area of 60 ha and Gad accumulation with a total volume of 20,500 mil. m^3), Bistra Mărului River (Poiana Mărului accumulation with a capacity of 96 000 *103 m^3), Pârâul Rece River (Poiana Ruscă accumulation with a total volume of 142 * 103 m^3), Sucu River (Scorilo accumulation with a capacity of 25 mil. m^3), Bârzava River and its tributaries (Secul with a total volume of 31*103 m^3, Văliug with a total volume of 1,200 mil m^3, Gherteniș, Gozna with a total volume of 11,500 mil m^2, Fizeș, Pastoane, Valea Satului and Valea Vina Satului accumulations) Pogăniș River (Cadâr-Budoz accumulation with a total volume of 41,4 mil m^3), Surugani River (Salcia accumulation with a total volume of 1,530 mil. m^3), Silagiu (Sulagiu accumulation with a total volume of 0,640 mil m3), Fața River (Herendeș accumulation with a total volume of 1,600 mil m^3), Sebeș River (Zervești accumulation with a total volume of 1,1 mil. m^3) Boculandia River (Boculandia accumulation), Moravița River (Butin and Nanoviște accumulations) Semnița River (Lățunaș accumulation) and Clopodia River (Pruni accumulation) (Aldescu, 2010, Liuba, 2003; *,2008; *, 2009; *, 2010-2011; www.caransebes.ro).

The most important reservoir of the Timiş water catchment is Trei Ape built in 1969. This is located on the upper course of the river Timiş River, at an altitude of 835 m, in Gărâna Depression and is fed by the water bodies Brebu, Semenic and Grădişte. The accumulation has an area of 526 *103 m^2 and a capacity of 4796 *103 m^3 (*, 2009). The lake serves the city water supply and industrial installations in Resita city and provides electricity.

Regulation and embankment works were made in sectors where hydrological risk is accentuated. According to CJ Timiş and Annex SH Banat management plan, the Timiş River basin is about 828 km dykes and 647.5 km regulation work distributed as: on Timiş River, the section between Lugoj city and border, embankment works occupies 472 km and regulation work have a length of 273 km; on Bârzava River, between Reşiţa city and border, embankment works have a length of 197 km and regulation work have a length of 155 km; on Moraviţa River, between Moraviţa River and border, embankment works have a length of 50 km and regulation work have a length of 48 km; on Bistra River, between Oţelu Roşu city and confluence with the river Timiş, a length of 3.0 km are damming and regulation works; on Pogăniş, between Apadia city and county boundary Timiş - Caraş-Severin, regulation and embankment works have approximative 63 km length; on Biniş River regulation work have approximative 3.8 km; on Chizdia River downstream of the confluence with Hitiaş River, regulation work have 7.2 km; on Timişana River the regularization of the bed have a length of 21 km while work impoundments have a length of 18 km; on Faţa River regulation works extends over the entire length (7 km); on Lanca Birda River, the section between Voiteg and Gad are damming works a portion of 25.1 km on the left and 24.7 km on the right bank; on Vâna Mare River regulation work reach a length of 16.3 km; on the Timişat River settlement works are executed on a length of 50.2 km.

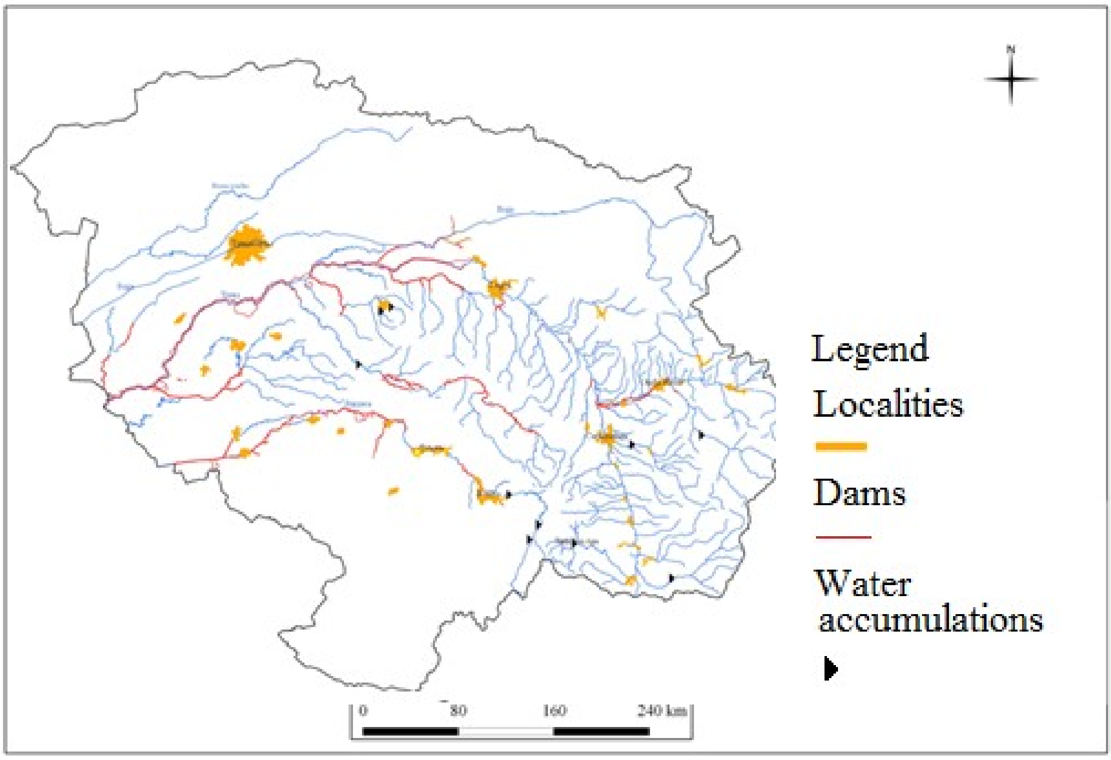


Figure 39: Hydro-technical structures.

Human settlements are permanent sources of pollution of water and air produced by human activity, industry and transport. Domestic and industrial wastewater discharge in rivers and lakes has led to serious degradation of water quality in impaired ability to self - purification and not least the removal of aquatic biota (O'Connor, 2005; Sommerwerk et al., 2009).

Construction of wastewater treatment plants has generated a major reduction in biodegradable organic matter and improved water quality but due to the fact that they are generally limited to large human settlements, a significant amount of dissolved organic matter and nutrients from smaller communities is evacuated today in lotic systems (Sommerwerk et al., 2009, Sabater et al., 2009).

To prevent the environment from the effects of the discharge of insufficiently treated municipal sewage and industrial biodegradable wastewater the Directive 91/271/EEC was created by which Member States ensure for all agglomerations, equipping with systems for the collection of urban waste water before it is discharged.

For the rehabilitation and conservation of water bodies, Romania joined and transposed the Directive 91/271/EEC into national law by H.G. 188/20.03.2002 provisions for approval of rules on the conditions for discharge into the aquatic environment of waste water treatment, as amended by Government decision 352/11.05.2005 as amended by Government decision No. 210 of 28.02.2007, which provides that human agglomerations: over 10,000 citizens shall be provided with wastewater collection systems by the end of 2013 and up to 31.12 in 2015 must provide tertiary treatment of wastewater; between 2000 - 10 000 citizens shall be provided with wastewater collection system and ensure a biological treatment of wastewater by 31.12.2018.

In view of the obligations and time commitments of the Romanian state through the Treaty of Accession, most settlements of the 69 administrative units existing in the basin of the Timiş River must conform to new provisions on the collection and the treatment of discharged wastewater in an emissary.

In 2012, the collection of wastewater took place in 29 municipalities while the mechanical and biological treatment activity wastewater was done in only 16.

The degree of adaptation of administrative units to collection systems and wastewater treatment depends on the number of people equivalent is shown in table number 1, and figures number 40 and 41.

Table 1: The relationship between wastewater collection and treatment.

Administrative units (a.u.)	The number of a.u. within the basin	Systems for the collection of waste water		Wastewater treatment
		No. of a.u. connected to wastewater collection systems	The degree of connection to the sewer a.u.	No. of a.u. connected to a wastewater treatment systems
>10 000 l.e.	5	5	35% - 71%	4
2 000 l.e. – 10 000 l.e.	39	15	14 % - 94 %	10
< 2 000 l.e.	25	2	20% and 80%	2

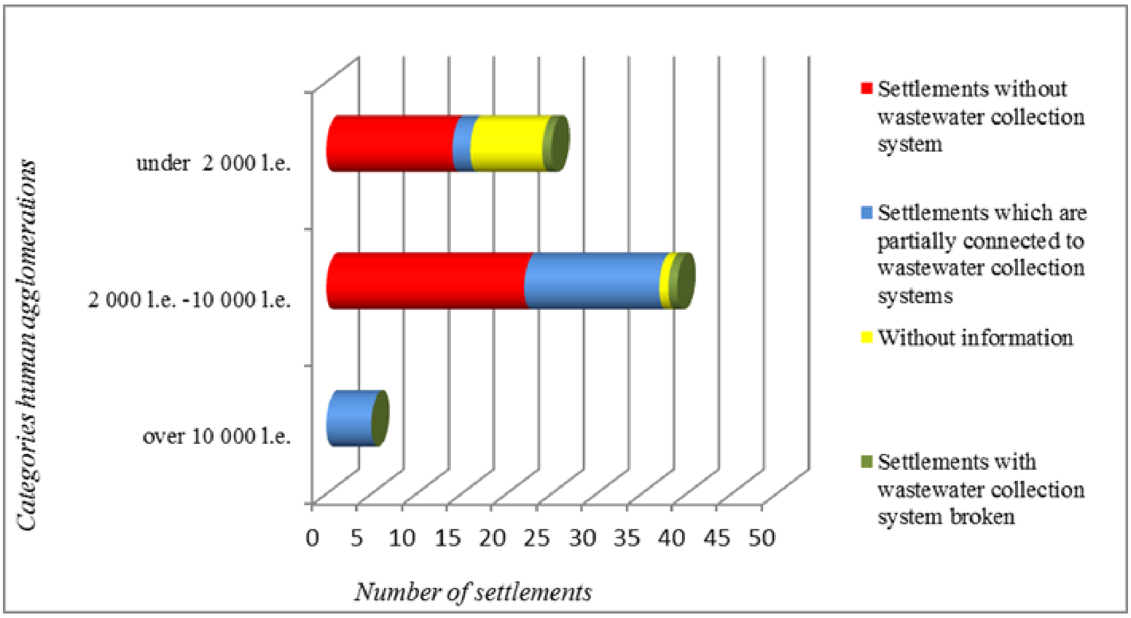


Figure 40: Situation degree of connection to wastewater collection systems.

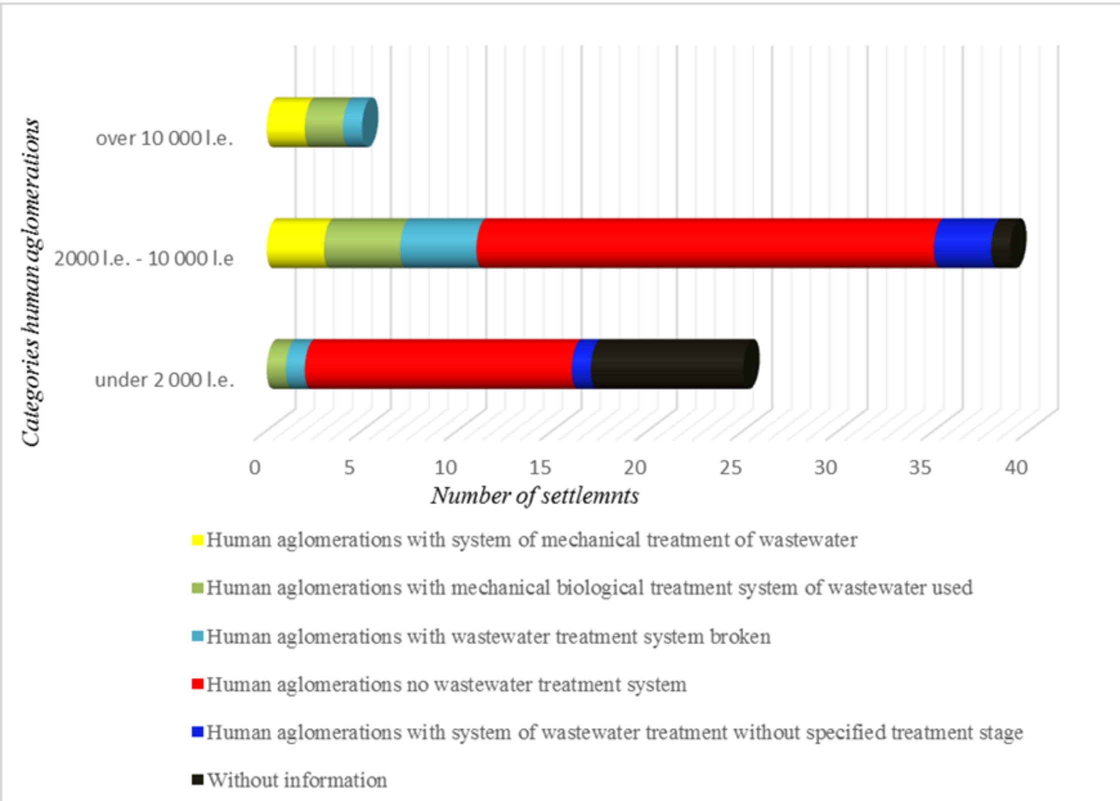


Figure 41: Situation degree of connection to wastewater treatment systems.

At that time most of the administrative units are beginning efforts to obtain financing for the construction and or extension of sewerage and waste water generated, but a large part failed to obtain the necessary financing.

In view of the above, to reduce human agglomeration pressures it is necessary to rehabilitate and/or upgrade existing sewerage and treatment; construction and/or expansion of these systems in all urban agglomerations in the basin including in that number is less than 2000 population equivalent.

Main economic activities in the basin of the Timiş River

In the hydrographic basin of the Timiş River, the quality of surface and groundwater is directly influenced by economic activity. The most significant changes in the state of water quality are mainly generated by industrial and agricultural units whose activity results in wastewater loaded with a number of organic compounds and chemicals.

Regarding the industrial activity in the studied area, this is characterized by a great diversity of activities. The main industrial sectors represented in Caraş-Severin County are mining, metallurgy and machine building industry while in the Timiş County a large share is held by the processing industry with its main branches: food industry, chemical industry, metal and wood processing industry (www.adrvest.ro).

As a result of the registry of pollutants from the Timiş River basin, the main economic activities that may be potential sources of pollution are presented in table number 2.

Table 2: Register of pollutants in the water catchment area of the river Timiş (2011-2012); Research contract PHARE CBC "Protective Measures for Timiş River"; SH banned Annexes management plan; www. rowater.ro; www.firme.info.

Crt. no.	Activity domain	Industry sector	No. of ind. units
1.	Processing industry	Food industry	17
		Manufacture of beverages	3
		Leather industry	10
		Wood processing industry	21
		Manufacture of wood, cork, straw and plaiting products	12
		Manufacture of paper and paper products	6
		Manufacture of chemicals and chemical products	6
		Manufacture and preparations of basic pharmaceuticals	1
		Manufacture of rubber and plastic	23
		Manufacture of other non-metallic mineral products	29
		Metallurgical industry	4
		Metallic construction and products, except machineries	24
		Manufacture of electrical equipment	3
		Manufacture of machinery and equipment	13
		Manufacture of motor vehicles, trailers and semi-trailers	8
		Manufacture of furniture	30
		Other manufacturing n.c.a.	1
		Repair and installation of machinery and equipment	2

Table 2 (continuing): Register of pollutants in the water catchment area of the river Timiş (2011-2012).

Crt. no.	Activity domain	Industry sector	No. of ind. units
2.	Electricity, gas, steam and air conditioning production and supply	Production and supply of electricity, gas, steam and air conditioning	2
3.	Water supply, sewerage, waste management and remediation activities	Collection, purification and distribution of water	6
		Collection, treatment and disposal; materials recovery activities	27
4.	Construction	Civil engineering and specialized construction	5
5.	Civil engineering and specialized construction	Wholesale and retail trade and repair of motor vehicles and motorcycles; Wholesale except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles.	100
6.	Transport and storage	Land and by pipes transport; Warehousing and support activities for transportation;	11
7.	Mining	Gravel pits.	19

The wastewater from these activities is discharged into the municipal sewer system or directly into a natural emissary. Making a correlation with the situation of wastewater collection and systems of wastewater treatment in the river basin, we can conclude that the domestic and industrial wastewater generated in the Timiş River basin is not sufficiently purified.

The absence or insufficient residual wastewater treatment leads to pollution of surface water with organic substances and with chemical substances. Pollution by organic substances produces a significant impact on aquatic ecosystems by changing species composition, decreasing the biodiversity in species and reducing the fish population or increasing fish mortality in the context of the drastic reduction of oxygen. Pollution by dangerous substances (synthetic pollutants and/or synthetic pollutants) produces toxicity, persistence and bioaccumulation in the aquatic environment (*, 2013).

Agricultural activity

Along with the industry, agriculture could become one of the major sources of pollutants with negative impact on the quality of the environment through environmental degradation or even the destruction of ecosystems. Nowadays it is almost universally accepted that intensive farming can lead to pollution of soil and water through excessive use of fertilizers, pesticides, improper irrigation water quality and quantity, and arable land excessively loose through various works. Polluting agents such as toxic substances can accumulate in quantities exceeding the maximum allowable limits in both surface waters and groundwater. (*, 2005).

Improper agricultural practices associated with irrigation and drainage, that may incorrectly add a disconnection of the management and use of agricultural land and irrational use of forestry, determine the rise and intensified physical degradation of the soil, through processes like deconstruction, compacting, crusting, wind and water erosion, overexploitation of groundwater, alteration of natural habitats, contributing even more to increased pollution in different ways to the main components of the environment. (O'Connor, 2005; *, 2006).

Large inputs of different compounds from agriculture have led to unexpected and very serious side effects in aquatic ecosystems, such as mass mortality of organisms, challenge of mutations and cancer diseases in humans and animals, reducing primary production process, accumulation in the food chain rings, high toxicity, and last but not least a tolerance induced (Barbu, 2010; *, 2005).

Major sources of agricultural pollution in the basin are represented by the ranches distributed mostly in the Timiş River floodplain area that according to the Registry of Protected Areas Banat is an area sensitive to nitrates.

The main agricultural units identified in the basin are the pig breeding farm, poultry farms, the sheep and goat farms, dairy farms and mixed activities farms. Their spatial distribution in the basin is shown in figure number 41.

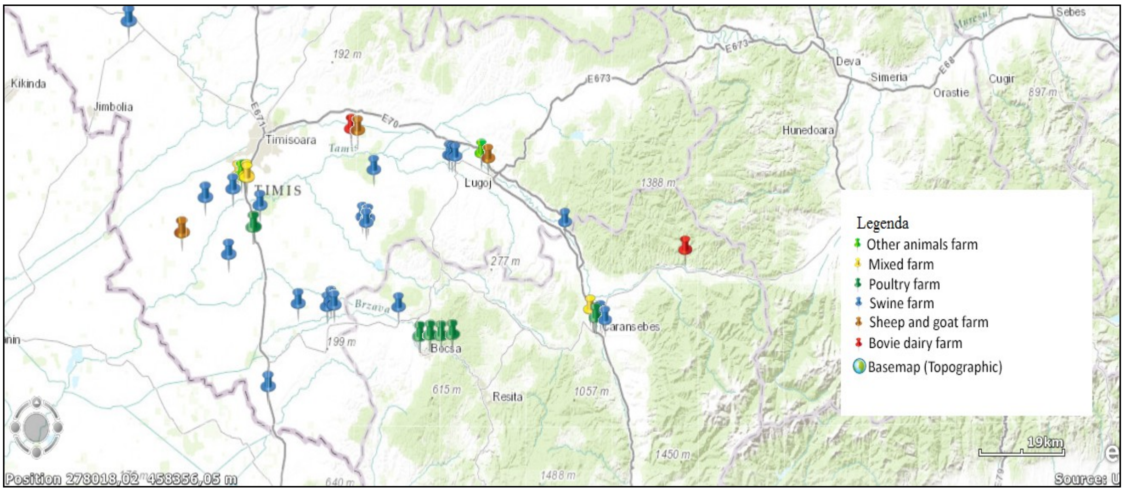


Figure 41: Spatial distribution of the main farms in the basin of the river Timiş, 2012.

Agricultural development in floodplains along the river regulation works made for different economic purposes (shipping, embankment works, and water accumulation) led to the loss of wetlands (approximative 50%) and flood plains (95%) (Tockner et al., 2009).

In Timiş River basin, such situations are encountered mainly in the middle of the river Timiş, specifically on the Caransebeş - Cruceni. The result of such operations is loss of arms, meanders cutting, river bed straightening, and disappearance of wetlands that used to characterize Timiş River (Fig. 2).

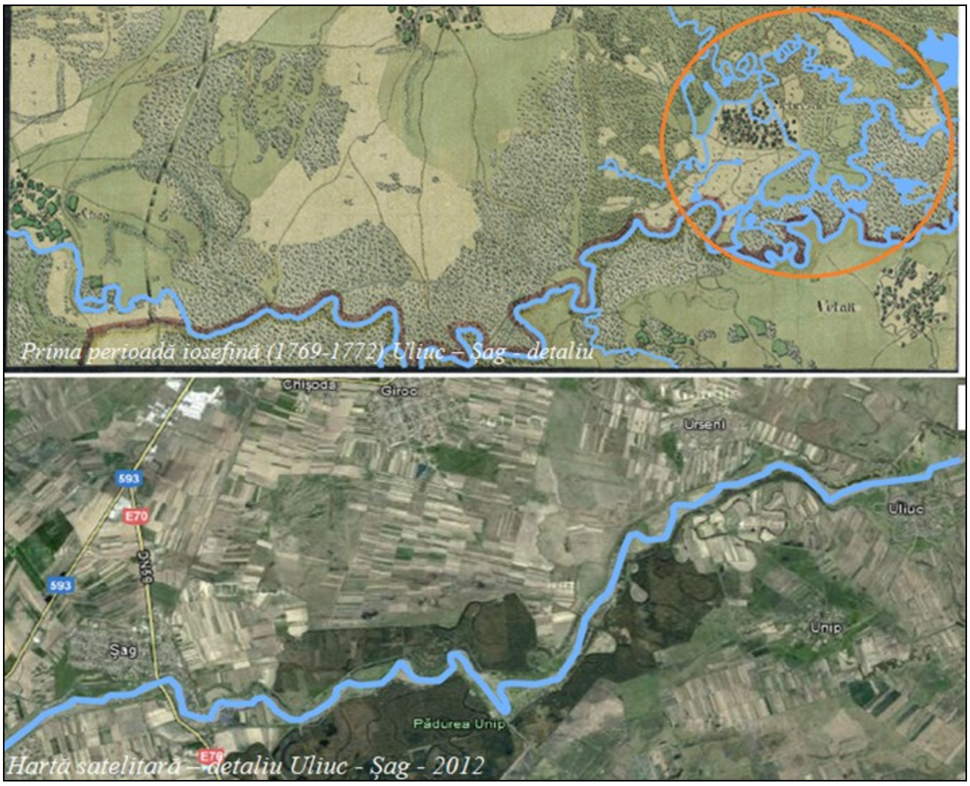


Figure 42: Changes in the Timiş River - detail Uliuc - Şag.

CONCLUSIONS

The main human pressures that have a negative impact on the Timiş River basin are hydraulic works (special hydro-technical works, water accumulations, settlement works and construction of dikes and banks defence), agricultural and industrial development, and urbanization.

In order to achieve the objectives of the Water Framework Directive it is necessary to implement management measures for the entire basin, so it is recommended to consider the following:

- in terms of hydraulic works: it should be established the ecological flow downstream of works and it should be studied their potential impact; regulating the transfer of water from one reservoir to another so none of the reservoirs should be under or over the optimal volume;

- to reduce pressure from agricultural and industrial development is recommended to reduce discharges of industrial wastewater in sewers, especially those from metallurgy, pharmaceutical and chemical;

- to reduce agglomeration pressure rehabilitation and/or modernization of sewage and waste systems is recommended; construction and/or expansion of wastewater treatment plants and collection systems, including agglomerations where the number of inhabitants is below 2000, i.e. waters discharged into the environment to be within legal required quality;

- development of a waste collection system from both household and economic activity, so waste will not be stored on the river's banks; also it is recommended to inform the population about the importance of selective collection and to provide the necessary infrastructure for selective collection.

ACKNOWLEDGMENTS

This paper results are based on the scientific field campaigns of the project "Study of the quality of Timiş water and registry of polluters source to border" (IV.1.2), a Phare CBS project, no. 411, - 90964/30.12.2010/07, of "Lucian Blaga" University, Faculty of Sciences, financed by the European Community.

REFERENCES

1. Alcamo J., Flörke M. and Märkle M., 2007 – Future long-term changes in global water resources driven by socio-economic and climatic changes, *Hydrological Sciences Journal - Journal des Sciences Hydrologiques*, 52, 247-275.
2. Aldescu V. C., 2010 – Studiul inundațiilor pe Râul Timiş amenajat în conceptul „mai mult spațiu pentru râuri” Lucrare de doctorat, Universitatea „Politehnica” din Timişoara, 150-152. (in Romanian)
3. Allan J. D., 2004 – Influence of land use and landscape setting on the ecological; status of rivers, *Limnetica*, 23, 187-198.
4. Antonescu S., Balintoni P., Balu I., Bârsescu A., Boldea V., Cătană N., Crișan I., Cristescu I., Deleanu M., Doclin O., Fried E., Galescu C., Hillinger N., Iordăchescu F., Jurjica T., Jurma G., Mănăilă N., Munteanu,V., Naidan I., Oallde P., Odărescu I., Olaru M., Popa I., Poterașu M., Răuț O., Rădăuț C., Reichenbach P., Sârbu N., Serban I., Tudor M., Țeicu S., Urseanu A., Uzum I., Vânătoru M., Vulpeş N. and Zeberca V., 1981 - Caraş-Severin - Monografie, Edit. Sport-Turism, Bucureşti. (in Romanian)
5. Badea L., Bogdan O., Bugă B., Cucu V., Donisă I., Gâștescu P., Ianovici V., Iordan I., Niculescu G., Oancea D., Posea G., Savu A., Sencu V., Velcea and Velcea, 1992 – Geografia României IV. Regiunile Pericarpatice: Dealurile și Câmpia Banatului şi Crișanei, Podișul Mehedinți, Subcarpații, Piemontul Getic, Podișul Moldovei, Edit. Academiei Române, București. (in Romanian)
6. Barbu C. H., 2010 – Factori chimici de risc ecologic. Suport de curs pentru uzul studenţilor, Universitatea “Lucian Blaga” din Sibiu - Catedra de Ecologie şi Protectia Mediului. (in Romanian)
7. Bradea M., Iordache M., Morodan I., Minda L. and Bălan R., 1981 – Timiş monografie, Edit. Sport-Turism, Bucureşti, 11. (in Romanian)
8. Curtean-Bănăduc A., 2005 – Râul Cibin, caracterizare ecologică, ISBN 973-739-195-0, 240. (in Romanian)
9. Curtean-Bănăduc A., Bănăduc D. and Sîrbu I., 2005 – *Transylvanian Review of Systematical and Ecological Research*, 2, The Târnava River Basin, 182.
10. Curtean-Bănăduc A., Bănăduc D. and Sîrbu I., 2011 – Transylvanian Review of Systematical and Ecological Research 11, The Upper Tisa River Basin, 204.
12. Diamond J., 2011 – Collapse: How Societies Choose to fail or Succeed: Revised Edition, Penguin Books, ISBN-10: 0143117009, 608.
13. Olteanu, F. 2004 – Toponimele şi hidronimele de origine nelatină în lucrările de antiquis et hodiernis moldaviae nominibus şi historia moldo-vlachica de Dimitrie Cantemir. Ovidius University Annals of Philology Volume XV, Number 143-152, 2004, 14, (http://litere.univovidius.ro/Anale/04%20volumul%20XV%202004/15%20Florentina%20Olteanu.pdf). (in Romanian)
14. Goubert J.-P., 1989 – The Conquest of Water: The Advent of Health in the Industrial Age. Princeton.
15. Griselini F. and Feneşan C. 1984 – Încercare de istorie politică şi naturală a Banatului Timişoarei, Edit. Facla Timişoarei, 22-234. (in Romanian)
16. Hughes J. D. (ed.), 1978 – An Environmental History of the World, Routledge, London.
17. ICPDR, 2004 – International Commission for the Protection of the Danube River (ICPDR) 2004, *Danube Basin Analysis* (WFD Roof report 2004). ICPDR Document IC/084, 18 March 2005, Vienna, Austria. http://www.icpdr.org/icpdr-pages/reports.htm.
18. Curtean-Bănăduc A., Bănăduc D. and Sîrbu I., 2011 – *Transylvanian Review of Systematical and Ecological Research*, 11, The Upper Tisa River Basin, 204.
19. ICPDR, 2006 – International Commission for the Protection of the Danube River (ICPDR). 2006. *Convention on Co-operation for the Protection and Sustainable Use of the River Danube*. 15 March 2006. Vienna, Austria. http://www.icpdr.org/icpdr-pages/drpc.htm

20. Lacoste Y., 2003 – Apa bătălia pentru viață, Enciclopedia Rao, București. (in Romanian)
21. Litvinov A. S., Mineeva N. M., Papchenkov V. G., Korneva L. G., Lazareva V. I., Shcherbina Grigory K., Gerasimov Y. V.; Dvinskikh S. A., Noskov V. M., Kitaev A. B., Alexevnina M. S., Presnova E. V., Seletkova E. B., Zinovíev E. A., Baklanov M. A., Okhapkin A. G. and Shurganova G. V., 2009 – Volga River Basin, in Tockner K., Uehlinger U. and Robinson C. T. (eds), Rivers of Europe, Elsevier Ltd., USA.
22. Liuba C., 2003 – Che Ruieni-Furnizor de servicii tehnologice pentru SEN (http://www.et.upt.ro/cee/ro/psc/works03/psc49.pdf). (in Romanian)
23. Malmqvist B. and Rundle S., 2002 – Threats to the running water ecosystems of the world, *Environmental Conservation*, 29, 134-153.
24. Mândruț O. 1993 – Geografia României (geografie generală și regională), Edit. Coresi, București. (in Romanian)
25. Müller N., 1995 – River dynamics and floodplain vegetation and their alterations due to human impact, in Lampe W. (ed.), *Archiv Für Hydrobiologie*, E. Schweizerbart'sche Verlagsbuchhandlung (Nägele U. Obermiller), Stuttgart.
26. Munteanu I. and Munteanu R., 1998 – Timiș monografie, Edit. Marineasa, Timișoara.
27. O'Connor P. J., 2005 – Human impacts, in Salminen R. (Chief-editor), Batista M. J., Bidovec M., Demetriades A., De Vivo B., De Vos W., Duris M., Gilucis A., Gregorauskiene V., Halamic J., Heitzmann P., Lima A., Jordan G., Klaver G., Klein P., Lis J., Locutura J., Marsina K., Mazreku A., O'Connor P. J., Olsson S. Å., Ottesen R. T., Petersell V., Plant J. A., Reeder S., Salpeteur I., Sandström H., Siewers U., Steenfelt A. and Tarvainen T., FOREGS Geochemical Atlas of Europe, Part 1: Background Information, Methodology and Maps, Geological Survey of Finland, Espoo, 63-66.
28. ICPDR, 2006 – International Commission for the Protection of the Danube River (ICPDR), Convention on Co-operation for the Protection and Sustainable Use of the River Danube, 15 March 2006, Vienna, Austria, http://www.icpdr.org/icpdr-pages/drpc.htm
29. Pandi G., 2002 – Riscul în activitatea de apărae împotriva inundaţiilor, *Riscuri şi catastrofe*, 2, Edit. Casa Cărţii de Ştiinţă, Cluj Napoca, 132, (http://riscurisicatastrofe.reviste.ubbcluj.ro/Volume/I_2002/PDF/Pandi.pdf) (in Romanian)
30. Pop G., 2002 – Carpații și subcarpații României, Edit. Presa Universitară Clujeană, Cluj-Napoca. (in Romanian)
31. Posea G., 2002 – Geomorfologia României. Relief- Tipuri, Geneză, Evoluție, Regionare, Edit. Fundației România De Mâine, București. (in Romanian)
32. Postel S. L, 2000 – Entering an era of water scarcity: The challendes ahead, *Ecological Applications*, 941-948, USA.
33. Roşu A., 1973 – Geografia Fizică a României, Edit. Didactică şi Pedagogică, București. (in Romanian)
34. Sabater S., João F., Maria G., Manuel A. S., Munõz I. and Romaní A. M., 2009 – The Iberian Rivers, in Tockne, Klement U., Urs R. and Christopher T. (eds), Rivers of Europe, Elsevier Ltd., USA
35. Schuyt K., 2005 – Freshwater and Poverty Reduction: Serving People, Saving Nature: An economic analysis of the livelihood impacts of freshwater conservation initiatives, WWF International: Gland Switzerland.
36. Solomon S., 2010 – Water: The Epic Struggle for Wealth, Power, and Civilization, ISBN 10: 0060548304, 608.
37. Sommerwerk N.; Hein T., Schneider-Jacoby M., Baumgartner C., Ostojić A., Paunović M., Bloesch J., Siber R. and Tockner K., 2009 – The Danube Rivr Basin, in Tockner K., Uehlinger U., Robinson C. T. (eds), Rivers of Europe, Elsevier Ltd., USA.
38. Teodorescu N. I., 2008 – The minimum flow in the upstream basin of the Timiş River, XIVth Conference of the Danubian Countries, IOP Publishing.

39. Tockner K., Uehlinger U. and Robinson C. T. (eds.), 2009 – Rivers of Europe, First edition, Academic Press Elsevier, ISBN-13, 978-0-12-369449-2, 728.
40. Turner W. R., Brandon K., Thomas M., Constanza R., Da Fonseca G. A. B. and Portela R., 2007 – Global Conservation of Biodiversity and Ecosystem Services, BioScience, 57, 10.
41. Ujvári I., 1972 – Geografia apelor României. Editura Ştiinţifică, Bucureşti. (in Romanian)
42. *, 2002 – H.G. 188/20.03.2002 provisions for approval of rules on the conditions for discharge into the aquatic environment of waste water treatment, as amended by Government decision 352/11.05.2005 as amended by Government decision No. 210 of 28.02.2007.
43. *, 1971 – Râurile României. Monografie hidrologică, Edit. INMH, Bucureşti. (in Romanian)
44. Soroceac M., 2005– Climatic regionalization between yesterday and tommorow. Study case: The Banat plain, Romanian rewiew of regional of regional studies, I, 1.
45. Teodorescu N. I., 2008 – The minimum flow in the upstream basin of the Timiş river, XIVth Conference of the Danubian Countries, IOP Publishing.
46. *, 2005 – ORDIN Nr. 1182 din 22.11. 2005 privind aprobarea Codului de bune practici agricole pentru protecţia apelor împotriva poluării cu nitraţi din surse agricole (http://www.mmediu.ro/legislatie/acte_normative/gospodarirea_apelor/Cod_Bune_Practici_Agricole.pdf). (in Romanian)
47. *, 2006 – Mediul și Agricultura. Principii și practici privind reducerea poluării apelor cu nitrați proveniți din agricultură (http://alma-ro.ngo.ro/doc/brosuraREC.pdf). (in Romanian)
48. *, 2010-2011 – Contract de cercetare încheiat cu primăria Caransebeş în cadru proiectului PHARE CBC "Protective measures for Timiș River" financed by the European Community, 411/90964/2010-2011. (in Romanian)
49. *, 2013 – Actualizare Plan de Amenajare a Teritoriului Județului Timiș. Etapa II, II, Cadrul Natural, Mediu, Zone de Risc; Beneficiar Consiliul Județean Timiș. (in Romanian)
50. Anexa planului de management SH Banat. (in Romanian)
51. geo-spatial.org, 1
52. www.caransebes.ro
53. www.cjTimiş.ro
54. www.firme.ro
55. *, 2006 – Mediul și Agricultura. Principii și practici privind reducerea poluării apelor cu nitrați proveniți din agricultură (http://alma-ro.ngo.ro/doc/brosuraREC.pdf). (in Romanian)
56. *, 2013 – Actualizare Plan de Amenajare a Teritoriului Județului Timiș. Etapa II, Vol II: Cadrul Natural, Mediu, Zone de Risc; Beneficiar Consiliul Județean Timiș. (in Romanian)
57. *. 2008 – Lista actualizată a micilor acumulări din categoriile de importanta C şi D, care intră sub incidenta OUG 138/2005, şi aprobată prin Legea 13/2006 , din S.H. BANAT reactualizare martie 2008, (www.mmediu.ro) (in Romanian)
58. *, 2005 – ORDIN Nr. 1182 din 22.11. 2005 privind aprobarea Codului de bune practici agricole pentru protecţia apelor împotriva poluării cu nitraţi din surse agricole (http://www.mmediu.ro/legislatie/acte_normative/gospodarirea_apelor/Cod_Bune_Practici_Agricole.pdf). (in Romanian)

FLOOD EFFECTS ON THE PHYTOPLANKTON DIVERSITY OF BEGA RIVER (BANAT, ROMANIA)

Hanelore MUNTEAN * and *Laura ALEXOAIE* **

* "Politehnica" University, Faculty of Hydrotechnics, Timişoara, Timiş County, Romania, RO-30022, hane_elena@yahoo.com
** "Politehnica" University, Faculty of Hydrotechnics, Timişoara, Timiş County, Romania, RO-30022, lora_tm@yahoo.com

DOI: 10.2478/trser-2013-0042

KEYWORDS: flood, Timiş-Bega water system, Bega River, phytoplankton density, water quality.

ABSTRACT

Situated on the Western Plains of Romania, the Banat region has an adverse natural condition that makes it a frequently-flooded area. A lack of natural drainage due to a low slope, shallow gound water, slow-moving water course densities, and precipitation in this close, mountainous area all contribute to periodic flood events. Water courses in the region have snake-like river beds and swamps present in the area before the XVIIIth century (Griselini, 1979) also create a tendency toward flood activity. The Bega is a river in the Timiș-Bega water system, originating from Poiana Rusca Mountains and the lower basin becomes channeled before entering Timișoara City.

Seasonal floods and overall water quality influence the quantity and quality of phytoplankton and macrozoobenthos in the Bega River. Phytoplankton obtains energy through the process of photosynthesis and must therefore live in the well-lit surface layer of a water body. Crucially dependent on minerals, phytoplankton primarily subsist on macronutrients such as nitrate, phosphate or silicic acid, which are governed by the balance between the so-called biological pump and the upwelling of deep, nutrient-rich waters. After floods the balance of nutrients in a river is changed and the effects can be observed by discerning differences in phytoplankton biomass and families living in the water body before and after the flood event (Muzaffar, 2007).

In this study, based on the information from local water administration, we provide data about the flood in 2005 and its effects on the biodiversity in the river. The measurements were made at 2 sites, one before the Bega River enters Timișoara and the other at Otelec station, 45.5 km downstream from Timișoara.

The runoff in 2005, caused by high precipitation in the upper basin, disturbed the nutrient balance in the river by transporting debris and sediment discharge from upstream, and carrying the local macrozoobenthos out of their normal habitat. Upstream from Timișoara, phytoplankton is dominated by species of diatomes like *Diatoma* sp., *Synedra* sp., *Navicula* sp., *Fragilaria* sp., *Rhoicospahenia* sp., *Gyrosigma* sp., *Cymatopleura* sp. and *Amphora* sp.

During floods the flow and speed of the water increases, which dilutes the water and modifies the concentration of nutrients and pollutants in the affected area, therefore changing the processes at a biological level. This specific process is important for the possibility of self-purification in water bodies.

RÉSUMÉ: Effets des inondations sur la diversité du phytoplancton de la Rivière de Bega (Banat, Roumanie).

La région de Banat est située dans les plaines occidentales de la Roumanie. Les conditions naturelles défavorables dans cette région sont la conséquence de fréquentes inondations. L'absence de drainage naturel en raison de faibles pentes, d'une eau peu profonde, d'un faible débit, de la densité des cours d'eau, des précipitations dans la région montagneuse du bassin hydrographique de la rivière qui serpente, induisent des inondations dans cette région. Ces éléments sont additionnés à la présence de marais avant le XVIIIe siècle (Griselini, 1979). Bega est une rivière appartenant au bassin hydrographique de Timiș-Bega (montagnes Poiana Rusca) dont le bassin inférieur est canalisé avant l'entrer dans la Timișoara.

Les inondations saisonnières et la qualité de l'eau influencent la quantité et la qualité du phytoplancton aussi que des macro-invertébrés benthiques de la rivière. Le phytoplancton obtient de l'énergie à travers le processus de la photosynthèse; il colonise la couche de surface superficielle bien éclairée d'un plan d'eau qui est régit par l'équilibre entre la pompe dite biologique et les remontées des eaux profondes riches en éléments nutritifs. Le phytoplancton dépendant essentiellement de minéraux, principalement de macronutriments tels que le nitrate, le phosphate ou l'acide silicique. Après la période d'inondation, l'équilibre des nutriments dans une rivière est modifié et les effets peuvent être observés dans les différences de biomasse du phytoplancton et des familles vivant dans l'eau avant et après l'événement. (Muzaffar, 2007)

Cette étude est basée sur les informations de l'administration locale de l'eau, les informations sur les inondations de 2005 et les effets sur la biodiversité. Les mesures ont été faites sur deux sites: l'un devant l'entrée du fleuve Timișoara et l'autre à la station Otelec à 45,5 km de Timișoara.

Les inondations de 2005, provoquées par de fortes précipitations dans le bassin supérieur, ont perturbé l'équilibre des nutriments dans le fleuve transportant en aval des débris et des sédiments, faisant dériver les macro-invertébrés benthique et affectant leur habitat. En amont du Timișoara, le phytoplancton est dominé par des espèces de diatomées comme *Diatoma* sp, *Synedra* sp, *Navicula* sp, *Fragilaria* sp, *Rhoicospahenia* sp, *Gyrosigma* sp., *Cymatopleura* sp., ainsi que sp. amphores.

Au cours des inondations, le débit et la vitesse de l'eau sont élevés. Ceci a pour conséquence le phénomène de dilution qui modifie la concentration en nutriments et en polluants de la zone affectée, altérant ainsi le processus biologique lié à ces concentrations. Ce processus spécifiques est important pour la capacité d'auto-purification des eaux.

L'auto-purification est un processus complexe où tous les facteurs physiques, chimiques et/ou biologiques, combinés ou séparés, conditionné par le temps de impurification (Mălăcea, 1964).

REZUMAT: Efectele inundațiilor asupra diversității fitoplanctonului râului Bega (Banat, România).

Regiunea Banat este situată pe Câmpia de Vest din România, condiţii naturale adverse determinând producerea frecventă a inundaţiilor. Lipsa de drenaj natural din cauza pantei mici, acviferul la adâncime mică, flux redus, densitatea cursului de apă, precipitațiile în zona montană incluse în bazinul hidrografic cu forma şerpuită sunt motivele pentru inundaţiile din acest domeniu, adăugându-se la mlaştinile prezente aici înainte de secolul al XVIII-lea (Griselini, 1979). Bega este un râu ce face parte din sistemul de apă Timiş-Bega, izorăşte din Munții Poiana Ruscă, bazinul inferior fiind canalizat înainte de a intra în Timişoara.

Inundaţiile sezoniere, precum şi calitatea apei, influenţează cantitatea şi calitatea fitoplanctonului şi macrozoobentosului în râu. Fitoplanctonul obţine energie prin procesul de fotosinteză şi, prin urmare, trebuie să trăiască în stratul de suprafaţă bine luminat al unui corp de apă. Este extrem de dependent de minerale, în primul rând de macronutrienţi cum ar fi nitraţi, fosfaţi sau siliciu, reglementate de echilibrul între aşa-numita pompă biologică şi apele de adâncime, bogate în nutrienţi. După perioada de inundaţii, echilibrul substanţelor nutritive într-un râu este schimbat, iar efectele pot fi observate în diferenţele de biomasă ale fitoplanctonului şi familiile care trăiesc în corpul de apă înainte şi după eveniment. (Muzaffar, 2007)

În acest studiu sunt analizate informaţii cu privire la inundaţiile din 2005 de la administraţia locală a apei şi efectele inundaţiilor asupra biodiversităţii. Măsurătorile au fost făcute în două sit-uri, unul în aval de Timişoara şi celălalt la Otelec, la 45,5 km de Timişoara.

Viitura din anul 2005, cauzată de precipitaţiile mari din bazinul superior, a deranjat echilibrul de nutrienţi în râu, datorită transportului resturilor şi a sedimentelor din amonte şi a condus la spălarea macrozoobentosului local şi modificarea habitatului. În amonte de Timişoara fitoplanctonul este dominat de specii de diatomee ca *Diatoma* sp., *Synedra* sp., *Navicula* sp., *Fragilaria* sp., *Rhoicospahenia* sp., *Gyrosigma* sp., *Cymatopleura* sp., *Amphora* sp.

În timpul inundaţiilor, viteza de curgere a apei a fost mare, producând un debit de diluţie care a modificat concentraţia de nutrienţi şi poluanţi în zona afectată, schimbând, prin urmare, procesele la nivel biologic, legate de aceste concentraţii. Acest proces specific este important pentru posibilitatea de autoepurare a corpurilor de apă.

Autoepurarea este o procedură complexă în cazul în care toţi factorii, fizici, chimici sau biologici, împreună sau separat, sunt condiţionaţi de timpul de poluare (Mălăcea, 1964).

INTRODUCTION

Hydrology and water quality are causes for concern because they can create a loss of balance between the wet and dry seasons. A water system can be at risk due to high variations in water flows, which are important for maintaining the quality of aquatic ecosystems. The Bega River basin collects water from different small rivers spread throughout a complex terrain with varying climates, with each contributing water body influencing the Bega flow.

Floods are the main factor that influences the communities of phytoplankton in water bodies and floodplains, followed by pollution and dissolved oxygen in the water as two other influential factors. Seasonal variations in phytoplankton diversity and density are mainly a response to the flow hydrograph of different hydrological periods (Sabir, 2007). Phytoplankton species composition and abundance change because of the duration and intensity of hydrological and water chemistry alterations (de Oliveira and Calheiros, 2000).

Variations in flow and sources of water are major factors affecting phytoplankton density and biomass. Phytoplankton has a low biomass when river flow is high, but it rapidly increases as flow decreases, suggesting that the length of time that the floodplain is inundated by the river is not as important as the hydrological processes affecting floodplain drainage (Schemelet al., 2004).

Self-purification is the process of transforming polluted water by changing the physical properties of the water and the removing undesirable chemicals and organisms, thereby creating clean water. This self-purification happens naturally by microorganisms, algae and other factors like dilution, absorption or chemical reactions, without the assistance of any anthropogenic methods.

Study area

The Bega River basin spreads through a surface area of 4470 square km and has a general orientation east to west. The length of the river in Romania, from its source spring to the border with Hungary is 170 km, with another 30 km until the Bega joins the Tisa River in Hungarian territory.

Agricultural and forested lands each make up about a third of the Bega River basin's surface area. The landscape of the Bega floodplain appears somewhat like steps descending in an east-west direction, with each of these steps representing phases of water stagnation. In terms of climate, the Bega Basin is part of a sub-Mediterranean-influenced temperate zone. This environment generates heat in the winter and relatively high amounts of precipitation, which increases the risk of flooding.

The water course suffers impairments in water quality downstream due to untreated water sources or discharges of improperly treated water, but also because of the introduction of storm water during periods of intense rainfall.

Significant pressure on the course of the river like hydromorphological stress, intakes for water supply, evacuation, derivations, regulations, and damming all lead to changes in river characteristics, both in terms of quantity and quality.

MATERIALS AND METHODS

For this study biological and chemical samples were taken from two sections of the Bega River: upstream of Timişoara and at Otelec. Hydrological measurements were made in the same locations.

Phytoplankton samples were collected with a 1-liter plastic container and preserved with Lugol's solution or 4 percent formaldehyde. A Burker-Turk blade was used to count phytoplankton and calculate the density of species. Macrozoobentos samples were taken with Ponar draglines (five) and preserved with 4 percent formaldehyde or 70 percent alcohol.

Macrozoobentos samples were processed using a microscope and stereomicroscope. Chemical samples were collected and processed according to laboratory standards. Each of the following was chemically analyzed: dissolved oxygen, BOD5, total nitrogen, total phosphorus, and ammonia.

To assess the ecological status of aquatic units based on phytoplankton and macrozoobentos characteristics, the Pantle–Buck method was used. For water quality classifications related to chemical evaluations, laboratory tests were performed according to the Order 161/2006. The results of these analyses were used to observe variations over time or in certain conditions and their correlations provided data or solutions to self-purification problems.

Water quality is regulated in Romania by law with water bodies classified into 5 categories by NTPA013/2005 and HG 1146/03. There are defined, categorical limitations for every indicator analyzed in this study.

RESULTS AND DISCUSSIONS

In past years, significant floods on the Bega River were documented as being caused by heavy rainfall and melting snow in the upper basin. In April 2005 there was a flood wave that breached dikes and caused other damage along the Bega. The flood wave was recorded at a rate of 35.8 m^3/s in the Luncani section, and 154.0 m^3/s in the Otelec section.

Water speed was 3 m/s at Luncani Mountains, later decreasing close to Timişoara where it reached 0.500 m/s. The water speed then increased to 1.25 m/s at Otelec. The effect of these floods was the destruction of many aquatic ecosystems and habitats. Species density downstream was also affected.

During floods the section between Timişoara and Otelec, where the water was polluted due to oil spills, the introduction of industrial wastewater and untreated or improperly treated water created a mixture of clean and poor quality water, which produced a "natural treatment". This stage has a chemical effect of diluting pollutants, along with influencing the quality and quantity of aquatic biodiversity.

A period of time after the flooding the measurement of hydrological, chemical and biological factors in September and November of 2005 showed relevant findings at sites upstream from Timișoara and Otelec (Fig. 1).

From a hydrological point of view the water flow upstream from Timişoara was considered average in September and November, however, water flow was lower than the average at Otelec in the same two months. The water flow rate was approximately the same at both sites at 0.4 m/s.

Maximum flow rates were relatively equal at both sites in November. In September, however, the difference in water flow between the sites was considerable, with a maximum flow of 23.5 m^3/s and a speed of 0.66 m/s at Otelec versus 11 m^3/s and speed 0.4 m/s upstream of Timişoara.

Note that in terms of the hydrological river course there are variations that contribute to all these changes in parameters, all of which have an effect on water quality. Beginning at the source of the river the water quality is Class I, which means very little pollution in the water and a large capacity for self-purification.

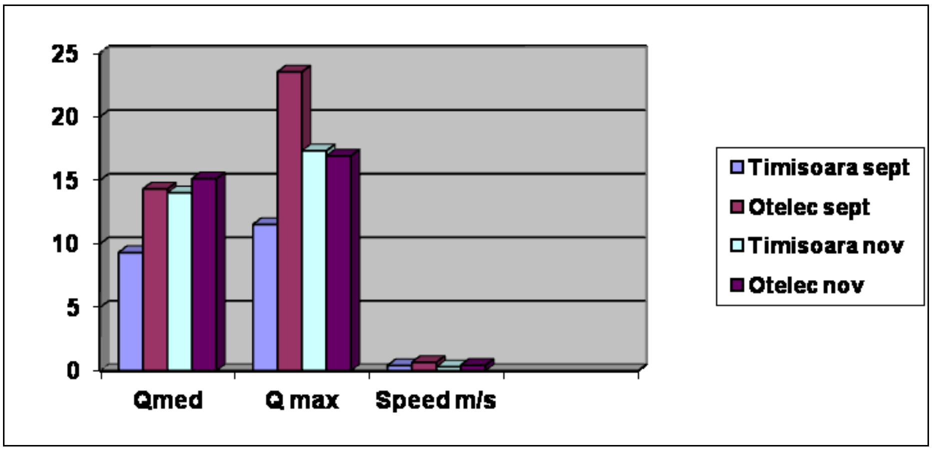


Figure 1: Hydrological characteristics in the stations upstream Timișoara and Otelec.

Gradually, due to human impact, water quality impairment occurs such that the upstream section of Timișoara water falls into class II water quality and at Otelec water quality reaches class V on some indicators.

The September and November readings at upstream of Timișoara and at Otelec showed dissolved oxygen values as depicted in figure 2.

Note the higher level of oxygen in the upstream section of Timişoara and a small amount of it at the Otelec section, which shows poor-quality water further downstream and consequently leads to a negative effect on the work of aquatic organisms in the purification process. Dissolved oxygen levels change with the seasons and typically there are lower levels in the summer and higher levels in the winter.

Major changes in biochemical oxygen levels at Otelec station put it at a Class-III water quality level with a maximum amount in November 6.85 mg O/l. The upstream of Timişoara section had a maximum oxygen level of 2.42 mg/l recorded in November while minimal oxygen levels were recorded at the site in May. In September the oxygen level reached 1.65 mg/l. In both September and November water quality upstream of Timişoara was rated as Class I, which indicates very good water quality.

Plants with chlorophyll have a very important role in the self-purification of water due to the plant's relationship with phosphorus and nitrogen in the analyzed sections. The section upstream of Timişoara has Class I water quality while the Otelec section phosphorus only exceeded acceptable limits by 0.4200 mg P/l in September and 0.2900 mg P/l in November, making the water quality fall into the Class III category.

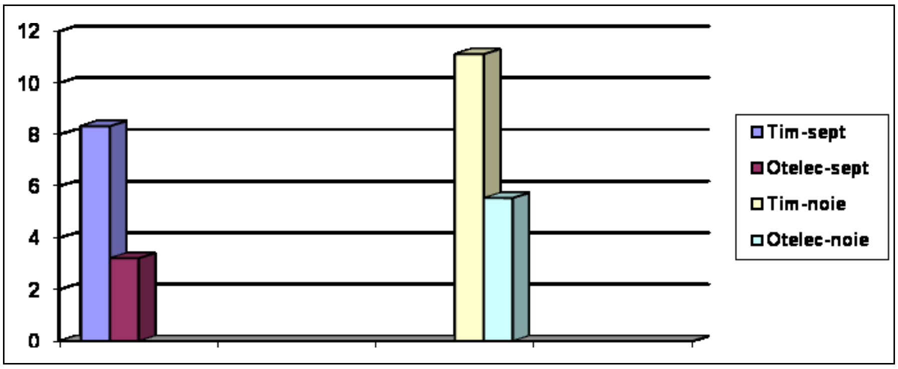


Figure 2: Dissolved oxygen (mg/l).

All these parameters and indicators in the aquatic environment affect biological activity. The biomarkers analyzed in upstream sections of Timişoara and Otelec were macrozoobentos and phytoplankton.

Upstream of Timişoara phytoplankton consists mostly of diatom with predominant genres like *Diatoms* sp., *Synedra* sp., *Navicula* sp., *Fragilaria* sp., *Rhoicospahenia* sp., *Cymatopleura* sp., *Gyrosigma* sp. and *Amphora* sp. Using the Pantle-Buck method, water from this section came in at Class II quality both in September and November.

One difference discovered between September and November was that the density of observed phytoplankton dropped from 320,000 expl/l in September to 240,000 expl/l in November.

The presence of aquatic invertebrates shows a good ecological state for the water in this section. Mostly Oligochaet and Gastropods species were present there with a density of 640 expl/sqm.

At Otelec station the density of phytoplankton species was 270,000 expl/l in September and 210,000 expl/l in November. Water at this station tends toward a poor ecological condition due to the presence of alpha and polisaprobe species. The number of phytoplankton species is relatively small and is limited to species belonging to the groups *Bacillariophyta, Chlorophyta* and *Euglenophyta*.

Macroinvertebrate species were found in a rather small number of only 78 expl/m at Otelec station. Also there were only a relatively low number of species of *Gastropods*, namely *Oligochaeta* and *Diptera*. The ecological status of water at this station is moderate.

CONCLUSIONS

Analysis of water samples collected in September and November 2005 showed that despite the fact that floods with high flow rates led to changes in aquatic ecosystems, those ecosystems were rebuilt in a relatively short time. The density of phytoplankton and macrozoobenthos increased rapidly after the water level stabilised and the balance was restored.

The process of dilution that occurred during floods did not result in an obvious improvement of water quality in the river section affected by pollutants as evidenced by the fact that the ecological status of water is still damaged.

In the Otelec section macroinvertebrates have a lower density due to the small amount of dissolved oxygen in the water, which prevents or hinders their participation in the process of self-cleaning. The reduced amount of nutrients in the water in this section also affects the development of oxygen-producing green algae, which in turn restricts the improvement of water quality.

Although dilutions occur during floods, the biological processes remain active, while the self-purification process is affected by the high quantity of the pollutants being discharged upstream.

Acknowledgements

This study was possible with the support of the Banat Water Basin Administration and was partially supported by the strategic grant POSDRU/88/1.5/S/50783, Project ID50783 (2009), co-financed by the European Social Fund – Investing in People, within the Sectoral Operational Programme Human Resources Development 2007-2013.

REFERENCES

1. Reynolds C. S., Huszar V., Carla Kruk C., Naselli-Flores L. and Melo S., 2002 – Towards a functional classification of the freshwater phytoplankton, *Journal of Plankton Research*, 24, 5.
2. Griselini F., 2006 – Încercare de istorie politică şi naturală a Banatului Timişoarei, Editura de Vest. (in Romanian)
3. Schemel L. E, Sommer T. R, Müller-Solger A. B. and Harrell W. C, 2004 – Hydrologic variability, water chemistry, and phytoplankton biomass in a large floodplain of the Sacramento River, CA, U.S.A., *Hydrobiologia*, 513, Kluwer Academic Publishers.
4. de Oliveira M. D and Calheiros D. F, 2000 – Flood pulse influence on phytoplankton communities of the south Pantanal floodplain, Brazil, *Hydrobiologia,* 427, Kluwer Academic Publishers.
5. Muzaffar S. and Fakhruddin A., 2007 – The effects of the flood cycle on the diversity and composition of the phytoplankton community of a seasonally flooded Ramsar wetland in Bangladesh,Wetlands Ecology Management.

…