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DIATOM SPECIES COMPOSITION IN THE RAŠKA RIVER (SOUTHWESTERN SERBIA)

ABSTRACT**:** The paper presents data on the composition of epilithic diatoms in the Raška River. Samples were collected by scraping stone surfaces with a brush from 5 localities along the Raška River in April, June, August and November 2011 and March and May 2012. Diatom frustules were cleaned using cold acid method, and mounted on permanent slides. An investigation of the Raška River resulted in description of 106 diatom taxa. The most species rich genera are *Navicula* (10), *Gomphonema* (10) and *Nitzschia* (9), while other genera are presented with one or more species. Detailed floristic analysis of the benthic diatom flora in this river has not been conducted before. Therefore, this paper provides a groundwork for future researches.

KEYWORDS: Diatoms, Raška River, species composition, taxonomy

INTRODUCTION

Diatoms are large and diverse group of single-celled algae [Round *et al*., 1990; Potapova and Charles 2002]. They are distributed throughout the world in nearly all types of aquatic systems and are one of the most important food resources in marine and freshwater ecosystems [Wichard *et al*., 2007; Medlin 2011]. A key issue in understanding diatom distribution is knowing the extent to which they are constrained by geographical factors that limit species dispersal vs. the extent to which they are limited only by the ability of the species

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to grow under a specific combination of environmental factors [Blanco 2014]. Ability of populations to compete and persist in a new local habitat depends on how well adapted they are to grow under its environmental conditions. Some of the factors most often found to be important for distribution of benthic river diatoms are water chemistry (particularly pH, ionic strength and nutrient concentrations), substrate, current velocity, light and grazing [Biggs 1996; O'Driscoll *et al*., 2012].

The Raška River is the left tributary of the Ibar River located in the southwestern part of Serbia. It belongs to the Black Sea drainage basin. It is 39 km long, 10–25 m wide with a catchment area of 1,040 km². The basin of the Raška River is located in Starovlaška – Raška highlands [Marković 1980]. There were 5 sampling sites along the river (RS1, RS2, RS3, RS4 and RS5) (Fig. 1).

There have not been any published data about diatom flora in the Raška River so far. An endangered red alga *Bangia atropurpurea* (Roth.) was found in the Raška River [Simić 2008]. Krizmanić *et al*. [2008] found *Hydrurus foetidus* (Vill.) in the same river. We sampled benthic diatoms to evaluate the floristic richness of the river. The main objective of the paper was to present 106 diatom taxa, which provides a groundwork for future researches.

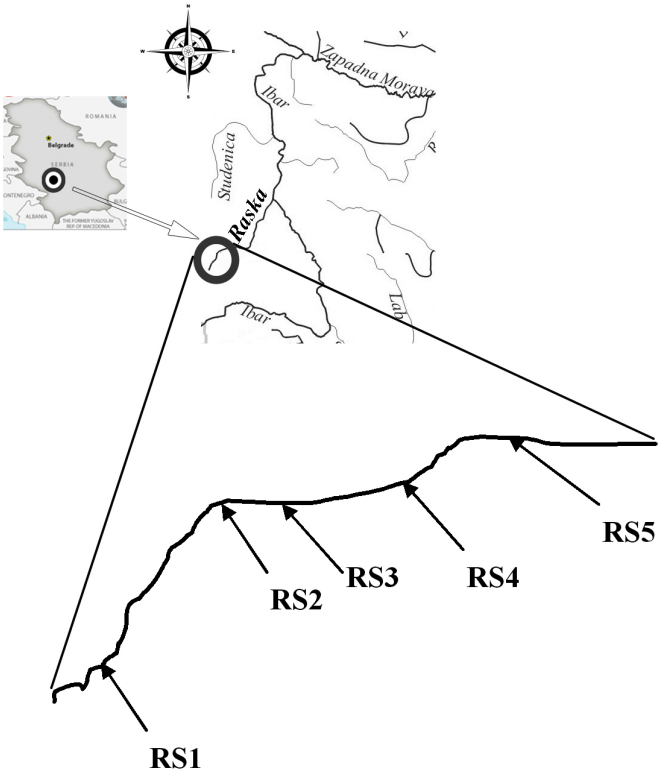

Figure 1. *Distribution of the sampling sites along the Raška River*

MATERIALS AND METHODS

The material was collected in April, June, August and November 2011 and March and May 2012 from 5 localities along the Raška River. Epilithic samples were scraped from the stone surfaces with a brush. Samples were fixed immediately with formaldechyde to a final concentration of 4%. Conductivity, oxygen, pH and water temperature were measured with a PCE-PHD at each sampling site. Chemical analysis of water was performed at the Institute of General and Physical Chemistry, University of Belgrade. The algological samples were treated in laboratory using standard methods to obtain permanent slides [Krammer and Lange-Bertalot 1986]. Permanent slides, prepared material and aliquots of the samples were deposited in the diatom collection of the Faculty of Biology, University of Belgrade. Light microscope observations and micrographs were made using a Zeiss AxioImagerM.1 microscope with DIC optics and AxioVision 4.8 software.

Terminology of valve morphology and identification were used according Hofman *et al*. [2013]. The abundance was estimated by counting 400 valves of each taxa present on a slide.

RESULTS AND DISCUSSION

Physico-chemical characteristics of water

According to Huet [1961], current velocity at the sampling sites along the Raška River ranged from moderate to very rapid (0.27–0.68 m/s). Low current velocity was caused by abundant vegetation. Water temperature of the Raška River ranged from 8 to 14 °C. The pH varied from neutral to slightly alkaline (7.02–8.23). The lowest pH value was recorded at RS2 sampling site in November and the highest was recorded at RS2 sampling site in March. Conductivity level had small variations (305–420 μS/cm). Total hardness was soft to slightly hard (6.6–121.0 mg CaCO3/l). The parameters providing information about a total content of organic matter are: biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and total organic carbon (TOC). BOD_5 was from 2.1 to 8.3 mg/l, COD from 4.2 to 18 mg/l and TOC was from 2.0 to 5.55 mg/l. Concentrations of other nutrients was low (ammonium ion, nitrates, nitrites, phosphates and orthophosphates) at all sampling sites along the Raška River.

Diatom species composition

A total of 106 diatom taxa have been recorded in the studied samples. We recorded two new taxa for diatom flora of Serbia: *Navicula jakovljevicii* and *N. catalanogermanica* [Vidaković *et al*., 2013]. Observed taxa were classified in 40 genera. The most abundant genera were *Navicula* (10), *Gomphonema* (10) and *Nitzschia* (9) (Tab. 1).

The presence of benthic diatoms in the Raška River for each of the six seasons is given in Tab. 2. Among the numerous species present in each season, *Achnanthidium minutissimum*, *Amphora pediculus* and *Navicula cryptotenella* were identified at all sampling sites along the Raška River. These taxa were abundantly developed and strongly predominated over other diatoms in the community.

Table 1. List of diatom genera with the number of taxa in the Raška River

Genus	No. of taxa	Genus	No. of taxa
Achnanthes	1	*Hantzschia*	1
Achnanthidium	5	*Hippodonta*	1
Amphora	3	*Luticola*	1
Caloneis	1	*Mayamaea*	1
Cocconeis	5	*Melosira*	1
Craticula	1	*Meridion*	1
Cyclotella	2	*Navicula*	10
Cymatopleura	3	*Neidiomorpha*	1
Cymbella	3	*Neidium*	1
Denticula	1	*Nitzschia*	9
Diatoma	4	*Placoneis*	3
Diploneis	2	*Planothidium*	3
Ellerbeckia	1	*Reimeria*	1
Encyonema	5	*Rhoicosphenia*	1
Fallacia	1	*Sellaphora*	4
Fragilaria	7	*Stauroneis*	1
Frustulia	1	*Staurosira*	1
Geissleria	1	*Staurosirella*	1
Gomphonema	10	*Surirella*	4
Gyrosigma	3	*Tryblionella*	1

The recorded composition of the benthic diatom communities is typical of running water and is similar to the diatom communities in other rivers in Serbia [Laušević 1993; Simić 1996; Nikitović and Laušević 1999; Krizmanić 2009; Andrejić *et al*., 2012]. *Achnanthidium minutissimum* is one of the most frequently occurring diatoms in freshwater benthic samples globally [Wojtal and Sobczyk 2006; Potapova and Hamilton 2007]. This species has been found in alkaline and acidic, oligotrophic and hypertrophic waters [Van Dam *et al*., 1994]. Various researches in Poland [Wojtal *et al*., 2011], South America [Potapova and Hamilton 2007] and Estonia [Vilbaste and Truu 2003] showed that *Achnanthidium minutissimum* was very abundant at the sampling sites. In the basin of the Zapadna Morava River, *Achnanthidium minutissimum* was also dominant taxon. In our study, this species was dominant at all sampling sites. Species such as *Amphora pediculus*, *Diatoma vulgaris*, *Navicula cryptotenella* and *Navicula tripunctata* are cosmopolitans and often dominant taxa in epilithic diatom community [Cremer *et al*., 2004; Wojtal 2009].

Table 2. List of the benthic diatoms in the Raška River (species names are listed in alphabetical order; '+' denotes the presence of a taxon).

Taxon	April 2011	Jun 2011	August 2011	November 2011	March 2012	May 2012
Achnanthes coarctata	+					
Achnanthidium affine	+	+	+	+	+	+
Achnanthidium biasolettianum		+	+	+	+	+
Achnanthidium exile		+	+		+	+
Achnanthidium minutissimum	+	+	+	+	+	+
Achnanthidium subatomus	+	+	+	+	+	+
Amphora inariensis	+	+	+	+	+	+
Amphora ovalis	+	+		+		+
Amphora pediculus	+	+	+	+	+	+
Caloneis bacillum	+	+	+	+	+	+
Cocconeis neodiminuta	+	+	+	+	+	+
Cocconeis pediculus	+	+	+	+	+	+
Cocconeis placentula var. lineata	+	+	+	+	+	+
Cocconeis placentula var. placentula	+	+	+	+	+	+
Cocconeis placentula var. pseudolineata	+	+	+	+	+	+
Craticula accomoda		+				
Cyclotella glabriuscula	+	+			+	+
Cyclotella meneghiniana	+		+		+	
Cymatopleura elliptica	+			+		
Cymatopleura solea		+				
Cymatopleura solea var. apiculata	+					
Cymbella compacta	+	+	+	+	+	+
Cymbella excisa	+	+	+			+
Cymbella parva	+	+	+	+		+
Denticula tenuis	+	+	+	+	+	+
Diatoma ehrenbergii	+	+		+	+	+
Diatoma mesodon		+			+	+
Diatoma moniliformis	+			+	+	
Diatoma vulgaris	+	+	+	+	+	+
Diploneis oblongela				+	+	
Diploneis parma	+					
Ellerbeckia arenaria		+	+	+	+	+
Encyonema lange-bertalotii	+	+	+	+	+	+
Encyonema minutum	+	+	+	+	+	+
Encyonema prostratum	+	+		+	+	+
Encyonema silesiacum	+	+	+	+	+	+
Encyonema ventricosum	+	+	+	+	+	+

Taxon	April 2011	Jun 2011	August 2011	November 2011	March 2012	May 2012
Fallacia subhamulata	+		+	+		+
Fragilaria acus		+				
Fragilaria biceps						+
Fragilaria capitellata				+	+	+
Fragilaria capucina	+			+	+	+
Fragilaria rumpens		+	+	+	+	+
Fragilaria ulna	+	+	+	+	+	+
Fragilaria vaucheriae	+	+	+	+	+	+
Frustulia vulgaris	+	+		+	+	+
Geissleria decussis	+	+	+	+	+	+
Gomphonema accuminatum	+	+		+	+	+
Gomphonema capitatum	+	+	+	+	+	+
Gomphonema micropus	+	+		+		+
Gomphonema minutum	+	+	+	+	+	+
Gomphonema olivacaeolacuum	+			+	+	+
Gomphonema olivaceum	+	+	+	+	+	+
Gomphonema parvulum	+	+	+	+	+	+
Gomphonema pumilum		+	+	+	+	+
Gomphonema sarcophagus	+			+	+	+
Gomphonema tergestinum	+	+	+	+	+	+
Gyrosigma attenuatum	+		+	+		
Gyrosigma obtusatum	+			+		
Gyrosigma sciotoense	+	+	+	+	+	+
Hantzschia amphioxys	+					
Hippodonta costulata						+
Luticola goeppertiana	+	+	+	+	+	+
Mayamaea atomus var. permitis			+	+		+
Melosira lineata	+	+	+	+	+	+
Meridion circulare	+	+	+	+	+	+
Navicula antonii	+	+		+	+	+
Navicula cari				+		
Navicula catalanogermanica			+	+	+	+
Navicula cryptocephala	+				+	+
Navicula cryptotenella	+	+	+	+	+	+
Navicula hintzii						+
Navicula jakovljevicii		+	+	+	+	+
Navicula lanceolata	+					
Navicula radiosa	+	+			+	+
Navicula tripunctata	+	+	+	+	+	+

Taxon	April 2011	Jun 2011	August 2011	November 2011	March 2012	May 2012
Neidiomorpha binodeformis	+			+		
Neidum dubium	+			+		+
Nitzschia dissipata	+	+	+	+	+	+
Nitzschia fonticola	+	+	+	+	+	+
Nitzschia heufleriana		+				
Nitzschia linearis	+	+		+	+	+
Nitzschia palea	+	+			+	+
Nitzschia pseudofonticola	+					
Nitzschia recta	+			+	+	
Nitzschia solita	+					
Nitzschia supralitorea	+			+	+	+
Placoneis paraelginensis	+					
Placoneis pseudanglica var. signata		+	+	+	+	+
Placoneis undulata		+	+	+	+	+
Planothidium dubium	+	+	+	+	+	+
Planothidium frequentissimum	+	+	+	+	+	+
Planothidium lanceolatum	+	+	+	+		+
Rhoicosphenia abbreviata				+	+	
Sellaphora bacillum	+	+				+
Sellaphora joubaudii			+	+	+	+
Sellaphora pupula	+	+			+	
Sellaphora seminulum						+
Stauroneis smithii	+					+
Staurosira binodis					+	
Staurosirella pinnata			+		+	
Surirella angusta	+	+	+		+	+
Surirella brebissonii var. kuetzingii	+	+		+	+	
Surirella linearis		+				
Surirella minuta	+	+				
Tryblionella angustata					+	

Seasonal dynamics of diatom species composition in the Raška River

At the first three sampling sites of diatom species composition in the Raška River, *Achnanthidium minutissimum* and *Amphora pediculus* appeared as dominant taxa. There was an exception in March 2013, when dominant taxon was *Diatoma vulgaris*. Besides these two taxa (*Achnanthidium minutissimum* and *Amphora pediculus*) at RS4 and RS5 sampling sites of diatom species composition there were present several other diatom taxa: *Achnanthidium affine*, *Gomphonema tergestinum* and *Achnanthidium subatomus*.

Percentage of valves for each taxon at the sampling sites from the six seasons is available on request from the authors.

The values of standard structure metrics (diversity indices and evenness) during all seasons are generally high (Fig. 2). In May 2012, the diatom community had high diversity indices (3.78) which influenced high evenness (0.78).

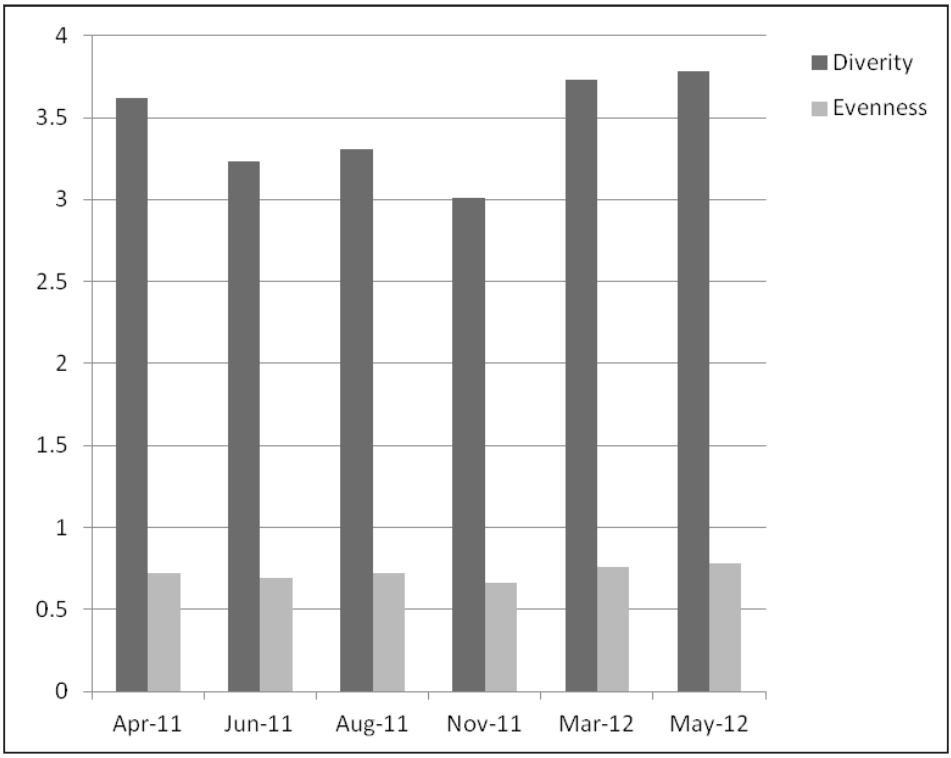

Figure 2. *The values of diversity indices and evenness during six seasons in the Raška River.*

The structure of the diatom assemblages in the Raška River agrees with the findings in the literature, which indicate that diatom communities are dominated by a few species that occur frequently and a large number of rare species that occur occasionally or sometimes only once [Kelly and Whitton 1995; Chatháin and Harrington 2008].

The diatom community was very similar at all sampling sites along the Raška River. In general, the most abundant diatom species were common at all investigated sites.

Some of the reported taxa were not frequent in the studied material (*Achnanthes coarctata*, *Craticula accomoda*, *Hippodonta costulata, Navicula hintzii*, *Nitzschia heufleriana*, *N. pseudofonticola*, and *Placoneis paraelginensis*) (Tab. 2). They are probably not ecologically significant for this river, but they are noticeable for floristic studies.

The presence of many diatom taxa could give evidence of a wide range of environmental possibilities for their development within the studied area [Wojtal *et al.*, 2005]. The study of diatom communities in rivers dates back many decades, therefore much information exist about species sensitivity to changes in the environment due to different pressures, particularly anthropogenic ones [Kelly and Whitton 1998; Kwandrans *et al.*, 1998; Gómez and Licursi 2001; Ivanov *et al.*, 2003; Vilbaste and Truu 2003; Ács *et al.*, 2004; Newall and Walsh 2005]. Evaluation of the floristic richness of diatoms in the river is a necessary, further step.

CONCLUSION

The main purpose of this study was to collect records on the floristics and the characteristics of the diatom assemblages inhabiting the Raška River.

There have not been any published data about diatom flora in the Raška River so far. These findings indicate the necessity for further fundamental investigations, since the diatom microflora in this part of the Balkan Peninsula remains poorly investigated regardless of a relatively long period of research. These new information increase our knowledge of the river system, which is important for further prediction of diatoms as bioindicators, as well as for monitoring programs.

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САСТАВ СИЛИКАТНИХ АЛГИ РЕКЕ РАШКЕ (ЈУГОЗАПАДНА СРБИЈА)

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РЕЗИМЕ: Рад садржи податке о саставу епилитских силикатних алги реке Рашке. Узорци су сакупљани у априлу, јуну, августу и новембру 2011. и у марту и мају 2012. године са пет локалитета дуж реке Рашке, стругањем четком са површине камена. Узорци су третирани стандардном лабораторијском методом и направљени су трајни препарати силикатних алги. Прегледом препарата идентификовано је 106 таксона силикатних алги. Родови најбројнији врстама су: *Navicula* (10), *Gomphonema* (10) и *Nitzschia* (9). Детаљна флористичка анализа бентоских силикатних алги реке Рашке није рађена раније па тиме овај рад даје основу за будућа истраживања.

КЉУЧНЕ РЕЧИ: река Рашка, силикатне алге, таксономија