

RESEARCH ON THE ENVIRONMENTAL QUALITY IN BRATIA RIVER

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Abstract

The main purpose of the study was to determine the quality of Bratia River. The present paper was based on the bibliographic material as well as the field research carried out during 2016-2017. The research objectives were the following: identification of qualitative and quantitative structure of phytobenthic biocenoses in the established monitoring points; determination of the phytoplankton algae families in the monitoring stations; identification of the structure of benthic biocenoses in the monitoring points; establishing saprobity indices for each species identified and incorporation of the monitoring sections into the appropriate saprobity class; determining the quality of Bratia River according to the Water Framework Directive 2000/60/EU. We have identified 54 species in the phytobenthonic samples, grouped in three phyla: Cyanobacteria, Bacillariophyta and Chlorophyta. We have also identified 47 species in the structure of benthic zoocenosis belonging to 25 families from 8 genera. The main benthic invertebrate groups in the Bratia River were: Ephemeroptera, Plecoptera, Chironomidae, Trichoptera, and Gammaridae. Oboarele Mari and Gămăcești recorded a high quality ecological status, while Berevoiesti station had a good ecological status.

Keywords: Bratia River, environmental quality, macrozoobentos, phytobenthos

1. INTRODUCTION

Bratia River is a hydrographic artery having important flowing and morphometric elements within Argeș basin, a general North-South flowing and a permanent character (fig. 1). It is situated in Mușcelele Argeș, in the Getic Sub-Carpathians. Doamnei River lies to the west of Bratia River. The river springs from Obârși Mountains, with an altitude of 2314 in the Iezer Massif, and flows into Târgului River, with a length of 56.9 km and an average annual flow of 2.6 m³/s. Bratia River basin is situated in Argeș County and has arteries on the southern slopes of the Southern Carpathians. The density of the hydrographic network is large, consisting of both permanent and temporary valleys. The main tributaries of the river are: Brătioara, Năvrap, Râușor (PMBH Argeș-Vedea, 2012).

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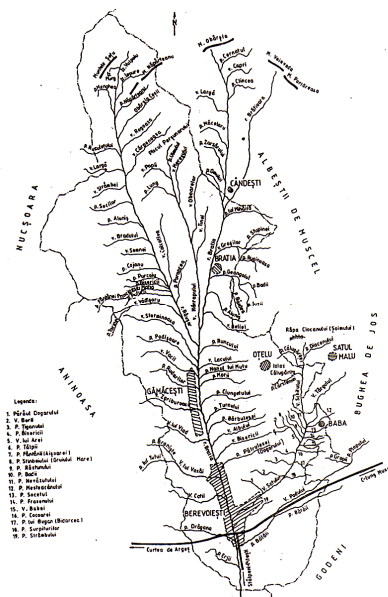


Figure 1. The hydrographic network of Bratia River in the upper course (Cadastral Map Berevoiești, 2010)

2. MATERIALS AND METHODS

We collected qualitative and quantitative samples of phyto- and macrozoobenthos from three stations: Oboarele mari, Gămăcești and Berevoiești. Sampling was done in November 2016 and April 2017 for phytobenthos and August, November 2016 and May 2017 for macrozoobenthos as recommended in the specialized studies. Phytobenthos sampling was done by scraping submerged stones with a smoother surface that stood in water at depths of about 25-30 cm for at least 14-21 days, covered with 100% microphytobenthic elements. Determination of the sampling surface was done by measuring the stones. We have had three samples for the quantitative analysis of the macrozoobenthos, with a Sorber-Sampler benthic mesh having a sampling surface of 0.16 m² and mesh size 200 μm. The samples were sorted and processed in the Hydrobiology Laboratory of the University of Pitesti. We have calculated a series of ecological indices for Ephemeroptera order, representative of the structure of Bratia River: ecological spectrum, frequency, species constancy, relative abundance, ecological significance index (W). We determined the ecological status in accordance with the methodology required by the Water Framework Directive 60/2000 /EC by calculating the multimetric index in each of the sampling stations, taking into account the following indices: Saprob Index (SI), EPT_I Index (individuals) (IEPT_I), Shannon-Wiener Index (SWI), Number of Families (FAM), OCH Index (Oligochaeta-Chironomidae) Index (IOCH/IO), Function Group Index (IGF), Preferred Water Flow Index (reophil /limnophil) (REO/LIM) by the formula:

$$IM = 0.3*IS+0.1*IEPT_I+0.2*ISH+0.1*FAM+0.1*IOCH+0.1*IGF+0.1*REO/LIM$$

3. RESULTS AND DISCUSSIONS

Due to the peculiarities and physico-chemical conditions providing a predominantly rocky underlayer, Bratia River is dominated by a cenosis made of lithophil periphyton. We have identified 54 species of three phyla in the three sampling stations: *Cyanobacteria*, *Bacillariophyta* and *Chlorophyta* (Table 1 - 3). The best represented in terms of phyla was *Bacillariophyta* (48 species/ 88.88%), followed by *Chlorophyta* with 4 species (7.40%) and *Cyanobacteria* with 2 species (3.70%) (fig.3).

Table 1. List of species and numerical density identified in Bratia River biodiversity - Oboarele Mari Station

No.	Species	Density thousand ex/m ²
Cyanobacteria		
1.	<i>Oscillatoria limosa</i>	820
	Total Cyanobacteria	820
Bacillariophyta		
2.	<i>Achnanthes clevei</i>	9400
3.	<i>Achnanthes exilis</i>	2800
4.	<i>Achnanthes minutissima</i>	6300
5.	<i>Amphora ovalis</i>	90
6.	<i>Caloneis amphibaena</i>	80
7.	<i>Cocconeis placentula</i>	1000
8.	<i>Cymbella affinis</i>	780
9.	<i>Cymbella prostrata</i>	230
10.	<i>Cymbella tumida</i>	640
11.	<i>Diatoma hiemale</i>	2100
12.	<i>Diatoma vulgare</i>	3000
13.	<i>Epithemia zebra</i>	920
14.	<i>Frustulia rhomboides</i>	140
15.	<i>Gomphonema acuminatum</i>	210
16.	<i>Gomphonema truncatum</i>	1200
17.	<i>Gomphonema ventricosum</i>	2900
18.	<i>Mastogloia brauni</i>	3600
19.	<i>Mastogloia elliptica</i>	1180
20.	<i>Mastogloia smithi</i>	1220
21.	<i>Melosira granulata</i>	40
22.	<i>Navicula cincta</i>	1250
23.	<i>Navicula minima</i>	1890
24.	<i>Navicula minuscula</i>	5200
25.	<i>Navicula placentula</i>	560
26.	<i>Navicula subtilissima</i>	6800
27.	<i>Neidium iridis</i>	820
28.	<i>Neidium productum</i>	380
29.	<i>Nitzschia linearis</i>	490
30.	<i>Nitzschia palea</i>	1390
31.	<i>Pinnularia gibba</i>	440
32.	<i>Pinnularia subcapitata</i>	1360
33.	<i>Rhoicosphenia curvata</i>	620
	Total Bacillariophyta	59030
Chlorophyta		
34.	<i>Cladophora sp.</i>	4960
35.	<i>Ulothrix sp.</i>	380
	Total Chlorophyta	5340
	TOTAL GENERAL	65190

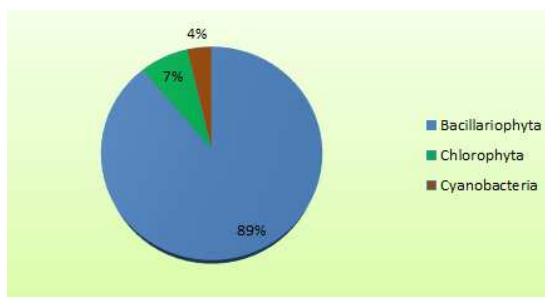


Figure 2. Number of phytoplankton algae phyla in Bratia River in the three sampling stations

Table 2. List of species and numerical density identified in Bratia River biodiversity - Gămăcești Station

No.	Species	Density thousand ex/m ²
Cyanobacteria		
1.	<i>Oscillatoria tenuis</i>	250
	Total Cyanobacteria	250
Bacillariophyta		

2.	<i>Achnanthes clevei</i>	1200
3.	<i>Cocconeis bacillum</i>	3500
4.	<i>Cocconeis placentula</i>	4000
5.	<i>Cymatopleura solea</i>	2200
6.	<i>Cymbella cistula</i>	4500
7.	<i>Diatoma vulgare</i>	1600
8.	<i>Epithemia zebra</i>	800
9.	<i>Frustulia rhomboides</i>	600
10.	<i>Gomphonema ventricosum</i>	100
11.	<i>Gyrosigma acuminatum</i>	400
12.	<i>Mastogloia brauni</i>	4200
13.	<i>Mastogloia elliptica</i>	3700
14.	<i>Melosira granulata</i>	300
15.	<i>Navicula minuscula</i>	4400
16.	<i>Neidium iridis</i>	6000
17.	<i>Neidium protractum</i>	4900
18.	<i>Nitzschia linearis</i>	2100
19.	<i>Pinnularia gibba</i>	1500
20.	<i>Stauroneis phoenicenteron</i>	700
21.	<i>Surirella linearis</i>	200
22.	<i>Surirella ovata</i>	500
23.	<i>Synedra ulna</i>	3600
	Total Bacillariophyta	51000
	Chlorophyta	
24.	<i>Cladophora sp.</i>	1300
25.	<i>Ulothrix sp.</i>	400
	Total Chlorophyta	1700
	TOTAL GENERAL	52950

Table 3. List of species and numerical density identified in Bratia River biodiversity - Berevoiești Station

No.	Species	Density thousand ex/m ²
Cyanobacteria		
1.	<i>Oscillatoria limosa</i>	300
	Total Cyanobacteria	300
Bacillariophyta		
2.	<i>Achnanthes clevei</i>	1300
3.	<i>Achnanthes minutissima</i>	3200
4.	<i>Cocconeis placentula</i>	600
5.	<i>Cymbella affinis</i>	450
6.	<i>Cymbella cistula</i>	820
7.	<i>Cymbella prostrata</i>	590
8.	<i>Diatoma vulgare</i>	360
9.	<i>Gomphonema truncatum</i>	920
10.	<i>Gomphonema ventricosum</i>	1320
11.	<i>Hantzschia amphioxys</i>	1310
12.	<i>Mastogloia brauni</i>	85
13.	<i>Navicula cincta</i>	690
14.	<i>Navicula minuscula</i>	2200
15.	<i>Navicula subtilissima</i>	3400
16.	<i>Neidium iridis</i>	150
17.	<i>Nitzschia linearis</i>	600
18.	<i>Nitzschia palea</i>	29000
19.	<i>Pinnularia gibba</i>	410
20.	<i>Synedra ulna</i>	840
	Total Bacillariophyta	48245
Chlorophyta		
21.	<i>Cosmarium botrytis</i>	180
22.	<i>Ulothrix sp.</i>	350
23.	<i>Zygnema sp.</i>	310
	Total Chlorophyta	600
	TOTAL GENERAL	49385

The relative density in all 3 sampling stations is dominated by diatoms - 95%, followed by chlorophytes - 4% and cyanobacteria accounting for only 1% (fig. 3).

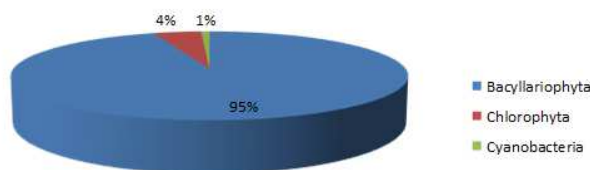


Figure 3. Relative density of algae taxa in the biodiversity of Bratia River

The numerical density of algae phyla in the biodiversity of Bratia River was nearly the same for bacillariophyta in each station. For chlorophytes, however, the situation is different, in the sense that the highest density was found in Oboarele Mari station, i.e 5340 thousand ex/m² (fig. 4). In the case of cyanobacteria, the density recorded the lowest values, being slightly predominant in number of species. The highest density of cyanobacteria was recorded in Oboarele Mari station.

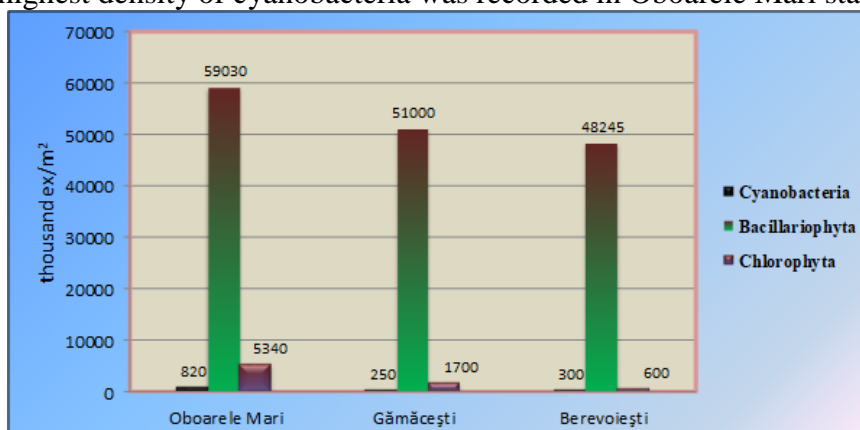


Figure 4. Numerical density of algae phyla in the biodiversity of Bratia River for each station

Taxonomic diversity decreased downstream upstream, with up to 35 taxons in the upstream sector, Oboarele Mari station, 25 taxons in Gămăcești station and 23 taxons in Berevoiești station (fig. 5)

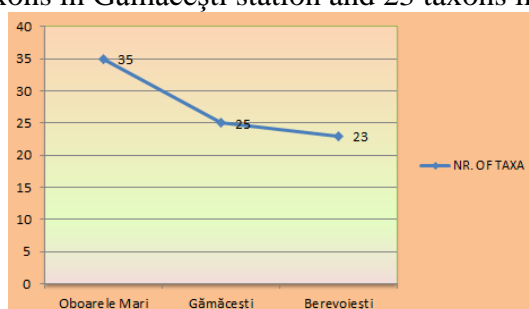


Figure 5. Variation of the number of taxa in the three sampling stations

As regards the structure of benthic zoocenosis, following the processing of the samples, we have found the following aspects:

August 2016 (fig. 6): ephemeroptera recorded high values of the numerical density both in Gămăcești and Oboarele stations (432 and 492 ind./m²), decreasing progressively from upstream downstream for the last station (Berevoiești), as opposed to chironomidae; plecoptera distribution from upstream downstream was variable, with high values in Gămăcești (132 ind./m²), but very low values in the other cases (minimum 15 ind./m² in Berevoiești).

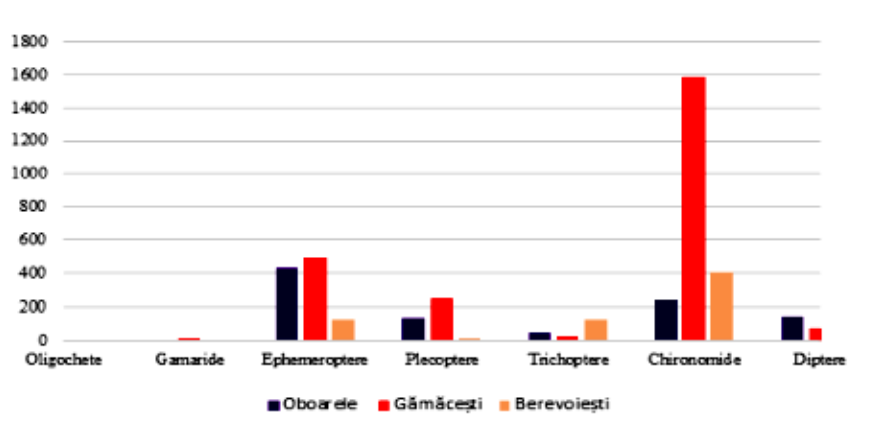


Figure 6. Comparative analysis of the macrozoobenthic structure of Bratia River upper basin – August 2016

November 2016: The analysis of the benthic zoocenosis structure in November, as shown in fig.7, revealed the clear dominance of ephemeroptera, followed by plecoptera, the other groups being poorly represented. The maximum number of ephemeroptera individuals/m² was recorded in Berevoiești (728 ind./m²), with a progressive decrease downstream to Oboarele station, followed by a slight increase in Gămăcești, but the values remained high, over 200 ind./m²; plecoptera distribution from upstream downstream was uniform in all three stations with very close values, 150 ind./m² on average.

The macrozoobenthic structure in **May 2017** (fig. 8) showed the following: Ephemeroptera and Plecoptera recorded a decrease in the number of ind./m² from upstream downstream; however, ephemeroptera recorded a surprising increase in Gămăcești station, where plecoptera were absent.

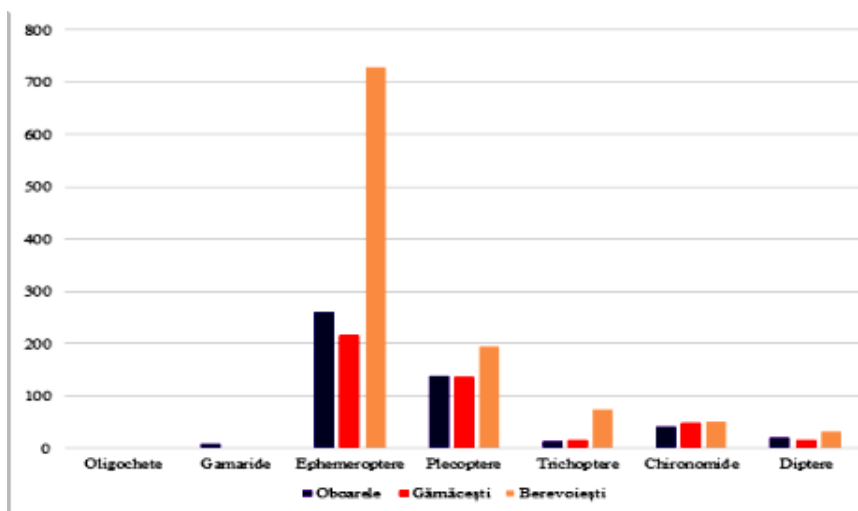


Figure 7. Comparative analysis of the macrozoobenthic structure of Bratia River upper basin – November 2016

Following the macrozoobenthic analysis and the samples taken from the three stations across Bratia River, we have identified 47 species belonging to 25 families (table 4).

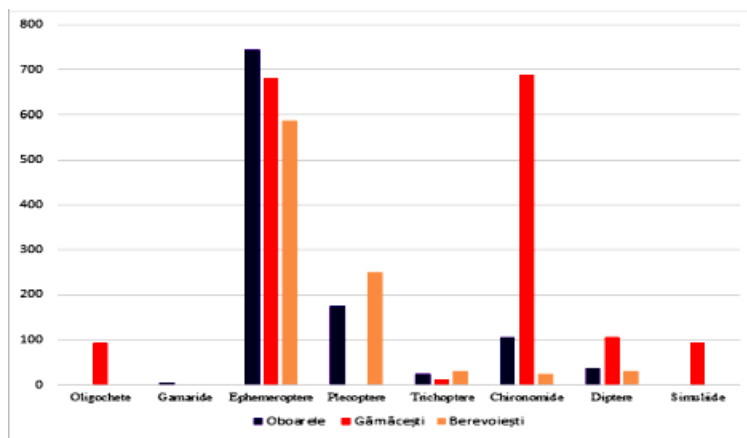


Figure 8. Comparative analysis of the macrozoobenthonic structure of Bratia River upper basin – May 2017

Table 4. The list of species

	Family	Species		
Oligocheta	<i>Naidae</i>	<i>Amphichaeta leydigi</i>		
		<i>Nais alpinus</i>		
	<i>Tubificidae</i>	<i>Psammoryctides barbatus</i>		
		<i>Ryacodrilus falciformis</i>		
Amphipoda	<i>Gammaridae</i>	<i>Gammarus fossarus</i>		
		<i>Gammarus pulex</i>		
Ephemeroptera	<i>Ephemeridae</i>	<i>Ephemerella dainca</i>		
	<i>Ephemerelliidae</i>	<i>Ephemerella ignita</i>		
		<i>Ephemerella vulgata</i>		
		<i>Caenis macrura</i>		
	<i>Baetidae</i>	<i>Baetis alpinus</i>		
		<i>Baetis lutheri</i>		
			<i>Baetis muticus</i>	
			<i>Baetis vernus</i>	
			<i>Ecdyonuridae</i>	<i>Ecdyonurus dispar</i>
			<i>Ecdyonurus torrentis</i>	
Plecoptera		<i>Epeorus sp.</i>		
		<i>Perlodidae</i>	<i>Isoperla gramatica</i>	
		<i>Leuctridae</i>	<i>Leuctra albida</i>	
		<i>Cupnidae</i>	<i>Cupnia nigra</i>	
		<i>Nemouridae</i>	<i>Nemura marginata</i>	
			<i>Protonemura intricata</i>	
			<i>Protonemura sp.</i>	
Trichoptera	<i>Hydropsichidae</i>	<i>Hidropyche pellucidula</i>		
	<i>Sericostomatidae</i>	<i>Sericostoma personatum</i>		
	<i>Ryacophilidae</i>	<i>Ryacophila fasinata</i>		
	<i>Hydropticidae</i>	<i>Hydroptica forcipata</i>		
Chironomidae	<i>Chironomidae</i>	<i>Cladotanytarsus mancus</i>		
		<i>Paratanytarsus lauternborni</i>		
		<i>Tanytarsus synuatus</i>		
		<i>Clapoduma viridula</i>		
		<i>Polypedilum convictum</i>		
		<i>Polypedilum lactum</i>		
		<i>Microspectra bidentata</i>		
		<i>Tanytarsus binulus</i>		
		<i>Myrospectra radialis</i>		
		<i>Polypedilum albicorn</i>		
		Diptera	<i>Blipharicedae</i>	<i>Liponeura spp.</i>
<i>Psychodidae</i>	<i>Pericoma spp.</i>			

	<i>Simuliidae</i>	<i>Simulium reptans</i>
	<i>Athericiidae</i>	<i>Atherix ibis</i>
	<i>Tipulidae</i>	<i>Tipula spp.</i>
	<i>Ceratopogonidae</i>	<i>Bezzia spp.</i>
	<i>Dixidae</i>	<i>Dixa spp.</i>
Simuliidae	<i>Simulidae</i>	<i>Simulium costatum</i>
		<i>Simulium monticola</i>
		<i>Simulium equinum.</i>

The distribution of ephemeroptera species per month showed the following aspects:

Almost all 11 species were identified in August 2016 (fig. 9), their number in each station increasing progressively from Berevoiești to Gămăcești and decreasing again in Oboarele station; We have identified all 5 genera: *Baëtis*, *Ephemerella*, *Epeorus*, *Ecdyonurus*, and *Caenis*; *Baëtis* had very high densities in all stations; *Baëtis alpinus* had the maximum density in Berevoiești station (324 ind./m²), but was absent in the other two stations; *Ephemerella ignita* had low numerical densities in Oboarele and Gămăcești stations; *Ephemerella danica* was present in all three stations, with the maximum density in Oboarele station; *Ephemerella vulgata* was present in all three stations, with the maximum density in Oboarele station; the other species were rare and low in number. Only 10 species out of 11 were present in November 2016 (fig. 10); *Baëtis alpinus* was present in all 3 upstream stations, with the highest numerical density in Berevoiești station (328 ind./m²); the values decreased sharply in Oboarele and Gămăcești (17 ind./m²); *Baëtis lutheri* was present only in two stations, Oboarele and Gămăcești, with the maximum density in Gămăcești (54 ind./m²); *Ephemerella ignita* was present in Oboarele and Gămăcești stations, with the maximum density in Gămăcești (157 ind./m²); *Ephemerella*, *Ephemerella* and *Caenis* were absent in Berevoiești station; *Epeorus sp.* and *Ecdyonurus dispar* were absent in Gămăcești, being present in Oboarele and Berevoiești stations; *Ephemerella vulgata* had the same density in Oboarele and Berevoiești stations.

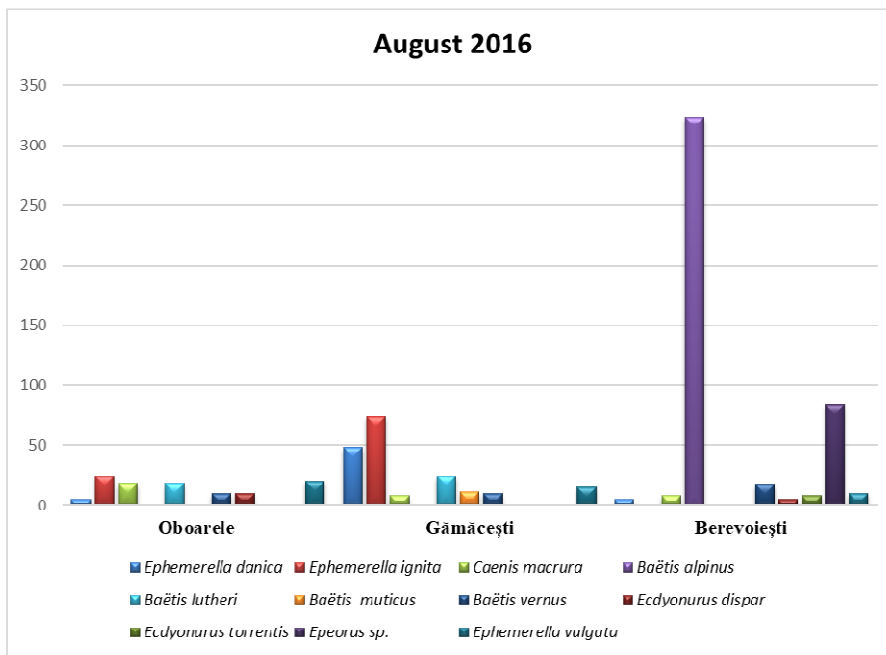


Figure 9. Structure of ephemeroptera fauna in Bratia River basin - August 2016

All 11 species were identified in May (fig. 11), their number increasing progressively to Gamăcești where we identified the maximum of 8 species; all five genera were present - *Baëtis*, *Ephemerella*,

Epeorus, *Ecdyonurus*, and *Caenis*; *Baëtis alpinus* had the highest density in Berevoiești and Oboarele (767, respectively 235 ind./m²), which gradually decreased to 30 ind./m² in Gămăcești station;

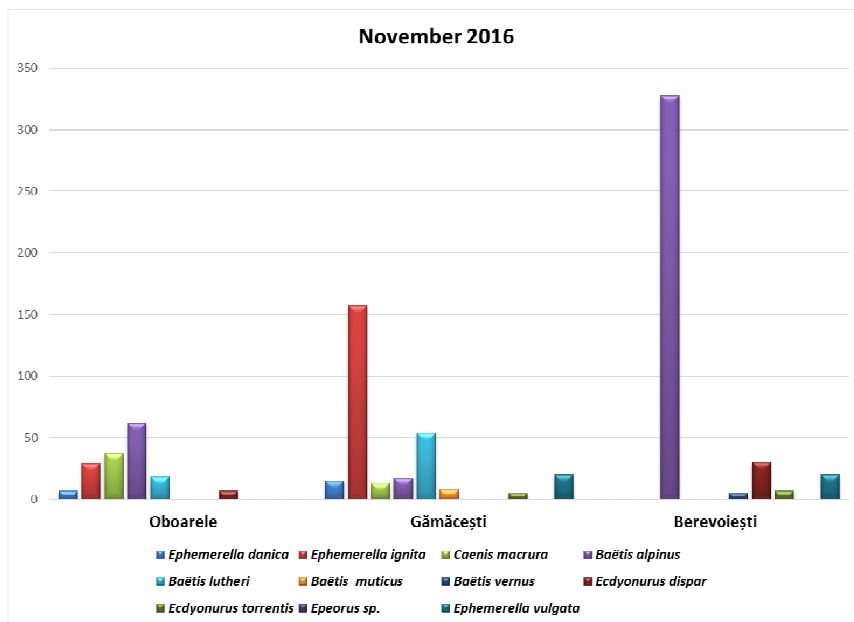


Figure 10. Structure of ephemeroptera fauna in Bratia River basin

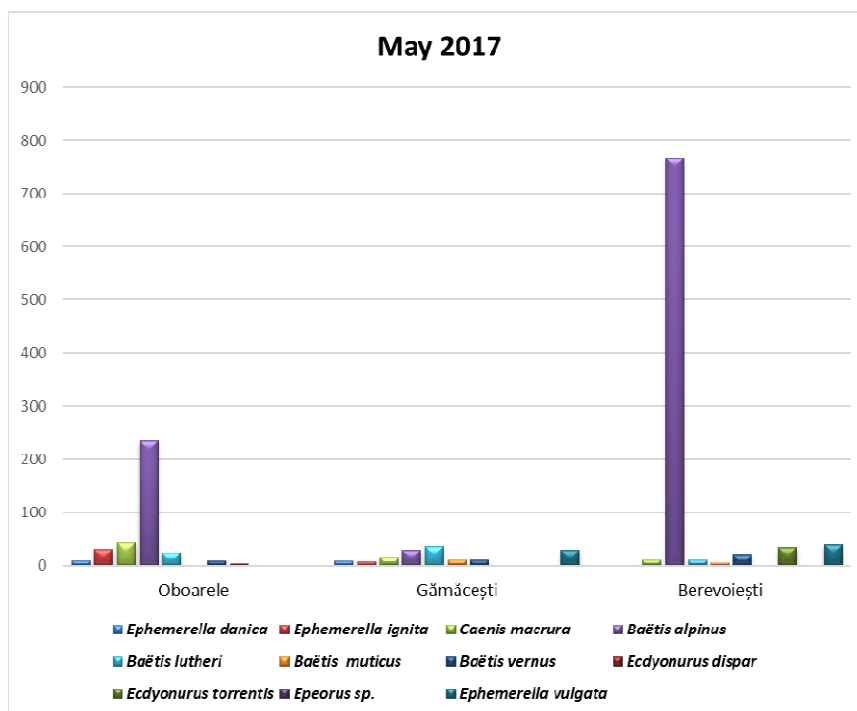


Figure 11. Structure of ephemeroptera fauna in Bratia River basin

Baëtis lutheri was present in Gămăcești station (37 ind./m²) and its density decreased progressively downstream to 25 ind./m² in Oboarele. However, its density was quite low in Berevoiești; *Baëtis vernus* was present in all three stations, reaching the highest density in Berevoiești (20 ind./m²);

Ephemerella ignita recorded low numerical densities in Oboarele and Gămăcești; *Ephemerella vulgata* was present only in two stations, Berevoiești and Gămăcești, with the maximum density in Berevoiești; the other species were rare.

The ecological spectrum (Fig.12.) shows the following aspects: Ecdyonuridae was dominant in Oboarele station, followed by *Ephemeridae* genus; the other genera accounted for less than 10%. *Caenidae* genus prevailed in the ecological spectrum of Gămăcești station, followed by Ephemeridae with a share of 3.5%. Caenidae was also dominant in Berevoiești station, with a share of 31.25%; the other families had a share below 10%.

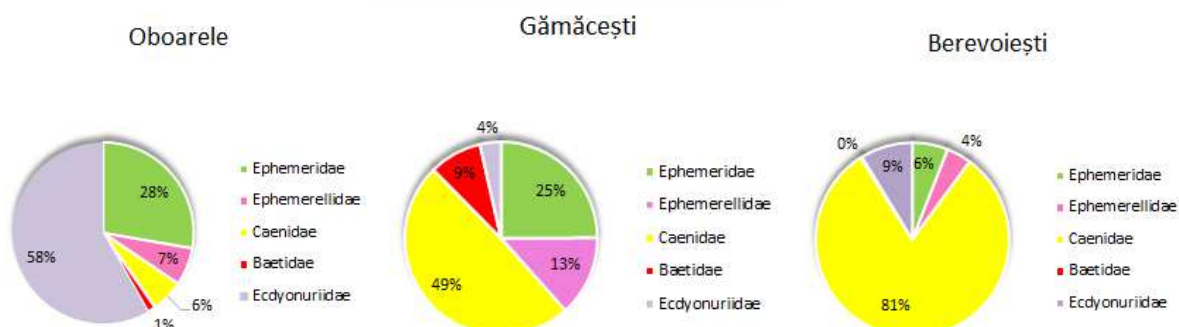


Figure 12. The ecological spectrum for Oboarele, Gămăcești and Berevoiești stations

In terms of the main ecological parameters, the processed data are listed in Table 5. It shows the frequency of species in each sampling station, abundance, constancy and the category to which each species belongs. *Ephemera danica* is characteristic of upstream stations, being a 1st class indicator. *Baëtis alpinus* is characteristic of downstream stations, as an indicator of 2nd-3rd class quality. *Ephemera danica* is characteristic for almost all the stations under research, which shows that the underlayer is rocky-cloddish, the flow speed is quite high, and the species is lithoreophil.

Table 5. Ecological characterization of the ephemeroptera biocenosis in the upper basin of Bratia river

	SPECIES	F%	Constancy sp.	n	A	W	W _x	Category of species
S 1	<i>Ephemera danica</i>	100	EUCONSTANT	58	8,5	8,5	W4	CHARACTERISTIC
	<i>Ephemerella ignita</i>	66	CONSTANT	98	14,3	9,4	W4	CHARACTERISTIC
	<i>Caenis macrura</i>	100	EUCONSTANT	34	4,53	4,9	W3	ACCESORY
	<i>Baëtis lutheri</i>	66	CONSTANT	42	4,76	4	W3	ACCESORY
S 2	<i>Ephemera danica</i>	66	CONSTANT	22	2,8	5,2	W4	CHARACTERISTIC
	<i>Ephemerella ignita</i>	66	CONSTANT	186	23,6	9,4	W4	CHARACTERISTIC
	<i>Caenis macrura</i>	66	CONSTANT	50	6,34	4,9	W3	ACCESORY
	<i>Baëtis lutheri</i>	66	CONSTANT	74	9,13	4	W3	ACCESORY
	<i>Baëtis muticus</i>	33	ACCESORY	8	1,01	0,5	W2	ACCESORY
	<i>Ephemera vulgata</i>	66	CONSTANT	20	2,4	5	W3	ACCESORY
S 3	<i>Baëtis alpinus</i>	100	EUCONSTANT	1032	80,9	80,9	W5	CHARACTERISTIC
	<i>Baëtis vernus</i>	100	EUCONSTANT	38	2,92	2,9	W3	ACCESORY
	<i>Ecdyonurus torrentis</i>	33	ACCESORY	35	2,7	0,8	W2	ACCESORY

According to the specialized standard methodology we have calculated the Multimetric Index (MI) based on the macrozoobenthos analysis in order to determine the quality of the ecological status (tab. 6). The upper course had a very good ecological status, unlike Berevoiești sector whose status was good.

Table 6. Determination of the multimetric index and the quality of ecological status for the sampling station

Index	OBOARELE	GĂMĂCEȘTI	BEREVOIEȘTI
Saprob Index (30%)	1,23	1,29	1,29
EPT_I Index (10%)	0,64	0,34	0,01
Shannon-Wiener Index (20%)	1,2	1,26	0,05
Number of Families (10%)	0,4	0,03	0,4
Index OCH (10%)	0,03	0,04	0,24
Function Group Index (10%)	0,07	0,94	0,79
Preferred Water Flow Index (10%)	0,01	0,004	0,92
MULTIMETER INDEX	0,72	0,77	0,63
ECOLOGICAL STATUS	very good ecological status	very good ecological status	good ecological status

4. CONCLUSIONS

- We have identified 54 species in the phytobenthic samples grouped in three phyla: Cyanobacteria, Bacillariophyta and Chlorophyta. As regards the share of phyla, Bacillariophyta was best represented with a number of 48 species (88.88%), followed by chlorophytes with 4 species (7.40%) and cyanophytes with 2 species (3.70%). We could also notice an increase in the number of species from downstream to upstream, with most of the species in Oboarele Mari (35), Gămăcești (25) and Berevoiești (23).
- We have identified 47 species in the structure of benthic zoocenosis belonging to 25 families from 8 orders. The main benthic invertebrate groups found in Bratia River were: Ephemeroptera, Plecoptera, Chironomidae, Trichoptera, and Gammaridae. Oboarele Mari had high quality ecological status unlike Berevoiesti whose ecological status was good.
- In the future, it is advisable to supervise Bratia River to prevent potential sources of anthropogenic negative impact and to monitor it with an annual frequency to ensure that the quality of ecological status is maintained at least at the current level.

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